AMARAVATI DEVELOPMENT CORPORATION LIMITED

Name of Assignment: Selection of Authority Engineer Consultant for Detailed Design Review, Construction Monitoring & Supervision, Quality Assurance & Technical Auditing (QA&TA) for "Water Treatment Plant and water supply network consisting head-works like Intake well, Raw water pumping main, Cushion tanks, semi-underground Reservoirs, SCADA Operated and Monitored water Transfer and Transmission system" being implemented on EPC mode in 'Amaravati' the New Capital City of Andhra Pradesh state, India.

RFP No: 19/CE/ADC/ENGG/2018-19. ADDENDUM-1 dated 06-08-2018

1. **The following Special Conditions of Contract shall constitute part of Section 8: Conditions of Contract and Contract Forms (Time Based)**

Number of GC Clause	Amendments of, and Supplements to, Clauses in the General Conditions of Contract
1.1(a)	The Contract shall be construed in accordance with the law of: Government of India & Government of Andhra Pradesh.
1.1 (b)	The date of the "Applicable Regulations" is: AP eProcurement Regulations (Current Version)
4.1	The language is: English.
6.1 and 6.2	The addresses are: **Client : Amaravati Development Corporation Limited** #20-4-15, Plot-1G, Anand Heights, Kedareswarapet, Vijayawada – 520003. Andhra Pradesh State. INDIA. **Attention : Chairperson & Managing Director (CMD)** **Consultant :** Attention : Telephone:
8.1	**Consultant / Lead member on behalf of JV:**
9.1	The Authorized Representatives are: For the Client: CE / SE @ ADCL For the Consultant:

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RFP No: 19/CE/ADC/ENGG/2018-19. ADDENDUM-1 dated 06-08-2018

11.1	The effectiveness conditions are the following : 1. Approval of the Contract by the GOAP. 2. Receipt by Client from the successful consulting firm a Performance Security in the form of Bank Guarantee (BG) in the format specified in Appendix-H for an amount of 2.50% of the Contract Value and valid for a period up to 2(two) months beyond the expiry of the contract period.
12.1	Termination of Contract for Failure to Become Effective: The time period shall be: one (1) month
13.1	Commencement of Services: The number of days shall be: Ten (10) days from Signing the Contract Agreement and the issuance of Work-Order. Submittal of Confirmation of Key Experts' availability to start the Assignment shall be submitted to the Client in writing as a written statement signed by each Key Expert: Yes.
14.1	Expiration of Contract: The time period shall be: Eighteen (18) months plus DLP 24 months.
23.1	The following limitation of the Consultant's Liability towards the Client can be subject to the Contract's negotiations: "Limitation of the Consultant's Liability towards the Client: a) Except in the case of gross negligence or willful misconduct on the part of the Consultant or on the part of any person or a firm acting on behalf of the Consultant in carrying out the Services, the Consultant, with respect to damage caused by the Consultant to the Client's property, shall not be liable to the Client: (i) for any indirect or consequential loss or damage; and (ii) for any direct loss or damage that exceeds **one time** the total value of the Contract;

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	(b) This limitation of liability shall not (i) affect the Consultant's liability, if any, for damage to Third Parties caused by the Consultant or any person or firm acting on behalf of the Consultant in carrying out the Services; (ii) be construed as providing the Consultant with any limitation or exclusion from liability which is prohibited by the "applicable law in the Client's country". **Imp. Note**: Any suggestions made by the Consultant in the Proposal to introduce exclusions/ limitations of the Consultant's liability under the Contract should be carefully scrutinized by the Client and discussed with the CMD, ADCL prior to accepting any changes to what was included in the issued RFP. In this regard, the Parties should be aware of the GOI/GOAP's policy on this matter which is as follows: To be acceptable to the CMD, ADCL any limitation of the Consultant's liability should at the very least be reasonably related to (a) the damage the Consultant might potentially cause to the Client, and (b) the Consultant's ability to pay compensation using its own assets and reasonably obtainable insurance coverage. The Consultant's liability shall not be limited to less than a multiplier of the total payments to the Consultant under the Contract for remuneration and reimbursable expenses. A statement to the effect that the Consultant is liable only for the re-performance of faulty Services is not acceptable to the CMD,ADCL. Also, the Consultant's liability should never be limited for loss or damage caused by the Consultant's gross negligence or willful misconduct. The CMD,ADCL does not accept a provision to the effect that the Client shall indemnify and hold harmless the Consultant against Third Party claims, except, of course, if a claim is based on loss or damage caused by a default or wrongful act of the Client to the extent permissible by the law applicable in the Client's country.
24.1	The insurance coverage against the risks shall be as follows: (a) Professional liability insurance, with a minimum coverage of Consultancy Contract Value; (b) Third Party motor vehicle liability insurance in respect of motor vehicles operated in the Client's country by the Consultant or its Experts or Sub-

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RFP No: 19/CE/ADC/ENGG/2018-19. ADDENDUM-1 dated 06-08-2018

	consultants, with a minimum coverage of: "in accordance with the applicable law in the Client's country"; (c) Third Party liability insurance, with a minimum coverage of state "in accordance with the applicable law in the Client's country"; (d) employer's liability and workers' compensation insurance in respect of the experts and Sub-consultants in accordance with the relevant provisions of the applicable law in the Client's country, as well as, with respect to such Experts, any such life, health, accident, travel or other insurance as may be appropriate; and (e) insurance against loss of or damage to (i) equipment purchased in whole or in part with funds provided under this Contract, (ii) the Consultant's property used in the performance of the Services, and (iii) any documents prepared by the Consultant in the performance of the Services.
27.1	No exceptions.
27.2	The Consultant shall not use these documents and software for purposes unrelated to this Contract without the prior written approval of the Client.
32.1 Removal of Experts or Sub-consultants	Key Experts, Non-Key Experts or Sub consultants who are found to be in breach of the Consultant's Code of Conduct (ESHS) shall be replaced by the Consultant, or at the Client's written request.
32.2	Key Experts, Non-Key Experts or Sub consultants, who are found to be incompetent or incapable in discharging assigned duties, shall be replaced by the Consultant, or at the Client's written request.
32.3	The time period shall be: Five (5) days
41.2	Contract Ceiling Value (Only GST will be Reimbursable):

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42.3	Beginning 19th month from commencement of services, Price adjustment /price escalation **"does apply"** to remuneration rates and local costs during Contract period (both Construction + Defects Liability periods) and /or during contract extension period applies to remuneration rates and local costs @ 5% for every 12 months.
43.1 and 43.2	The Consultant has to pay, include the following: (a) any indirect taxes, duties, fees, levies and other impositions imposed, under the applicable law in the Client's country, on the Consultant, the Sub-consultants and the Experts in respect of: (b) any payments whatsoever made to the Consultant, Sub-consultants and the Experts (other than nationals or permanent residents of the Client's country), in connection with the carrying out of the Services; (c) any equipment, materials and supplies brought into the Client's country by the Consultant or Sub-consultants for the purpose of carrying out the Services and which, after having been brought into such territories, will be subsequently withdrawn by them; (d) any equipment imported for the purpose of carrying out the Services and paid for out of funds provided by the Client and which is treated as property of the Client; (e) any property brought into the Client's country by the Consultant, any Sub-consultants or the Experts (other than nationals or permanent residents of the Client's country), or the eligible dependents of such experts for their personal use and which will subsequently be withdrawn by them upon their respective departure from the Client's country, provided that: (i) the Consultant, Sub-consultants and experts shall follow the usual customs procedures of the Client's country in importing property into the Client's country; and (ii) if the Consultant, Sub-consultants or Experts do not withdraw but dispose of any property in the Client's country upon which customs duties and taxes have been exempted, the Consultant, Sub-consultants or Experts, as the case may be, (a) shall bear such customs duties and taxes in conformity with the regulations of the Client's country, or (b) shall reimburse them to the Client if they were paid by the Client at the time the property in question was brought into the Client's country.
44.1	The currency of payment shall be the following: **Indian Rupees.**

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<table>
<tr><td>45.1(a)</td><td>"DELETED"</td></tr>
<tr><td>45.1(c)</td><td>The Client shall pay the Consultant's invoices within forty-five (45) days after the receipt by the Client of such itemized invoices with supporting documents.</td></tr>
<tr><td>45.1(e)</td><td>The Consultant's Accounts are:
for foreign currency: "Not Applicable"
for local currency:
<table><tr><td>Name of the Account holder</td><td></td></tr><tr><td>Account Number</td><td></td></tr><tr><td>Name of Bank</td><td></td></tr><tr><td>Address of Branch / Fax No.</td><td></td></tr><tr><td></td><td></td></tr><tr><td>Bank IFSC No. / Swift Code</td><td></td></tr></table></td></tr>
<tr><td>46.1</td><td>"DELETED"</td></tr>
<tr><td>49.</td><td>Disputes shall be settled by arbitration in accordance with the following provisions:
1. <u>Selection of Arbitrators</u>. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:
(a) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply to Indian Road Congress for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) days of the date of the list, Indian Road Congress shall</td></tr>
</table>

	appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute. (b) Where the Parties do not agree that the dispute concerns a technical matter, the Client and the Consultant shall each appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by *Indian Council of Arbitration*. (c) If, in a dispute subject to paragraph (b) above, one Party fails to appoint its arbitrator within thirty (30) days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the *Indian Council of Arbitration* to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.
	2. Rules of Procedure. Arbitration proceedings shall be conducted in accordance with procedure of the Arbitration & Conciliation Act 1996, of India. 3. Substitute Arbitrators. If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator. 4. Nationality and Qualifications of Arbitrators. The sole arbitrator or the third arbitrator appointed pursuant to paragraphs 1(a) through 1(c) above shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of the Consultant's home country *[Note: If the Consultant consists of more than one entity, add:* or of the home country of any of their members or Parties*]* or of the Government's country. For the purposes of this Clause, "home country" means any of:

	(a) the country of incorporation of the Consultant *[Note: If the Consultant consists of more than one entity, add:* or of any of their members or Parties*]*; or (b) the country in which the Consultant's [or any of their members' or Parties'] principal place of business is located; or (c) the country of nationality of a majority of the Consultant's [or of any members' or Parties'] shareholders; or (d) the country of nationality of the Sub-consultants concerned, where the dispute involves a subcontract.
	5. Miscellaneous. In any arbitration proceeding hereunder: (a) proceedings shall, unless otherwise agreed by the Parties, be held in Vijayawada, *INDIA;* (b) the *English* language shall be the official language for all purposes; and (c) the decision of the sole arbitrator or of a majority of the arbitrators (or of the third arbitrator if there is no such majority) shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

2. The following Qualification of Key Personnel: Hydraulic Engineer / Water supply network Expert shall constitute part of Section 7: Terms of Reference (TOR) Enclosure-B:

He will be responsible for Design and oversee construction of projects involving provision of potable water, perform hydraulic modelling and pipeline design, identify design alternatives, design water storage tanks or other water storage facilities, water supply networks, perform hydrological analyses using three dimensional software, to model the movement of water, perform hydraulic analyses of water supply systems or water distribution networks to model flow characteristics, test for pressure losses, or to identify opportunities to mitigate risks and improve operation efficiency. Conduct cost benefit analysis for water supply systems, analyse the efficiency of water delivery

structures, Design pumping systems, pumping stations, pipelines force mains, conduct environmental impact studies related to water distribution.

He should have the following qualification / experience.

(i) Essential Qualifications.

(a) Graduate in Civil Engineering/ Chemical Engineering/Environmental Engineering or Post Graduation in Environment science from a recognized University.

(b) Professional Experience of 15 years in handling Water treatment and water supply network projects.

(c) 10 years' experience in Design of water supply network projects.

(d) Must be familiar with modern trends in design and construction of water supply networks and pumping stations etc.

(ii) Preferential Qualifications.

(a) Post Graduate Degree in Public Health Engineering/ /Chemical engineering/ Environmental Engineering.

3. **The attached Schedule-K, Schedule E, Annexure I(c) of Schedule –D shall constitute part of Clients input in terms of documents related to this project**

SCHEDULES

Schedule A - Site of the project

(See Clause 2.1 and 8.1)

Contents

The Site of the Project

1.1 The Site of E3 road of Amaravati Trunk road network is as described in Annexure-I of this Schedule-A.

1.2 The dates of handing over the Land to the Contractor are specified in Annexure-II of this Schedule-A.

1.3 An inventory of the Site including trees and any other immovable property on, or attached to, the Site shall be prepared jointly by the Employer's Representative and the Contractor, and such inventory shall form part of the Agreement.

Schedule-A

Annexure - I

1.0 Site

E3 – Seed Access Road is the road considered under package-XV.

This road is designed as 6-lane carriageway along with 3-lane BRT.

Details of this road are furnished in the following table.

S. No.	Road Name	Type of Road	Length (Km)	Start of Project Stretch	End of Project Stretch
1	E3	Seed Access	18.270	16°32'41.75"N 80°26'10.90"E	16°29'53.52"N 80°35'43.45"E

2.0 Existing Features

Existing carriageway details:

The project road is having existing carriageway of 7.25 m on both sides including the shyness. A median of 16.3 m width is present for the total length of 18.27 km. Existing carriageway details for the project road is given in the below table.

S. No.	Road Name	Existing carrigeway width (m)	Existing median width (m)
1	E3	7.25 + 7.25	16.3

2.1 Electric Line / Electric Pole/ Utilities

2.1.1 Since the alignment is a green-field, no existing features are identified along this road of the trunk network. Additional site surveys shall be conducted with contractor to confirm and finalise relocation of utilities.

2.2 Religious Structures

No existing religious structures are identified along the package XV roads.

(Schedule-A)

Annexure - II

Land Details

1.0 Existing Land

Total project area of 217 sq.km is distributed in the capital area with main trunk road network and internal roads network. Seed Access road in this package has been designed for a length of 18.270 km.

2.0 Handing over of Site to Contractor

Details of Site Handing over are as follows:

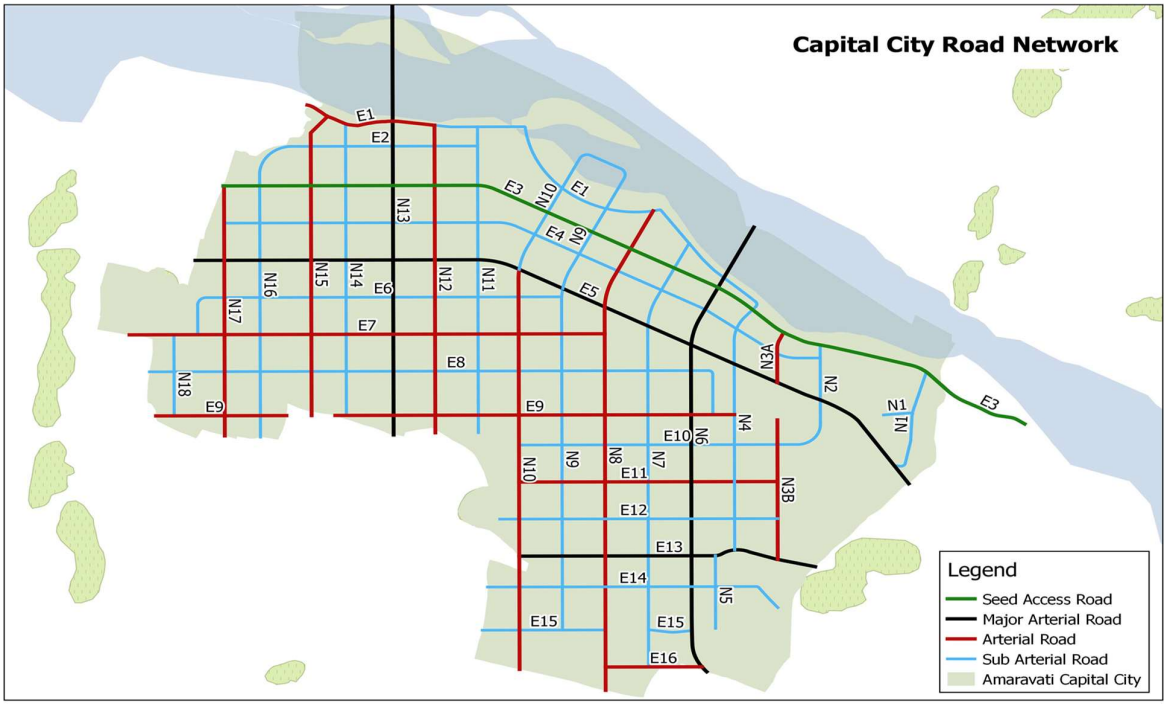
A. At the time of Appointed Date

Table 1: Handing over of site for Road and Other Infrastructures to Contractor

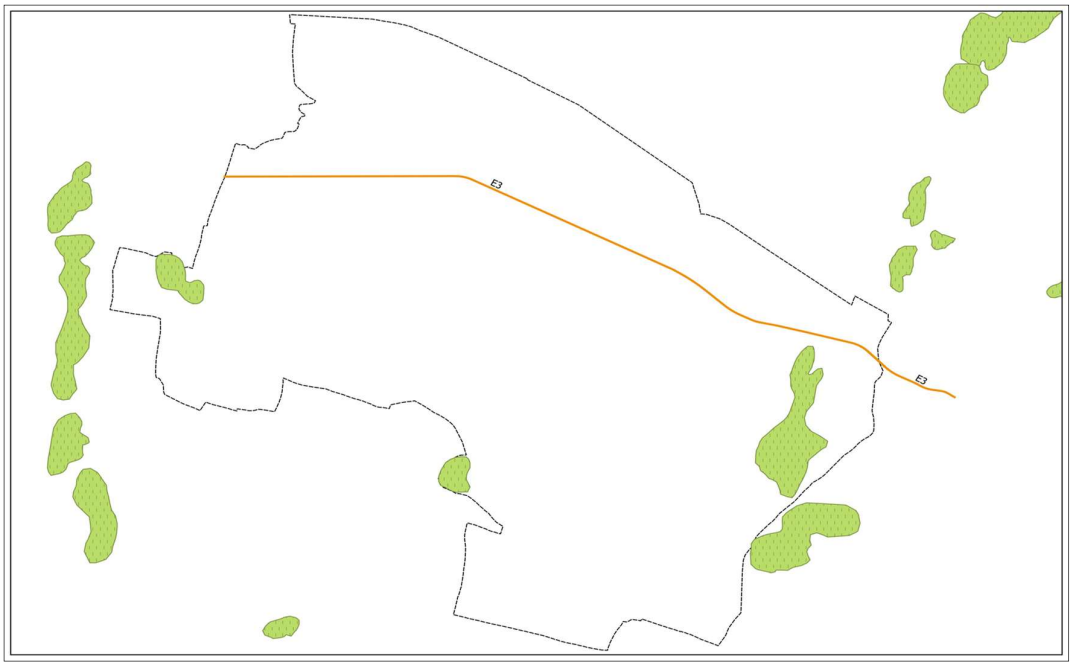
S. No.	Road Name	Road Type	ROW	Chainage		Length(Km)
				From (Km)	To (Km)	
1	E3	Seed Access	60 m	0.000	18.270	18.270

B. Within 90 days of Appointed date – NIL

Appendix-A1



Map showing the total trunk road network within the capital region



Map showing the package XV (E3) road within the total trunk road network

Schedule B - Development of the Project Roads and Utilities/Services

(See Clause 2.1)

Contents

General

A Special purpose vehicle viz "Amaravati Development Corporation Limited" is formed with the equity participation of State Government for procurement and construction of trunk Infrastructure in Amaravati Capital City Area in Andhra Pradesh.

The Amaravati Development Corporation Limited (ADCL) represented by Chairperson & Managing Director, now invites BIDs from eligible Contractors for the following Project:

Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India.

This project involves the following:

- Construction of Road section for approx. 18.270 km length of 50 mts ROW (Sub-Arterial) as stated in the relevant section along with bridges and/or cross over Pala vagu and Kondaveeti vaagu channels.
- The contactor has to design and plan for construction, the design principles of Road and Utilities matching the end conditions of the backward and forward reaches including all connectors without compromising the objectives of the project as specified by the Authority.
- Construction of Storm water collection network and Disposal
- Construction of Intake-well-cum-raw water pump house of capacity 17050 m3/hr
- Construction of Water treatment plant capacity of 8261 m3/hr (190 MLD) with ZLD concept, the proven technology installations are to be demonstrated to the Authority/Authority engineers for approval
- Construction of 64 ML capacity underground clear water reservoir-cum- pumping station
- Construction of 7 Nos of cushion tanks (ELSRs) as given in
- Construction of 8 SUGRs cum Pump houses
- Construction of water supply network on continuous pressurized supply system

- Construction of approach road to Intake site complete with all civil, electrical & mechanical works, instrumentation & controls including SCADA through optical fibre cable and wireless redundant system, including erection, testing and commissioning of pumps, motors, VFDs, valves, flow meters, RMS, BMS, integration of full water supply system, trail run for 3 months, DLP for two years and O&M for 8 years
- Construction of Domestic Sewage Collection Network
- Under-ground Power Transmission and Distribution Network using RCC ducts and HPPE pipe conduits for power cables up to 220KV, 33 KV & 415 V.
- ICT Distribution Network for OFC cables using HDPE pipe conduits
- Street Lighting all along the road network
- Laying of HDPE pipe conduits for ITS systems.
- Completeness of the Offer as per complete scope of works
- Any other work required for the above but not mentioned elsewhere.

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Facility on EPC basis including all Civil, Structural Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system capable of achieving the required output in an efficient and economical manner, and to include all plants, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are essential or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the successful Bidder within the tendered cost. The Contractor shall endeavor to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements. The Contractor

shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance and operations.

Scope of Project

The scope of works covers:

- The Bidder shall be responsible for the design, engineering, manufacturing, fabrication, assembly, testing and inspection at supplier's works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis .
- Upon completion of the Performance Test and issue of Completion Certificate,
- Site clearance
- The contractor before start of any works, as a first task overlap the master plan for the given road on the ground by importing the coordinates through Total Station only. After setting the coordinates, shall demark the site area for the road with pre cast M-20 cement concrete including reinforcement permanent boundary stone of size 150 mm x 150 mm at top and 300 mm x 300 mm at bottom, total height 1.20 m at turnings/corners, fixing in ground in all types of stratas, 0.45 m above GL and 0.75 m below GL including excavation having pit size 60 cm x 60 cm x 75cm depth including fixing, firmly with hard murum, metal obtained from excavation, including engraving "ADCL" letters on two sides and painting with two coats of blue colour cement paint, two coats of white wash to exposed sides with all labour, material including transportation etc. complete. All works shall only begin once the demarcation of the boundary is duly approved by Employers Engineer.
- The Bidder shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents.

- Throughout these Tender Documents, the terms "Bid" and "Tender" and their derivatives ("Bidder/Tenderer", "Bidding/ Tendering", etc.) are synonymous, and Day means calendar day of twenty-four (24) hours. Singular also means plural. "Bidder" or "Applicant" and "Bid" or "Application" for the purpose of interpretation of Instructions to Bidders shall mean the same. Any other term not defined herein should be interpreted in a manner as defined in General Condition of Contract as defined in the EPC Agreement.
- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Training of ADCL Operating and Maintenance personnel.
- The Bidder’s proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided.

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the positioning of pipes, air vents and rotating machinery.

Prior to commencement of the work, the Contractor shall submit the following:

1. Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
2. Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
3. Technical data sheets and calculations for all bought out and manufactured item
4. Hydraulic & Mechanical design calculations
5. List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
6. Sequence and protection interlock schemes
7. Type test reports
8. Foundation Plan and Loading Data for Civil Design and drawings.
9. Model study reports wherever applicable
10. Functional & guarantee test procedures and test reports
11. Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification

Geotechnical Investigations

Site-specific geotechnical investigations were carried out by the client for the existing site and are enclosed as Schedule U.

This is for reference only and a detailed geotechnical investigation shall be performed at the Site for given road area before starting works by the Bidder.

The Bidder is required to verify the sub-soil strata including the CBR value by performing its own site investigation prior to developing the civil/structural design.

The geotechnical parameters necessary for the detailed foundation designs would depend on the findings of site specific ground investigation.

Geotechnical Investigation Report:

For structural design purposes, Geotechnical investigation shall be conducted and SBC shall be found out at required depths at locations of Intake well, Each unit of WTP, SUGRs, Cushion Tanks, Pump houses, Bridge structures and other important structures by the contractor confirming to relevant IS Code, through the Government approved agencies. The soil test shall include bore log, SPT, UDS test, Tri-axial test, Vane shear

test, core sample test, plate load test depending upon requirement of the structural design of the structures. Before detailed engineering & design of the structures the contractor shall submit detailed soil test report along with calculation of SBC to the Engineer-in-Charge's for approval of SBC to be adopted for structural design. On approval of the SBC the contractor shall design the structure considering the recommended SBC. In case further data would be necessary before or after submission of tender / during execution of the work, the tenderer / contractor shall collect the same of his own & at his cost.

Ignorance of any data shall not relieve the contractor of his obligation to complete & commission the work as per the provisions of the Agreement. For detail structural design of the intake well and bridges, the contractor has to collect all the required hydraulic & flow parameters of the river/water way where the intake well and bridge structures are to be constructed, from the Water Resources Department, and other data as will be required from the concerned departments, at his own cost and risk & shall submit to the Engineer-in-Charge's for approval. Then based on the approved data the agency has to prepare detail design & drawing of Intake well and bridge structures.

While designing of the structures, it shall be ensured that the weight of the structure including foundation, water, over burden earth on foundation / slab / raft etc. as applicable shall be within the permissible limit of S.B.C. allowed by the Engineer-in-Charge.

Topographical and other relevant Survey:

The Contractor is required to reconfirm the topographical surveys and soil investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents will be available for inspection at the Employer's addresses provided in Conditions of Contract.

He should be ready with the qualified agencies he intends to use for the purpose and ensure that the work starts within a fortnight of the Letter to Proceed. He shall conduct investigations as are normally necessary to ensure full and satisfactory designs and safety.

Field laboratories

The Contractor will be required to establish a field laboratory as approved by Employers Representative, suitably equipped to carry out tests as stipulated in the QA/QC Manual, including all specialized equipment which will be required for testing the material and equipment being supplied under the Contract. Suitable trained laboratory staff will have to be posted with full facility of computerized record keeping. The minimum equipment to be provided in the laboratory shall be as listed below in the Table 1. Additional equipment as may be deemed necessary may be added to the same in due course on requirement of the Employer/Contractor. The Contractor shall provide a laboratory as approved by Employer's Representative for the testing of materials.

In addition to the equipment in the laboratory, the Contractor will also provide field testing equipment as directed by the Employer's Representative on sites where work is in progress.

The contractor shall put a concrete batching plant of required capacity within the site area for efficient working.

The laboratory shall have the following facilities required for sampling and testing materials and concrete in the field. All such facilities shall be provided by the Contractor at no extra cost to the Employer. The following equipment with operators shall be made available at Employers /Employers Representative request (all must be in serviceable condition):

Table-1 List of Equipment to be provided for Laboratory by the Contractor

1.	Concrete cube testing machine suitable for 15 cm cubes of 100 tonnes capacity with proving calibration ring	1 No.
2.	Cast Iron Cube moulds 15 cm size	50 Nos. (Minimum)
3.	Slump cone complete with tamping rod (as required to suit concrete plan)	5 sets
4.	Laboratory balance to weigh upto 5 Kg. with sensitivity of 10 gm.	1 No.
5.	I S. Sieves for coarse and fine aggregates	1 Set
6.	Set of measures from 5 litres to 0.1 litre	1 Set
7.	Electric oven with thermostat upto 120^{o}C	1 No.
8.	Flakiness gauge	1 No.

9.	Schmidt Hammer	2 Nos.
10.	Elongation index gauge	1 No.
11.	Sedimentation pipette	1 No.
12.	Pycnometer	1 No.
13.	Calibrated glass jar (1 litre capacity)	1 Nos.
14.	Glass flasks and metal containers	As required
15.	Chemical reagents like sodium hydroxide, tannic acid, litmus papers, etc.	As required
16.	Laboratory balance of 2 Kg capacity and sensitivity of 1 gm	1 No.
17.	Total Station	1 nos.
18	Staff and associate equipment's for total station	2 nos.
19.	SS Std. Measuring Tap	15 nos.

Arrangement can be made by the Contractor to have the cubes tested in an approved laboratory in lieu of a testing machine at site at his expense, with the prior consent of the employer.

The outside laboratory shall also be used for routine testing of cement, reinforcement, coarse and fine aggregate and other items.

Temporary Works

Not less than 14 days before commencing any portion of the Works, the Contractor shall submit to the Employer's Representative for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Employer's Representative of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

Workability and maintenance

Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the Plant. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.

All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.

Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

Development of the project roads and utilities/services

Development of the Project Roads and Utilities/Services shall include detailed design and Construction of the following as described in this Schedule-B and in Schedule-C.

Standards and specifications

The Project Roads and Utilities/Services shall be designed and constructed in conformity with the Standards and Specifications given in **Schedule-B and D** respectively.

Appendix B-I

Development of the Project Roads

Development of the Project Roads shall include detailed design and construction of the following as described in this Schedule-B and in Schedule-C.

1.0 Project Roads and Utilities / Services

- Design and Construction of Roads, Carriageway details are given in Appendix B I (a)

i) Typical Cross Section details are given in Appendix B I (b)

ii) Geometric design and other features are given in Appendix B I (c)

iii) Embankment and Pavement design details are given in Appendix B I (d)

iv) Longitudinal storm water drains details are given in Appendix B II (a)

v) Storm water crossings details are given in Appendix B II (b)

vii) Drawings are given in Appendix B IX

2.0 Standards and Specifications

The Project Roads shall be designed and constructed in conformity with the Standards and Specifications given in **Schedule-D.**

Appendix B-I (a)

1.0 Design and Construction of Roads

1.1 The **Design and Construction of Roads for package XV roads** as specified in **Appendix B I (a)** of Schedule-B. Notwithstanding anything to the contrary contained in the Schedules, the Finished Road Level (FRL) provided in the Plan & Profile Drawings shall be followed. (Appendix B IX).

1.2 Width of Carriageway

Width of carriageway is as given in typical cross sections drawings in Appendix B I (b).

Appendix B-I (b)

1.0 Typical Cross Sections

Typical Cross Sections details are as given below in **Table -1**

Table -1

S. No.	Road Name	Applicable TCS	PROW
1	E3	Provided as per drawing	60 m

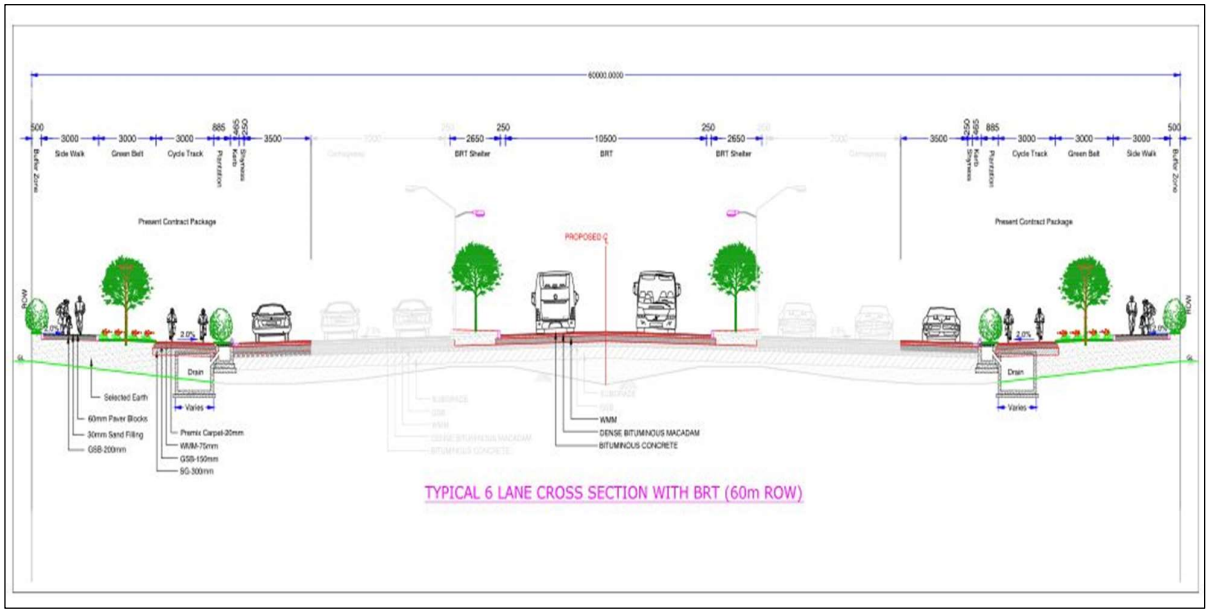
1.1 Cross Section along the project road

Package XV road (E3) has to be constructed with a 3 lane (BRT) in the middle, single lane main carriageway of 3.5 m on both the sides, cycle track of 3 m, green belt of 3 m and side walk of 3 m at both the ends of the carriageway for the present contract package.

Configuration of main carriageway, BRT lanes, cycle track, green belt and side walk has to be followed from the typical cross section drawing attached.

Proposed cross section for the package XV roads has been furnished in the below figure.

Proposed cross sections for this package **E3** road is furnished in below figure.



PROPOSED CROSS SECTION OF E3 ROAD

Appendix B-I (c)

1.0 Package XV road (E3) has to be constructed with a 3 lane (BRT) in the middle, single lane main carriageway of 3.5 m on both the sides, cycle track of 3 m, green belt of 3 m and side walk of 3 m at both the ends of the carriageway for the present contract package.

Configuration of main carriageway, BRT lanes, cycle track, green belt and side walk has to be followed from the typical cross section drawing attached.

Proposed cross section for the package XV roads has been furnished in the below figure.

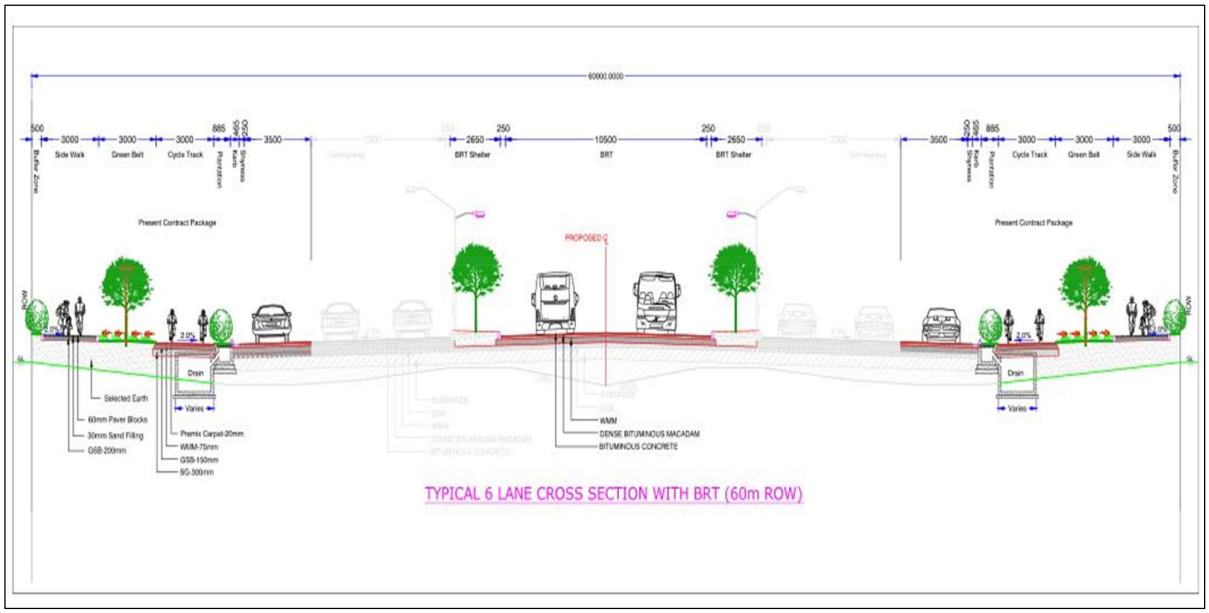


Fig. No:1 **PROPOSED CROSS SECTION OF E3 ROAD**

Appendix B I (c)

1.0 Geometric design and other features

1.1 General

Geometric design and other features of the Project Roads shall be in accordance with the Standards and Specifications as per Schedule D.

1.2 Design speed

The Design Speeds for different category of roads are as given below in **Table: 2**

Table-2:

S. No.	Road Name	Length (Km)	Design Speed (Km/h)
1	E3	18.270	80

1.3 Coordination on Geometric Design

All the roads of trunk network zones are designed in coordination with major arterial, arterial and sub-arterial roads considering the road levels of the neighbouring roads. The design details related to the package-XV roads shall be obtained from the employer for integration of the geometric design features and other services of the project. The approval of the employer for the design integration has to be obtained.

Appendix B-I (d)

1.0 Embankment & Pavement Design

Construction of embankment and pavement shall conform to the Standards and Specifications as per Schedule D.

2.0 Pavement Design Criteria

Pavement design shall conform to the Standards and Specifications as per Schedule D.

2.1 Type of pavement

Flexible pavement have been designed for Main Carriageway (WMM, DBM and BC layers) and BRT lane (WMM, DBM and BC layers).

The proposed crust composition for the main carriageway and BRT lane is furnished below.

S. No.	Description	Thickness (mm)
1	Bituminous Concrete (BC)	50
2	Dense Bituminous Macadam (DBM)	110
3	Wet Mix Macadam (WMM)	250

2.2 Design requirements

2.2.1 Design Period

Flexible pavement shall be designed for a minimum period of 20 years.

2.2.2 Design Traffic

Notwithstanding anything to the contrary contained in the Schedules, the Contractor shall design the pavement for 100 MSA.

2.3 Cycle track

Cycle track of width 3 m has been proposed on both the sides of the carriageway.

The proposed crust composition for the cycle track is furnished below.

S. No.	Description	Thickness (mm)
1	Premix Carpet	20
2	Wet Mix Macadam	75
3	Granular Sub-base	150
4	Subgrade	300

2.4 Sidewalk

60 mm thick paver blocks are to be used for sidewalk and shall be in confirmation with the technical specifications in Schedule-D.

Paver blocks are to be placed over sand bed of 30 mm and GSB of 200 mm.

Appendix B-II (a)
Storm water drainage

Storm water drainage system design for Trunk roads shall be based on following parameters.

- Invert levels of Trunk and LPS storm water drainage system at the outfalls to primary channels/vagu's shall be as far as possible higher than the 1 in 100 year HFLs of channels/vagu's but in any case, all design event HGL within Trunk and LPS storm water will be higher than 1 in 100-year HFLs of channels/vagu's.
- Design event of 1 in 5-year event flows shall be considered for storm water drains.
- Storm water drainage system design shall confirm to the design criteria given in Schedule D.
- Contractor has to get the confirmation about the final HFLs of vagus and maximum water levels in Trunk storm water drains with Engineer-in-charge/CRDA/ADC before proceeding with the detailed design of Trunk storm water Drains. Expenditure incurred towards this, if any, shall be borne by contractor only. No extra payment shall be given by CRDA/ADC for ascertaining this data and any consequent design changes.
- The Contractor shall consider the upstream catchment flows contributed to the zone considered in design of Storm water drain network, based on IDF Curves provided by the Authority.
- The suggested frequency of flooding is once in 5 years or as appropriate based on the field conditions.
- A minimum free board of 150 mm has to be followed. The guidelines provided in IRC SP 50-2013 regarding the freeboard requirements shall be followed in conjunction with the 80% utilization of drains.

2.0 General Requirements of SW Drains

The general arrangement shall be as shown in the drawings. All the structural elements shall be elegantly harmonized in respect of shapes, sizes lines and levels. All the lines of the storm water drains shall be continuous without any break.

The decision of the Authority/Authorities representative shall be final in respect above requirements.

The preliminary Geo-Technical investigation report enclosed in the bid document are for guidance only. The nature of the strata need re-confirmation from the EPC's contractors end. The EPC agency must conduct necessary Geotechnical Investigations where ever necessary and submit the same to Engineer-in-charge for approval.

The Drawings enclosed/attached are indicative only. The network, drainage basins and the cross sections are purely for indication & guidance to the EPC agency but not exhaustive. The detailed designs and drawings shall be furnished by the EPC contractor for approval after which the BoQs have to be worked out as per deliverables which will form the basis of payment.

3.0 Drainage Layout Plan and typical details

Drawings of storm water drainage layout plan and typical details of the drainage arrangement are given in the "Drawings" Volume.

4.0 Longitudinal storm water drains

Longitudinal storm water drain along the road has been proposed keeping in view of the storm water run-off within the project stretch. The details of the storm water drains proposed along the package roads are given below in **Table 3**.

Table - 3 Details of Longitudinal drains along package roads

E3 Road		
LHS		
S. No.	**Size (m x m)**	**Length (m)**
1	0.6X0.6	1234.88
2	0.75X0.75	1219.7
3	0.9X0.9	891.46
4	1.05X1.05	508.19
5	1.2X1.2	1345.37

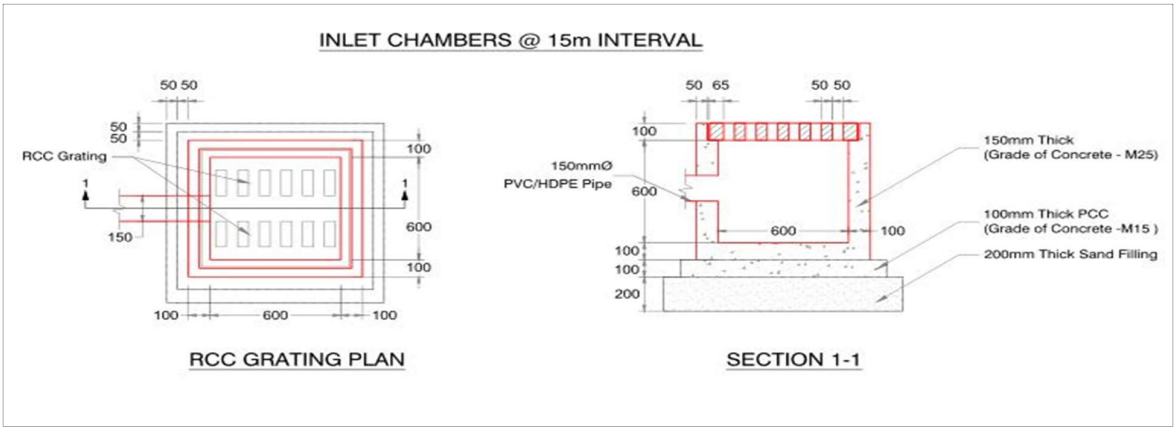
E3 Road		
6	1.35X1.2	914.98
7	1.35X1.35	275.41
8	1.5X1.35	71.38
9	1.5X1.5	7029.28
10	1.65X1.5	1931.55
11	1.65X1.65	159.65
12	1.8X1.65	132.49
13	1.8X1.8	637.21
14	1.95X1.8	154.11
15	2.1X1.95	111.04
16	2.1X2.1	1049.05
17	2.4X2.25	107.8
18	3X3.5	14.99
RHS		
S. No.	**Size (m x m)**	**Length (m)**
1	0.6X0.6	2165.62
2	0.75X0.75	1221.27
3	0.9X0.9	761.78
4	1.05X1.05	1002.92
5	1.2X1.2	1133.94
6	1.35X1.2	122.8
7	1.5X1.35	122.8
8	1.5X1.5	747.48
9	1.65X1.5	422.98
10	1.65X1.65	985.86
11	1.8X1.8	400.62
12	1.95X1.95	1255.62
13	2.1X1.95	629.11
14	2.1X2.1	531.32
15	2.25X2.1	298.06
16	2.25X2.25	3281.19
17	2.4X2.25	721.74
18	2.4X2.4	924.15
19	3X3	980.24
20	3X3.5	21.5

5.0 Inlet chambers

Inlet chambers have been provided at an interval of 15 m along the project road to collect the surface run-off. The details about the inlet chamber has been given in the below figure.

3D view of the proposed Inlet chamber has also been shown in the below figures.

Typical section showing the Inlet Chamber provided at 15 m interval, The clear depth of these inspection chambers shall be increased to 900mm at the valley locations (lowest points) along the road in account for the silt accumulation buildups and maintenance requirements.



3D view of Inlet Chamber (a)

3D view of Inlet Chamber (b)

6.0 Access inspection chambers & covers

Access inspection chambers with cover shall be designed and provided subject to minimum c/c distance of 30 m interval.

7.0 Temporary Drainage/ Diversion of Streams and mobile pumping arrangements

The Contractor shall handle all flows from natural drainage channels intercepted by the work under these specifications, perform any additional excavation and grading for drainage as directed and maintain any temporary construction required to bypass or otherwise cause the flows to be harmless to the work and property.

The contractor shall always carry out construction of cross drainage works in a manner creating least interference to the natural flow of water while consistent with the satisfactory execution of work. Temporary diversion shall be formed by the contractor at his cost where necessary. No extra payment shall be made for this work. No separate payment will be paid for bailing out sub-soil water/drainage, bailing of pumping water either from excavation of soils from foundations or such other incidentals and safety measures for men and materials and all necessary arrangements to complete the work.

Necessary coffer dams and ring bunds have to be constructed at the cost of contractor and same are to be removed after the completion of the work. The contractor must quote be keeping the above in view.

The work of diversion arrangements should be carefully planned and prepared by the contractor and forwarded to the Engineer-in-charge technically substantiating the proposals and approval of the Engineer-in-charge obtained for execution.

Contractor shall arrange for all necessary diversion channel works for the storm water drain outfall connections to nearest water bodies and mobile pumping arrangements to drain and bail out the inundated rain water.

Anti-erosion measures such as silt fences shall be planned along diversion channels such that to prevent silt entering in to the nearest water bodies. Sand / silt removal facilities such as sand traps, silt traps and sediment basins should be provided to remove sand / silt particles from run-off.

8.0 Maintenance Requirements

All relevant Materials, Works and Construction operations shall confirm to CPHEEO Manual on Storm water 2013 Part-B; Operation and Maintenance and Good Industry Practice to the satisfaction of Engineer-in-charge for storm water drain networks and outfalls.

During the mandatory maintenance period, the Contractor shall carry out a detailed pre-monsoon inspection of all existing bridges, culverts and drainage system. The Contractor shall complete the proposed maintenance works such as clearing debris and cleaning before the onset of the monsoon and send a compliance report to the Engineer-in-charge. Post monsoon joint inspection shall be undertaken by the Contractor/ Engineer-in-charge and the inspection report together with details of any damages observed and proposed action to remedy the same shall be conveyed to the Engineer-in-charge.

9.0 Pumping Machinery

The pumping machinery of the prescribed type and capacity should be supplied and commissioned including maintenance. Pumping Machinery shall be essentially ISO 9001 Certification. The mobile pumping stations procured during operation and maintenance period shall be handed over to the Authority.

Appendix B-II (b)
Storm Water Crossings list

The proposed storm water Crossings list in the project stretch are given in **Table – 2**.

Table - 2 : Proposed Storm Water Crossings across package XV roads

S. No.	Road Name	Chainage	Proposed Span Arrangement (m * m)	Type
1	E3	11.712	1.95 * 1.8	Box Culvert

Appendix B-III(a) - Headworks
Potable Water Supply Network

A) General

A safe and reliable water supply is the most basic need of a community for living. Apart from drinking water needs, standard of living to support basic health and sanitation in a city is judged by the ample provision of a wholesome water supply. Vision of the proposed water supply system in Amaravati capital city is to provide water supply to all the stakeholders: domestic, municipal, commercial, industrial and fire services. ensure continuous 24 x 7 water supply, maintain best potable water quality standards, and benchmarking the design, operation and maintenance to international best practices.

The work involves:

Survey, Geotechnical Investigations, planning, designing, supply materials, construction of Intake-well-cum-raw water pump house of capacity 17050 m3/hr, Water treatment plant capacity of 8261 m3/hr (190 MLD) with ZLD concept, 64 ML capacity underground clear water reservoir-cum- pumping station, trunk pipeline mains, 7 Nos of cushion tanks (ELSRs), 8 SUGRs cum Pump houses and approach road to Intake site complete with all civil, electrical & mechanical works, instrumentation & controls including SCADA through optical fibre cable and wireless redundant system, including erection, testing and commissioning of pumps, motors, VFDs, valves, flow meters, RMS, BMS, integration of full water supply system, trail run for 3 months, DLP for two years and O&M for 8 years.

Agency shall supply and lay Optical Fibre Cable (OFC) through PLB HDPE duct and PLB duct laid by the Agency. Integration of instruments through SCADA for the entire water supply network from intake well, raw water pumping main, WTP, clear water reservoir-cum-pumping station, clear water pumping main up to Water Distribution Centres is under the scope of works by the Agency. O&M of intake well-cum-raw water pumping station, WTP, clear water reservoir-cum-pumping station inclusive of pumps, motors and other aligned correlated machineries of the entire water supply network for a period of 8 years from the date of completion of DLP (for two years as specified) will be part of the scope of works by the Agency.

B) Location:

Intake Well -cum-raw water pumping station will be located on the right bank of river Krishna, 2 Km upstream of Prakasam barrage at geographical coordinates 16°30'23.27"N latitude and

80°34'58.70"E longitude. The site of proposed WTP and CWPS will be at Amaravati capital city near Undavalli village at geographical coordinates 16°30'0.33"N latitude and 80°35'0.62"E longitude. The water supply network will be for the entire Amaravati capital city.

C) Works under this Tender:

Phase-I of the water supply system comprises the following headwork components:

(i) **Intake Well-cum-Raw Water Pumping Station** on the right bank of Prakasam barrage to draw and transmit 17050 m3/hr (392 MLD) of raw water from the river.

(ii) Supply, installation, testing, commissioning, trial run of **2W+1S pumps & motors** of capacity 1184.00 LPS discharge and 21 m head each including all other electro-mechanical components.

(iii) **Approach Road & elevated platform:** Intake campus shall be provided with two level bridge of length 290 Rmt (approx.) (i.e. One level for carrying raw water pipe line and other for vehicular movement) upto karakatta bund and approach road of length 218 Rmt (approx.) from bund to seed access road (E3), crossing through bund Road. The top width of bridge should be 10.60m (two lane carriage way 7.0m and 1.80m projection on either side for Crash barriers, walkway and utility ducts). Top width of approach road shall be 11.20m, 1.2m walkway on one side, 2.0 m walkway on other side & extra 0.5 m on either side and 2-lane (7.0 m) motorable CC road for inspection, operation and maintenance of the Intake installation. The elevated platform should be connected between two proposed intake wells and approach bridge, with provision for installation of manifolds and vehicular movement during maintenance.

(iv) A pressurized **Raw Water Transmission Main** of approximately 580 Rmt. length with 1900 mm diameter to convey **17050 m3/hr (392 MLD)** of raw water along with OFC cable and PLB HDPE duct upto the water treatment plant.

(v) **Water Treatment Plant** of 16522 m3/hr (380 MLD) capacity at Undavalli with modular concept of **8261 m^3/hr (190 MLD)** capacity with modern space saving technology & Zero Liquid Discharge (ZLD) concept for immediate construction in this tender and another 8261 m^3/hr (190 MLD) addition at a later stage.

(vi) A **Clear Water semi underground Reservoir** (CWR), of total capacity 128 ML to be located in WTP campus. However, 64 ML capacity CWR with 2 compartments

of 32 ML each shall be under the scope of this tender. Minimum depth of CWR shall be of 5.0 m.

(vii) **A Clear Water Pumping Station** shall accommodate 19 horizontal split-casing centrifugal pumps of varying capacities: 10W+3S of capacity 826.39 LPS discharge and 54 m head each, 2W+1S of capacity 414.00 LPS discharge and 48 m head each to meet water demand for the entire city apart from Undavalli area and 2W+1S of capacity 130.25 LPS discharge and 39 m head each to meet water demand for Undavalli area, with inlet and outlet manifolds, service bay and control panels to operate the pumps. The Pumping station will be a RCC semi underground structure with water retaining structure and fire proof protection including round the clock light arrangements with proper ventilation.

(viii) Design and construct with pleasant **architectural plan & view** for Administrative building & Guest house at Intake, Clear water pump house (WTP site & WDC site), Electric Substation building, Office building, Facade of Pump house, filter house annexe, staff quarter building, bungalows and office building at WTP premises.

(ix) Supply, installation, testing, commissioning, trial run of **pumps & motors** with **5w+2S of capacity** 826.39 LPS discharge and 54 m head each**, 2W+1S of capacity** 414.00 LPS discharge and 48 m head each**, 2W+1S of capacity** 130.25 LPS discharge and 39 m head each **for Undavalli area** including all other electro-mechanical components.

(x) Pressurized ***Clear Water Transmission Mains*** consisting of different diameters of SWMS & DI K9 pipelines along with OFC cable and PLB HDPE duct.

(xi) **Water Distribution Centres** comprising 51 **Cushion Tanks (ELSRs)** and 8 **Semi Underground Reservoir** (SUGRs) cum pumping stations. Construction of only 7 Nos of cushion tanks (ELSRs) is within the scope of this tender. Construction of remaining 44 cushion tanks are beyond the scope of this tender, which will be at later stage. Construction of boundary wall with ornamental gates, security cabin, operators room & local PLC/SCADA control rooms, Bypass Management System etc. in all sites of cushion tanks is under the scope of this tender. Design, detail engineering and construction of 8 Nos. SUGR cum pumping stations along with its electro-mechanical component, boundary wall with ornamental gates, security

cabin, operators room & local PLC/SCADA control rooms, Reservoir Management System etc. is under the scope of this tender.

(xii) **Flow Control Devices** to regulate flow in the Water Distribution Centres (WDCs). It shall consist of 16 No actuator operated SCADA compatible isolation valve along with flow meter and pressure transmitter with remote and local display at Tapping points on ring main. 8 No. of Reservoir Management System(RMS) at SUGRs location, 7 No. of Reservoir Management System(RMS) at Cushion tanks (ELSRs) location, and 51 No. Bypass Management System(BMS) shall be provided at WDCs. There shall be 164 No. of air valves in the entire network.

(xiii) **Electrical Works:** Supply, installation, testing commissioning of complete electrical distribution system inside the Intake well, WTP, Clear water pumping station and WDCs and all infrastructure created in this tender. The work shall be carried out as per the data sheets and SLDs which include electrical items which are given herewith. Dedicated feeder mains with power cables of suitable capacity from 2 substations for getting 24 x 7 power supply.

(xiv) **Illumination Works:** Supply, installation, testing commissioning of complete lighting distribution system inside the Intake well, WTP, Clear water pumping station and WDCs, yard lighting for all premises as per the data sheets and SLDs.

(xv) **Earthing system & Lightning protection:** Supply, installation, testing commissioning of complete Earthing system & Lightning protection inside the Intake well, WTP, Clear water pumping station and WDCs as per the data sheets. All civil works associated with the earthing and lighting protection system will be under the work scope of the Agency.

(xvi) **Liaison** and getting approval from competent authority for electrical installations.

(xvii) **Instrumentation, control and Automation system:** Design, supply, installation, testing, commissioning, trial run for 3 months with O&M for a period of 10 years including 2 years DLP of complete Instrumentation Control system of Intake well, Raw water raising main, WTP, Clear water pumping station, Clear water pumping main and WDCs. The instrumentation and control system shall comprise of SCADA, PLC based control system and peripherals, Field instrument impulse pip-

ing, tubes and fittings, field accessories junction boxes, local control panels, transmitter racks, instrumentation control cables, communication data cables, cable trays, loop testing, calibration of field instruments and its field integration.

A smart and comprehensive Water Supply SCADA and web SCADA system which will allow an operator to monitor and control the water supply system at every stage of its operation. An air-conditioned control room, 2 Nos 55-inch LED monitor, 2 Nos work station with 32 inches screen at Raw water pumping station, remote sites shall allow to communicate with a Control Command Centre (C3) facility (to be located at WTP control Centre) and shall provide the necessary data to control processes in the entire water supply system. SCADA should have provision of fully auto mode, semi auto mode and manual mode, programming shall be made accordingly. The Agency shall appoint experienced specialized SCADA agency for implementing as per the approved list.

(xviii) **Control Command Centre (C3):** Design Supply, installation, testing, commissioning, trial run for 3 months, 2 years DLP and 8 years operation & maintenance of control command centre (C3) located at WTP, shall collect the data from Intake well, Raw water raising main, WTP, Clear water pumping station, Clear water pumping main, WDCs shall monitor on 2 Nos 90" Video wall & control, CCTV footage of WTP. Provision need to be made connecting to C4 (City control command centre). It should comprise of Engineering station, historian station along with real time data acquisition server.

(xix) Design, supply, installation, testing, commissioning of **CCTV covering** entire premises of Intake well, WTP & WDCs compound. Scope also includes CCTV installation in pump houses, panel rooms, substations, transformer yards, control rooms, filtration plant, entrance gates, security cabins and major equipment areas.

(xx) Designing, drawing and construction of **Approach/other connecting road** including kerb channels & footpath, apron & surface drains, sewerage system, compound lighting/street lighting within the Intake well compound, WTP compound & WDCs compound and connecting the drainage system outside the campus.

(xxi) Design and providing **landscaping** within Intake well compound, WTP compound & WDCs compound.

(xxii) Agency shall also provide **as-built drawing** indicating all assets related to water supply in GIS & AutoCAD format.

(xxiii) Supply of minimum **inventory spares** as per specifications.

(xxiv) Supply of **laboratory instruments, glass works & chemicals**.

(xxv) **Integration** of entire water supply system of Amaravati capital city.

Tender for this work pertains to headwork components of the Amaravati capital city water supply system as described above.

D) Detail Scope of Work

Scope of works, in general, comprises:

Surveys, investigations, designs, detailed engineering, construction, supply, installation, testing, commissioning and operation & maintenance of the proposed water supply system in Phase-I.

Headworks components-wise, the Scope of Works is described as given below:

- ***Intake Well cum Raw Water Pumping Station:***

i. Bathymetric survey of the river reach on 250 Rmt on both the sides of exact location of Intake and 500 Rmt inside the river using latest echo-sounding instruments and data loggers synchronised with boat speed shall be under this scope of work. From this Bathymetric survey data, contour lines at 1m interval shall be prepared and map of Bathymetric survey for a scale of 1:500. The exact location of the Intake well cum raw water pumping station shall be decided and layout plan of the structure shall be superimposed on to the Bathymetric chart. The complete dataset, map and report shall be submitted to Engineer-in-Charge for approval.

ii. Detailed geotechnical investigation of the Intake site (both on the river bank and inside the river) using core borehole drilling shall be undertaken by the Agency. Percussion type Core drilling shall be performed for a minimum depth of 25m from G.L/ Bed level of the river or up to the bedrock whichever is higher. Four drilling locations shall be explored, two on the bank side and two in the river portion as per approval of Engineer in Charge. Standard procedure of geotechnical investigation as per the relevant IS code shall be followed. Report on geotechnical investigation including Safe Bearing Capacity, pile capacity for different diameter piles for foundation design shall be submitted to Engineer-in-Charge for approval.

iii. Designs, detailed engineering, construction, supply, installation, testing, commissioning, operation and maintenance of the Intake Well-cum-Raw Water Pumping Station of capacity 17050 m^3/hr. Intake at river bank shall consist of twin RCC Jack Wells of capacity 8525 m^3/hr each inside the river at suitable location as obtained from Bathymetric survey and approved by Engineer in charge. Raw water will be lifted by Vertical Turbine Pumps (2 working + 1 standby) in each well. Wells will have sluice gates with screen at different levels to allow river water to enter with respect to level variation in the river through the lean, normal and high flow seasons. Diameter of the Intake well shall be ascertain based on hydraulic requirement as well as space requirement for 3 Nos of pumps & motors, valves, specials etc. VFD control panel and other accessories required at the pump house. Arrangements of pumps, motors, manifolds and outlets of the Raw Water transmission mains etc. shall be finalised in consultation with Engineer in charge, QAP and data sheet shall submit for Engineer in Charge approval before procurement. Agency shall provide EOT crane of capacity 15 tonne. The electrically operated crane/hoists travel together circumferentially (long travel of the crane) and travel both independently and synchronised in the radial direction in full 360° (cross travel and lift). Agency shall construct 2 RCC cast in-situ jack wells in all respect based on Geotechnical investigation and structural requirement. Agency shall supply & install 3 Nos of pumps and motors along with its all accessories only in a single well. Agency shall make necessary provision in common manifold so that future expansion with other well can be done without shutdown of raw water pumping station. Agency shall make necessary provision of tees, actuator compatible sluice valves with blind flange in common manifold of capacity 17050 m^3/hr.

iv. Design, detail engineering, construction of building of the RWPS shall be circular with symmetry to the shape of Jack well with proper side ventilation and spacing of pumps, motors and control panel. Besides, the building shall have unique architectural design with dome shape/inverted cone shape roof top and decorative artefacts outside which gives a pleasant look to its surroundings and resembles a signature structure of the Amaravati capital city. Two intake wells shall be connected by a platform at pump floor level with unique architectural design compatible with pump house. The platform shall be designed to carry heavy commercial vehicular load and it shall be connected with

elevated approach road with sufficient turning radius. The building with complete architectural design shall be prepared and submitted along with 3D view to the Authority for appreciation/ modification and approval from the Engineer in charge. Supply, fabrication, installation/ construction of signage, graphics as per the approved Architectural design.

v. Agency shall design and construct boundary wall of height 1.8 m above finished GL for entire premises and shall provide ornamental gate with MS angle flat and sheets at entrance one at main entrance and other at river side. The boundary wall shall be of 250 mm thick panel wall with RCC column and beam framework at an interval of 3 m. Agency shall construct security cabin of size 10 sq.m. Agency shall also construct approach road from platform level/road level to the raw water pump house premises.

vi. Agency shall design and construct office building cum guest house at raw water pump house campus. The building shall be of RCC framed structure resting on pile foundation with 250 mm thick external wall and 125 mm thick internal wall. This building shall be of 300 sq.m built up area in each floor. Ground floor of the building shall be car parking and one servant room with toilet and kitchen. First floor shall be office for administration staff which contains two cabins with air conditioned, ten cubicals with necessary furniture. Second floor shall be 4 bedrooms with attached bathroom, separate hall and dining space in 250 sq.m area & 50 sq.m open terrace with an ornamental parapet wall including all furniture. There shall be a common washroom in hall. The first-floor level i.e. office floor level shall be same as pump floor level. There shall be access from platform level to the first-floor level/office floor level through gangway. Finishing of the building shall be as specified in Schedule D.

vii. Agency shall design and construct one staff quarter (G+4) RCC frame structure building resting on pile foundation with 250 mm thick external wall and 125 mm thick internal wall. This staff quarter shall have two quarters of size 100 sq.m built up area in each floor. Ground floor of the building shall be car parking. Each quarter shall contain two bedrooms, (one master bed room with attached toilet, one bed room), hall, dining, kitchen, one common bathroom and a balcony. The building shall consist of one RCC staircase of width 1.20 m and stair head room of 2.4 m height. Finishing of the building shall be as specified in Schedule D.

viii. Agency shall design and construct internal road including storm water drainage network, footpath, kerbs and channels, campus lighting, landscaping of campus etc. as per the approved internal layout submitted by Agency and as per specification given in Schedule D.

ix. Agency shall design and construct indoor substation cum SCADA Control room building of area 607.50 Sqm, transformer yard with separate boundary wall as per electrical component design given in Schedule D. Floor level of substation building shall be 150 mm above the elevated approach bridge level. There shall be minimum 3.5 m approach way by RCC gangway from elevated approach road to substation building. The Ground floor shall be car parking space. Substation building shall be framed structure over RCC pile foundation. Finishing of the substation building shall be as per specification given in Schedule D.

x. <u>Electrical:</u>

The Scope of electrical works is given in elsewhere in bid document.

xi. Instrumentation & Control System through SCADA

The scope of works under this sub-head includes the following as given below:

a. Design, Supply, erection and commissioning Instrumentation control through SCADA with optical fiber networking for 392 MLD Intake-well-cum-Raw water pumping station. Scope include of all field instruments (gauges/sensors/transmitters/ switches etc.) for control/monitoring/alarm annunciation system of Intake well, Raw water Pumps (8525 m^3/hr) for Phase-I development, Raw water pumping main (17050 m3/hr), process and electrical system equipment & systems. Design and provision of expansion and panel with space for PLC and terminals for future expansion 392 MLD.

b. Preparing I/O list & P&ID for Intake well, Raw water Pumps (8525 m3/hr), Raw water pumping main (17050 m3/hr), process and electrical system equipment & systems. The preparation of I/o and P&ID as per detailed specification in schedule D and shall be submitted for approval of the Engineer-in-Charge.

c. Design, supply, erection, loop checking & commissioning of PLC based control system for complete Raw water pumping station comprising of Intake well, raw water pumping main upto WTP, 33kV/6.6 KV substation & associated electrical

systems and remote I/O cabinet complete with all hardware, software, system cabinets, marshalling cabinets, interfaces & accessories as required & considering future expansion with specified requirement detailed subsequently. The installation, commissioning & upgradation of PLC system shall be in line with phase-wise installation & commissioning activities as specified in Schedule D.

d. Design, supply, erection & commissioning of all erection hardware and accessories like branch cable trays from field sensors to junction boxes, junction boxes for terminating field sensors etc. as required for erection of field instruments/sensors/PLC Control system/ local panel etc. for complete scope of work.
e. Design, supply, erection & commissioning of Local UPS Power supply with distribution boards & distribution to I&C system equipment.
f. Design, supply, laying & termination of Instrumentation & Control cables as required for complete control/ monitoring of entire Raw water pumping. Scope also includes preparation of engineering documentation like cable schedule and Interconnection schedule.
g. Design, supply of necessary consoles & other furniture & accessories to mount MMI & peripherals including construction of air-conditioned control room, 2 No 55-inch LED monitor, 2 No work-station with 32-inch monitor and good quality high back cushioned wheeled chairs at Raw Water Pumping station as per specification and layout in Schedule D.
h. Design and creation of HMI MIMICS which should graphically represent total architecture, functioning for the proposed system.
i. Local SCADA shall consist of Information Management System (IMS) which shall analyze Annual O&M cost estimate: - Annual energy usage model that will allow estimation of early utility cost and will assemble all annual costs for operation, maintenance and repair of plant, distribution and energy transfer station assets. Web based SCADA shall be supplied for monitoring and recording the hydraulic parameters and overall operations of the water supply system.
j. PLC controller as required complete with required I/O modules to be located at Intake well cum pumping station in local control room (air conditioned) in Control building. Number of PLC controllers (each hot redundant) to be based on I/O han-

dling capacity, specified I/O spare philosophy and controller spare loading requirement for 392 MLD (17050 m^3/hr) Intake well as specified in Schedule D. PLC controllers for entire plant as detailed below shall be provided.

k. The instrumentation system shall comprise of field censors, gauges, switches, transmitters, PLC based control system and peripherals, field instrument piping/slashing tubes, fittings, field accessories like junction boxes, transmitter racks, instrumentation and control cable, communication data cable, supply and installation of cable trays, loop testing, calibration of filed instruments and its PLC interfacing etc. as per specification provided in Schedule D.

l. One (1) No. colour laser printer and one number black and white laser printer.

m. Provision of remote I/O cabinet for interfacing field instruments located at raw water pumping main covering upto WTP.

n. Provision of OFC communication data cable (Fibre Optic Cable) along with PLB HDPE duct between main PLC of Intake well & Control Command Centre at WTP.

o. Provision of 3 sets of communication hardware for OPC communication link and standby wireless communication network (Ethernet on TCP/IP protocol) for interfacing with overall project master control system at Central Command Centre at WTP premises for additional facility of operation & monitoring.

p. Provision of 2 sets of spare serial communication links (each for RS-485 & RS-232 using Transmission Control Protocol/Internet protocol) hardware with MODBUS protocol for future interfacing with other plant control systems like Fire Alarm System.

q. SCADA, networking & other necessary software, required for smooth & satisfactory functioning of Intake well pumping system & raw water pumping main, to be installed with latest, compatible versions and future system & software upgradation to be carried out with no extra costs to the ADC during phase-wise installation & commissioning, trial run, DLP and operation maintenance period.

xii. Agency shall plan, design & execute toilet/washroom, parking facade/floor finishing in each building and in each floor. Finishing shall be as per details provided in Schedule D.

xiii. All structures/platforms shall be designed considering pile foundation.

xiv. Floor/platform level of pump house, substation building, shall be at least 150 mm above elevated approach bridge level (25 m).

xv. Necessary firefighting as per NFPA guidelines/IS code for Intake well cum pump house, office building, substation shall be within this scope of work.

xvi. Entire Intake well cum raw water pumping station premises shall be monitored through CCTV camera with one-month backup storage. Live CCTV footage shall be transmitted to SCADA screen at Intake well and as well as CCC at WTP.

xvii. Design, supply, installation, testing and commissioning of EPBAX and intercom phone facility shall be provided in the entire Intake well area.

- ***Approach Road to Intake Well***

The scope of works includes the following as given below:

i. Topographical survey shall be carried out using Total Station and DGPS supported with electronic Auto Level for accurate alignment plan, L-section and cross-sections of the Approach Road. For this, nearest GTS bench mark shall be carried forward to the start / end point of the road and double leveling to close any inaccuracy in levels and alignment plan. Cross-sectional survey at 100m interval with spot level at every 10m spacing to cover bottom width of the approach road plus 10m additional on either side shall be carried out. Alignment plan, L-section and cross-sections shall be prepared on 1:5000 scale and shall be submitted to the Engineer-in-Charge for approval.

ii. Geotechnical investigation using electrical resistivity survey and auger well pits at 50m interval shall be carried out all along the alignment of the approach road to arrive at soil profile upto 3m depth from the GL. These soil profiles along with the report shall be submitted to the Engineer-in-Charge for approval.

iii. Approach road from flood bund road shall be combination of elevated platform and earth-fill road made of cement concrete (M30) with expansion joints at suitable intervals. Formation of the approach road embankment shall be made of earth compacted with roller. Length of elevated platform shall be approximately of 290 Rmt and approach road shall be of 218 Rmt. There shall be connectivity from elevated platform/road to electrical substation also. The elevated platform/road shall be designed with consideration of single Class-A loading as per IRC with allowable gradient of 1 in 20. Suitable size of RCC cable trench/alley is to be constructed for transmission of power and control

cables between the elevated substation platform and pump house on the integrity on both sides of elevated platform/road as well as on earth-fill road. The approach elevated platform/ road towards Intake well shall have to accommodate common delivery manifold and pumping main. The top width of approach road shall be minimum width of 11.20m. The Intake well shall be constructed in such a fashion that elevated platform/road shall connect in between two Jack wells. There shall be sufficient space in between two RCC Jack wells to facilitate entry of heavy vehicles upto Jack wells. The Project Roads and Utilities/Services shall be designed and constructed in conformity with the Standards and Specifications given in Schedule D.

- ***Raw Water Transmission Main:***

The scope of work includes the following as given below:

i. Survey, Geo-technical Investigation, Detailed Engineering of the pipe line based on the design principle provided by the Authority (pipe diameter, pipe material, valves as provided in Schedule - D). For SWMS pipes, recommended in-lining is 406-micron food grade fusion bonded Epoxy and out-coating is 3-layer polyethylene/polyolefin.

ii. Provide Detailed plans, Preparation of L section, Cross Sections etc., GFC's of pressurized potable pipeline without deviating the design concept considered and details given below. Agency shall also provide as-built drawings indicating all assets related to water supply in GIS and AutoCAD format.

iii. Each pump shall have a common manifold of dia 1500 mm, minimum thickness of 14 mm and each manifold will connect with another common manifold of dia 2200 mm, minimum thickness of 18 mm from which pressurized raw water transmission main of approximately 580 Rmt length (upto WTP) of 1900 mm diameter SWMS pipe with minimum thickness of 16mm which shall be provided out by the EPC Agency. All the pipe line shall have one PLB HDPE duct along with its trench at proper location approved by the Engineer-in-Charge. Agency shall make necessary provision in the pumping main at WTP, so that future expansion with other stilling chamber of next phase WTP can be done without shutdown of raw water pumping station. Agency shall make necessary provision of tees, actuator compatible sluice valves with blind flange in raising main of capacity 17050 m3/hr. 1900 mm dia raw water pumping main will be bifurcated at WTP premise with two No of 1500 mm dia SWMS pipe, minimum thickness 14 mm, one will connect with stilling chamber of proposed WTP and other one for next

phase WTP. Each 1500 mm dia SWMS pipe will have electrical actuator SCADA compatible sluice valve complete in all respects. The external coating shall be 3 LPE/polyolefin coating and inside with 406-micron food grade epoxy coating.

iv. Agency shall supply, install, testing and commissioning of 1 No. of 1900 mm dia butterfly valve with electrical actuator and SCADA compatible. Agency shall also supply, install, testing and commissioning of 1 No. 1900 mm dia electromagnetic flow meter for measurement of raw water flow. Agency shall also construct chambers for valves and meter.

v. Based on the survey, geo-tech investigation, pipe design analysis, etc., Agency shall provide accurate alignment Plan, L section, Cross-Sections, geo-tech investigation and pipe analysis data and reports including provision of surge protection devices at appropriate locations at the outlet pipe of the RWPS for approval of the Authority before proceeding for the construction works.

vi. Agency shall provide necessary surge analysis report for approval by the Engineer in charge and shall provide necessary surge protection device (bladder vessel) having capacity 15m^3 and minimum 2 Nos.

vii. Construction of RWTM shall be carried out as per approved design and drawings and as per the following item of works:

- Construction of RWTM shall be buried 1.2 m below the approach road level
- Supplying, fabricating, loading, unloading, transporting and handling of Mild Steel pipes, specials etc.
- Loading, Unloading, Transporting and handling of PLB HDPE ducts and laying of ducts along with SWMS Pipes and accessories for laying of OFC.
- Neoprene gaskets required for flange joints shall be supplied by the Agency.
- Lowering, placing and laying such pipe specials, valves etc., properly in trenches, jointing by proper neoprene gasket, submerged arc welding to the SWMS pipes including derusting, scraping, brushing and applying heat shrink sleeves as per specification and hydraulic pressure testing.
- Supplying of all labour, tools & tackles, plants, instruments, equipment, machinery, accessories as are needed to complete the job in the manner as specified to the entire satisfaction of the Engineer-In-Charge.
- Construction of supporting arrangements / thrust blocks.

- Earth work in excavation in trenches
- Pumping out sub-soil water and water from other sources accumulated in excavated trenches.
- Any other work related to laying of water supply pipe which is not mentioned above shall be executed by the Agency.

- ***Water Treatment Plant (WTP)***

The scope of work includes planning, designing, detailed engineering, drawing, construction, supply, erection, testing, commissioning, operation and maintenance of entire water treatment plant complete in all respects. The plant is proposed to be located at Undavalli. The details of site plan and land area are provided in the Annexure.

The water treatment plant shall be *Modular* in construction with 190 MLD (present) + 190 MLD (future expansion). The Agency shall prepare layout plan with unit sizing and Hydraulic Flow Diagram (HFD) for two (2) No of 8261 m^3/hr (190 MLD) capacity water treatment plant, 2 No of 64 ML capacity clear water reservoir and one clear water pump house for housing 19 No of pumps and motors of capacity as given in Schedule D along with all components given hereunder in approximately 25 acres allocated land for the said purpose. The Agency shall construct only one 8261 m^3/hr (190 MLD) capacity WTP with 1 No. of 64 ML capacity Clear water reservoir and the pump house for housing 19 pumps along with other items which are given herewith.

The plant shall be a state-of-art facility with modern space saving water treatment technology with Zero Liquid Discharge (ZLD) concept for raw water treatment of Krishna river and shall consist of the following units given below. The WTP units shall be planned & designed in such a way that there shall be 100% flexibility in operation. Any process unit of WTP shall not be connected directly to the consecutive process units. Each unit shall be connected with a common channel.

(a) Stilling chamber and Parshall flume with ultrasonic flow measuring device
(b) Pre-chlorination with liquid chlorine.
(c) Chemical (Alum/PAC) dozing with thorough mixing of raw water
(d) Flash mixer for Coagulation
(e) Flocculation
(f) Sedimentation with plate settler technology
(g) Rapid sand gravity filters with modern under drainage system.

(h) Backwash sump-cum-pump house for filter beds

(i) Sludge drainage/treatment/thickened, make sludge cake and waste drained water disposal with ZLD concept

(j) All pumps, motors, compressors, air blowers & other electro-mechanical equipment related to water treatment process

(k) Storage of disinfectant

(l) Filter water conveying main upto semi-underground clear water reservoir

(m) Weigh bridge of capacity 30 MT.

(n) Disinfection/post Chlorination

(o) Chemical house

(p) Recirculation pump house

(q) Filter house annex building

(r) Well-equipped laboratory

(s) WTP control with SCADA & integration with main SCADA

Available Raw water quality parameter of river Krishna water and required clear water quality parameter are given in Schedule D. However, the Agency shall undertake testing of raw water quality parameters by their own and design WTP accordingly, then proven technology installations are to be demonstrated to Authority/Authority engineers for the approval. Detail specification of WTP units are given in Schedule D.

Apart from the above treatment units, the following works are also under this scope of this tender.

i. Architectural boundary wall with ornamental gates of entire WTP premises.

ii. Internal road network along with storm water drainage network on both sides of road, kerb channel & footpath, internal lighting, landscaping of campus and gardening over the semi underground reservoir roof.

iii. Supply, fabrication, installation/ construction of signage and graphics as per the approved Architectural design.

iv. Agency shall plan, design & execute toilet/washroom, parking facade/floor finishing in each building and in each floor. Finishing shall be as per details provided in Schedule D.

v. Administrative building shall contain reception, visitors lobby, Control Command Centre (C3) with 2 No 90-inch video wall, office space for Chief Engineer, Superintending

Engineer, Executive Engineers, Dy. Executive Engineers, Assistant Executive Engineers as provided elsewhere in the bid document.

vi. Two No staff quarter (G+4) building each having 8 No quarters, one building for Group C employee and 2nd building for Group A&B employees. The built-up area of group C employee shall be of 100 sq.m and for group A&B shall be of 120 sq.m.

vii. Decorated boundary wall of entire WTP with electrically operated ornamental gate made of MS flat, angle, square bar, sheet etc. Administrative building, staff quarter, bungalows and WTP compound shall have separate boundary wall and gate of same specification. Boom barrier with vehicle access control shall be provided at the entry of both administrative building and WTP. Number of gates shall be finalized at planning stage in consultation with Engineer-in-Charge. Each gate shall have one security cabin of size 10 sq.m.

viii. Two bungalows (G+1 storied) of built-up area of 150 sq.m in each floor with boundary wall, gate, internal lighting, storm water drainage, internal roads etc., one for the plant Superintendent and one for the Chief Engineer.

The scope of above stated work includes planning, design, drawing and construction of civil works with pile foundations for the various units of the plant as listed above including, planning, design, drawing, manufacture, supply, delivery at site and erection of all mechanical and electrical equipment including pipes, valves with electrical actuators, pumps, motors and all other electrical and mechanical equipment as per detailed technical specification and vendor list that may be necessary and specified herein to make the treatment plant complete in all respects to treat raw water (quality as shown in Appendix) delivering 8525 m^3/hr of potable water of specified quality (physical, chemical and bacteriological). The foundation of all civil structures will be of direct mud circulation bored piles. The scope also includes leak-proof testing of various water retaining units of the plant, commissioning of the same and trial run for a period of three (3) months. Thereafter, two-year DLP and operating and maintaining the plant for a period of 96 (Ninety-six) months from the date of completion of DLP including the SUGR, CWPS and entire water supply system of Amaravati capital city including instrumentation (SCADA) as specified, under the overall supervision of the Employer/his representative. The date of commencement of the Trial Run shall be decided by the Authority after taking into consideration the existing status of the entire works under this tender and after being

satisfied that the plant is completed in all respects to begin trial run. During the period of trial run, DLP, operation and maintenance, the Agency shall have to supply all type of coagulant, chlorine, laboratory reagents and all equipment and chemicals required to run the plant. During the period of trial run, DLP and operation maintenance, except for the power charges, which will be borne by the Authority, all other costs related to trial run shall be borne by the Agency. During the trial run & DLP, it shall be obligatory on the part of the Agency to justify his process and designs by showing the quality of treated water and the performance of the electro-mechanical equipment. The tests which shall be undertaken by the Agency during trial run, DLP and operation maintenance are given below in the Table.

S No	Required Test Parameters	Sample Water	Frequency of Testing	Remarks
1	Turbidity	Raw Water, Clarified water, filtered water at each filter bed, filtered water at SUGR sump, common manifold, WDC	Online record through SCADA	Agency shall also provide necessary instruments at laboratory for testing turbidity thrice in a day to compare with online data.
2	Residual chlorine	Clarified water, filtered water at each filter bed, filtered water at SUGR sump, common manifold, WDC	Online record through SCADA	Agency shall also provide necessary instruments at laboratory for testing residual chlorine six times in a day to compare with online data.
3	Temperature, Total Dissolved Solids,	Raw Water, filtered water at common manifold	Online record through SCADA	Agency shall also provide necessary instruments at laboratory for testing temperature, TDS once in a day to compare with online data.
4	pH	Raw Water, raw water after flocculator, filtered water at common manifold.	Online record through SCADA	Agency shall also provide necessary instruments at laboratory for testing pH

				once in a day to compare with online data.
5	Total Alkalinity , Hardness, Chloride	Raw Water, filtered water	Once in a day	Laboratory test
6	Jar Test	Raw Water	Twice in a day	Laboratory test
7	Fluoride, Sulphate, Nitrate	Filtered Water	Once in a week	Laboratory test
8	Arsenic, Iron, Lead, Mercury,	Filtered Water	Twice in a month	Laboratory test
9	Mineral Oil, Pesticide	Filtered Water	Once in a month	Laboratory test
10	Presumptive Coliform Count, Faecal Coliform Count	Filtered Water	Twice in a month	Laboratory test

The Agency shall have to perform all tests in the newly built laboratory of WTP with necessary reagents, instruments, equipment except those for the Mineral Oil, Pesticide, arsenic, lead and mercury. The Agency shall arrange to have these tests carried out by any Government or renowned approved laboratory and shall submit the results to the Engineer-in-Charge regularly at the Agency's cost.

The item-wise detailed scope of work and specifications are provided in Schedule D.

B. Electrical:

The scope of work for electrical is given elsewhere in the bid document.

C. Instrumentation & Control System through SCADA:

i. Design, Supply, erection and commissioning of Instrumentation and control through SCADA with optical fiber networking within the 190 MLD Water Treatment Plant. Scope includes all field instruments (gauges/sensors/transmitters/switches etc.) for control/ monitoring/alarm annunciation system of WTP consisting inlet chamber, chemical dozing, Parshall flume, flash mixture, flocculator, plate settler, rapid sand filter beds, Back wash reservoir, common filter water channel, sludge sump & pump

house, sludge thickener, centrifuge, Clear water reservoir, clear water pumping station, clear water pumping mains, Tapping Control Management System (TCMS), Bypass Management System, Reservoir Management System, WDCs and all electrical panels. Design and provision of spare I/O channels/cards considering future expansion for additional (190 MLD) in the WTP premises as specified in Schedule D.

ii. Preparing I/O list & P&ID for WTP process & electrical system, clear water pumping main and WDC. The preparation of I/O and P&ID as per detail specification in schedule D. The prepared P&ID and I/O list shall be submitted for Engineer-in-Charge approval.

iii. Design Supply, erection, loop checking & commissioning of PLC based control system for complete water treatment, clear water pumping main, Tapping Control Management System (TCMS) with Sluice valve & Electromagnetic flow meter, Bypass Management System, Reservoir Management System and WDC, 33kV/6.6kV switchyard & associated electrical systems and remote I/O cabinet complete with all hardware, software, system cabinets, marshalling cabinets, interfaces & accessories as required & considering future expansion with specified requirement detailed subsequently. The installation, commissioning & upgradation of PLC system shall be in line with phase-wise installation & commissioning activities as specified in Schedule D.

iv. Design, Supply, erection & commissioning of all erection hardware and accessories like branch cable trays from field sensors to junction boxes, junction boxes for terminating field sensors etc. as required for erection of field instruments/sensors/PLC Control system/ local panel etc. for complete scope of work.

v. Design, Supply, erection & commissioning of Local UPS Power supply with distribution boards & distribution to I&C system equipment.

vi. Design Supply, laying & termination of Instrumentation & Control cables as required for complete control/ monitoring of entire Raw water pumping station. Scope also includes preparation of engineering documentation like cable schedule and Inter-connection schedule.

vii. Design Supply, installation, testing, commissioning, trial run for 3 months, 2 years DLP and 8 years operation and maintenance of control command center (C3) with 2 Nos 90-inch LED Video wall located at WTP, shall collect the data from Intake well,

Raw water raising main, WTP, Clear water pumping station, Clear water pumping main Air Management System (AMS), Tapping Control Management System (TCMS), Bypass Management System, Reservoir Management System and WDCs. Operator shall monitor on 2 Nos 90" Video wall and control. It shall comprise of Engineering station, historian station along with real time data acquisition server. Control Command center shall contain 6 No. work station near video wall. Visitors lobby with furniture and reception as per specification and layout in Schedule D

viii. Design and creation of HMI MIMICS which should graphically represent total architecture and functioning for the proposed system.

ix. From Control Command Center (C3), provision shall be made connecting to C4 (City Control Command Center).

x. SCADA shall consist of Information Management System (IMS) which shall analyze Annual O&M cost estimate: Annual Energy usage model that will allow estimation of utility cost and will assemble all annual costs for operation, maintenance and repair of plant, distribution and energy transfer station assets.

xi. SCADA system shall be designed for automatic bill generation for every individual customer by collecting data from WDCs. Provision of data acquisition system at WDC shall be provided to collect the data of individual consumers through Water Management District (WMD).

xii. PLC controller as required complete with required I/O modules shall be located at local control room (air conditioned) in WTP. Number of PLC controllers (each hot redundant) shall be based on I/O handling capacity, specified I/O spare philosophy and controller spare loading requirement for 380 MLD WTP as specified in Schedule D.

xiii. The instrumentation system shall comprise of field censors, gauges, switches, transmitters, PLC based control system and peripherals, field instrument piping/slashing tubes, fittings, field accessories like junction boxes, transmitter racks, instrumentation and control cable, communication data cable, supply and installation of cable trays, loop testing, calibration of field instruments and its PLC interfacing etc. as per specification provided in Schedule D.

xiv. Total two (2) No PC based VDU/Keyboard type Operator-cum-Engineering Stations (OES) complete with SCADA MMI software shall be located in clear water pumping

station with Local Control Room (LCR) complete with associated furniture for mounting the same.

xv. Total one (1) No. colour laser printer and one number black and white laser printer.

xvi. Provision of remote I/O cabinet for interfacing field instruments located at clear water pumping main and WDC.

xvii. Optical Fibre Cable (OFC) communication data cable (Fibre Optic Cable) along with PLB HDPE duct between Intake well, raw water pumping main, WTP, clear water pumping main and WDC.

xviii. Provision of 3 sets of communication hardware for OPC communication link and redundant wireless communication network (Ethernet on TCP/IP) for interfacing with overall project master control system at Central Command Centre located at WTP for additional facility of operation and monitoring.

xix. Provision of 2 sets of spare serial communication links (each for RS-485 & RS-232) hardware with MODBUS protocol for future interfacing with other plant control systems namely Fire Alarm System.

xx. SCADA, networking & other necessary software, required for smooth & satisfactory functioning of Intake well pumping system & raw water pumping main, shall be installed with latest, compatible versions future system and software upgradation shall be carried out with no extra costs to ADC during phase-wise installation and commissioning, trial run, DLP and operation maintenance of the system.

xxi. Entire WTP premises shall be monitored through CCTV camera with one-month backup storage. Live CCTV footage shall be transmitted to SCADA screen at WTP and as well as CCC at WTP.

xxii. Design, supply, installation, testing and commissioning of EPBAX and intercom phone facility shall be provided in the entire WTP & WDC area. All the locations of Intake well, WTP, WDCs has to be interconnected.

- ***64 ML capacity Semi Under Ground Reservoir (SUGR):***

The scope of work includes planning, designing, detailed engineering, drawing, construction, supply, erection, testing, commissioning, operation and maintenance of the semi-underground reservoir complete with inlet, overflow and scouring arrangement. The finished ground level shall be +22.0 **m** and existing ground level is approximately +19.0 m. Hydraulic design of treatment plant and clear water reservoir shall be such that the top

water level of semi-underground reservoir will be 0.05 m below the invert level of filter water channel of water treatment plant and Horizontal Pumps of clear water pumping station will have positive suction. Accordingly, levels of all the other units of water treatment plant such as collection well, flash mixers, flocculators, clarifiers, Filter Beds, Clear water duct, inlet ducts of reservoir etc. shall be fixed.

The SUGR shall be of two compartments with a facility for cleaning and maintenance of any one compartment without taking any shut down of clear water pump house as well as depressed sump. There shall be dividing wall between two compartments as well as depressed sump and compartments. To maintain minimum dead storage within the reservoir near the dry pit, a depressed sump floor level has to be provided adjoining the dry pit pump floor having floor level 2.50 m below the reservoir floor level or as prescribed by the pump manufacturer whichever is higher. The suction pipe of designed diameter from each individual pump along with the bell mouth shall be placed in the sump. The pipe line, the bell mouth and puddle collar at prescribed level of the suitable size are also under the scope of work. The sump floor will gently dip from the reservoir floor level with 45-degree slope. There shall not be any constriction/column in the suction sump area. Agency shall provide necessary arrangement for connection to the sump from second 64 ML reservoir for future expansion. One dewatering sump of suitable size shall be provided in each compartment of the reservoir for dewatering purpose and shall be marked properly at the top of the reservoir. Two manholes shall be provided just above the sump. The full water depth should be at least 5.0 m or more at the time of reservoir full condition. The foundation of pump house and reservoir will be of direct mud circulation bored pile. The pile shall have adequate strength to take tension for uplift due to subsoil water assumed at the existing ground level when the reservoir is empty and also for vertical loads in worst condition. The construction of pump house shall be completed earlier to facilitate the erection work of electrical and mechanical equipment. The free board in reservoir shall be of 0.5 m. There shall be proper overflow arrangement and ventilation arrangement in the reservoir and depressed sump. Prior approval shall be taken by the Agency for overflow and ventilation arrangement. There shall be a park with well-designed landscaping arrangement and walkway (1.5 m wide) with anti-skid tiles over the roof of SUGR. The roof is to be designed for a live load of 400 Kg/m^2 and a superimposed load of saturated compacted earth of 500 mm depth. No relief shall be allowed due to this superimposed load of saturated earth while

computing the uplift on the pile of SUGR. The roof slab shall be flat slab designed based on IS: 3370 and shall have minimum 300 mm projection on all sides and the parapet wall of the SUGR roof shall be of 200 mm thick RCC. The Agency shall provide proper roof treatment and drainage arrangement over the roof of SUGR. The site of SUGR shall be camouflaged with surrounding landscaping. The top of SUGR roof slab shall be one meter above the Finished GL. Agency shall construct four stairs to reach the top of the SUGR/Park from FGL. The reservoir shall have 1.0m wide plinth protection along with proper overflow and storm water drainage arrangement surrounding it. The plinth protection shall be constructed with 100 mm thick PCC (M15 grade) over single brick flat soling finished with 25 mm thick artificial stone flooring. There shall be 3.5 m road surrounding the SUGR and pump house. Agency shall provide proper lighting arrangement over the roof of SUGR.

The total work includes the civil construction & electro-mechanical installation work of reservoir, pump house and pump sump and inlet connection to the reservoir from the clear water duct receiving filter water from filter beds in the filter house. A suitable sluice gate shall be installed on the clear water duct in front of the semi-underground reservoir so that the reservoir and the treatment plant can be completely separated as and when required. RCC Inlet Duct has to be drawn from the clear water duct from filter house.

- **Clear water pumping *station***

The scope of work includes planning, designing, detailed engineering, drawing, construction, supply, erection, testing, commissioning, operation and maintenance of clear water pumping station. The work includes proper ventilation system, firefighting system in entire pumping station as well as air conditioning system in the control room. The pump house shall be planned for hosing 19 Nos of VFD controlled pumps and motors with different capacities specified herewith along with valves with electrical actuators and SCADA compatible, piping arrangement and all other necessary equipment and accessories. Construction of control room for VFD control panel, SCADA room, battery room, operators room, toilet etc. are also under this scope of work. The roof of sump portion may be utilized for construction of control room. The depth of dry pit pump house shall be compatible with the sump level of adjacent SUGR. RCC staircase to access pump floor from MCC room shall

be provided by the Agency. Height of the soffit level of the roof beam of pump house building shall be minimum 10.0 m from FGL. There shall be walkway of 1m width surrounding pump room inside the pump house.

Capacity of pumps and motors

S. No	Description	No. of Pumps to be installed	Discharge for each pump (LPS)	Head (m)	Remarks
1	To Ring Main Peak Flow	5W + 2S	826.39	54.00	7 Pumps out of 13 Pumps to be installed
2	To Ring Main Avg. Flow (Half size Pump)	2W + 1S	414.00	48.00	
3	Undavalli Area	2W + 1S	130.25	39.00	

It is proposed to install 13 Nos of horizontal split case centrifugal pump directly coupled with drive motor by flexible coupling. The capacity of the electro-mechanical component shall be as per the above table. The Agency shall install suction pipe with electrically operated actuator control and SCADA compatible valve for all 19 pumps and shall provide blind flange on six unused suction pipes & valves. The Agency shall provide 13 Nos delivery header and additional 6 Nos of delivery line from common manifold to the pump house and blind flange the same for future expansion. The Agency shall design, detailed engineering and construct pump foundation and other allied civil structures for all 19 Nos of pumps and motors. The Agency shall provide space for holding down bolts in civil structures of 6 Nos of pumps. The positive suction pumps shall be connected to the reservoir through suction pipes of designed diameter/diameter supplied by the manufacturer along with electrical actuator operated valves compatible with SCADA & specials. The pumps & motors must be of continuous duty type. The individual pump delivery pipe lines shall be connected to a common delivery manifold of designed diameter but not less than 2500 mm placed outside the pump house 1.2 m below G.L. The individual delivery line shall have a Duck Foot bend inside the pump house. The delivery manifold shall be equipped with actuator operated SCADA compatible Butterfly valves, electro-magnetic flow meter, flow meter chamber,

valve chamber, blank flange if necessary (detail of which is given in Schedule D). There shall be two separate manifolds outside the pump house having minimum size of 2500 mm dia with minimum 20 mm thickness and 1000 mm dia with minimum 10 mm thickness for Ring Main and Undavalli area. The two manifolds shall be connected with 1000 mm dia with minimum 10 mm thickness pipeline with electrical actuator with SCADA control sluice valve. The vertical portion of the delivery line shall be covered with proper cladding as approved by the Engineer-in-Charge. All the design of the pipelines shall be such that so as to ensure streamline flow.

The Agency has to submit in due course the specific size of all machineries & equipment offered along with data related to static & dynamic loads in different operating conditions. The size of pump house shall be selected in such a way, that all the equipment with sufficient maintenance space can be housed in the pump room. There shall be proper drainage arrangement & dewatering sump to evacuate the water accumulated over the pump floor. The size and location of sump pump along with sump shall be designed in such a manner to evacuate the accumulated water from pump floor from any source within maximum 10 minutes to eliminate the chance of inundation in any case. Minimum 50% standby for the sump pumps is to be provided.

Gantry arrangement and one E.O.T crane (10 MT) with another 3 MT auxiliary E.O.T crane are to be provided by the Agency in the pump house. The installed E.O.T crane should cover three dimensionally entire footprints of the pump house. In order to accommodate the cables, battery room and control panel room equipment/appliances will be house at a level higher than pump floor as shown in the tender drawing. Minimum requirement has been mentioned in Schedule D.

i. The vibration & noise shall be within the acceptable limit as per ISO 10816 code (latest revision) or as per existing norms for all equipment.
ii. The dimension and centre line of pedestals for supporting the Pumps as well as the valves shall strictly be in line for both Civil & Electromechanical works.
iii. The clearance in between successive pump sets, clearance from wall for pump sets shall be based on I.S code, CPHEEO manual and vendor data whichever is higher.
iv. The clearance for installation of all H.T. & L.T. electrical equipment should be strictly as per I.E. Rules.

v. The minimum distance from the pump impeller centre to suction sump wall shall be maintained in such a level so that no vortex formation takes place in the entry of pump i.e. the flow should be maintained streamlined at the entry point of pump.

vi. The elevation of pump centre line shall be designed in such a manner to maintain adequate clearance between the bell mouth and the floor of the suction sump to avoid choakage or vortex formation.

vii. The Agency has to submit parallel operation curves for pumps & the same is to be matched with the system resistance curve of the delivery grid. Pump selection shall be based upon that. Family curves for individual and multiple operations at all possible consequences depending upon the variation in % opening of the PDV are to be submitted.

viii. The Agency has to consider all sluice valves, PDVs, dismantling joints in individual pump suction & delivery pipe lines as per detailed technical specification.

ix. The puddle collars needed to be fixed into the wall for entry & exit of suction and delivery pipelines shall be considered.

x. The Agency shall work out the natural frequency analysis for the structural work and the same shall be verified with the RPM & critical speed of the rotating equipments to eliminate any chance of vibration. such a level so that no vortex formation takes place in the entry of pump i.e. the flow should be maintained streamlined at the entry point of pump.

xi. The puddle collar need to be fixed on the suction and delivery sides inlet and outlet on the concrete wall and are to be supplied and fixed as per specification/requirement.

xii. All the cable works from 33KV RMU to all 6.6KV and LT loads are within the scope of works. Cabling works required to operate the equipment at pump house, water treatment plant complex etc., shall be considered from this 33/6.6 KV indoor sub-station. Power cables of all sizes must be AL, 3 or 3.5 core armored XLPE cable.

The design of pump house shall be made on the basis of the Static load as prescribed and Dynamic loading and vibration level supplied by the manufacturer that will be generated due to operation of each pump motor set or as per relevant IS code.

The Agency, whose tender will be accepted in due course, shall have to furnish details of the design of the pump house and sump with all levels to connect the reservoir considering all the parameters as supplied by the pump manufacturer within the dimensions of the pumping station provided by them for housing the pumping machinery, compact substation equipment/appliances. The inlet connection shall be made at a level as shown in the obligatory data in Schedule D. The Agency shall undertake soil investigation studies of their own and thereby formulate the design criteria for structural work which will be subject to the approval of the Engineer-in-Charge.

- ***Laying of Clear Water Pumping main***

General scope of work includes laying of 2400 mm dia SWMS pipe (minimum thickness 20 mm) from the common manifold of the clear water pumping station upto E3 road and making connection with the ring main. Also, Agency shall supply, install 800 mm dia DI-K9 pipeline for Undavalli area upto E3 road.

Detailed scope of work includes the following as given below:

i. Survey, Geo-technical Investigation, Detailed Engineering of the pipeline system based on the design principle provided by the authority for civil structures (pipe diameter, pipe material, valves and specifications as provided in Schedule D). For SWMS pipes, recommended in-lining is 406-micron food grade fusion bonded Epoxy and out-coating is 3-layer polyethylene/polyolefin.
ii. Provide Detailed plans, Preparation of L section, Cross Sections etc., GFC's of pressurized potable system without deviating the design concept considered and details given below. Agency shall provide as-built drawing indicating all assets related to water supply in GIS and AutoCAD format.
iii. Agency shall provide necessary surge analysis report for approval by Engineer in charge and shall provide necessary surge protection device (bladder vessel) having capacity 100m^3 and minimum 6 Nos.
iv. Submission of plans, designs and engineering drawings for further approval of the authority.
v. Construction of Water Supply Network as per approved design and drawings
vi. Loading, Unloading, Transporting and handling of 800 mm dia DI-K9 Ductile Iron pipes and laying of Ductile Iron Pipe and special.

vii. Supplying, fabricating, loading, unloading, transporting and handling of 2400 mm dia (minimum 20 mm thickness) Mild Steel pipes, specials etc.,

viii. Loading, Unloading, Transporting and handling of PLB HDPE ducts and laying of ducts along with MS Pipes & DI-K9 pipeline and accessories for laying of OFC.

ix. Neoprene gaskets, tyton gaskets for maintaining proper alignment shall be supplied by the Agency.

x. Lowering, placing and laying such pipe specials, valves etc., properly in trenches, jointing by proper neoprene gasket (Push on joint/ tyton joint etc.,), submerged arc welding to the MS pipes including derusting, scraping, brushing and applying heat shrink sleeves as per specification and hydraulic pressure testing.

xi. Supplying of all labour, tools & tackles, plants, instruments, equipment, machinery, accessories as are needed to complete the job in the manner as specified to the entire satisfaction of the Engineer in Charge.

xii. Construction of supporting arrangements for pipes.

xiii. Construction of thrust blocks.

xiv. Earth work in excavation in trenches

xv. Pumping out sub-soil water and water from other sources accumulated in excavated trenches.

xvi. Erection, Testing, Commissioning and O&M of the Potable Water System

xvii. Any other work related to laying of water supply pipe which is not mentioned above has to be executed by the Agency.

xviii. The Agency shall construct the water supply pipelines for the pressurized water supply system on continuous running basis, along with installation of scour valves, thrust blocks and Isolation valves etc. as required.

xix. The Agency shall supply, install, test and commission 2 Nos. of SCADA compatible electromagnetic flow meters of size 2400 mm dia & 800 mm dia at proper location inside WTP campus.

xx. The Agency shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this tender.

Size of all valve chambers shall be considered for electrically actuated valve & compatible to SCADA connectivity except scour and air release valves as per the valve data sheet and location provided in drawings.

- ***Semi Under Ground Reservoir (SUGR) for WDCs:***

Scope of work includes construction of eight (8) Nos of SUGRs at different locations in the entire capital city area. The details of these 8 SUGRs are given in the table below.

S No	WDC No	Capacity (ML)	EGL (m)	FGL (m)	Remarks
1	18	1.6	33.50	33.50	
2	23	1.5	40.50	41.00	
3	24	1.8	29.50	30.50	
4	42	1.5	33.00	33.50	
5	43	1.6	39.00	39.50	
6	44	0.85	40.00	41.00	
7	45	1.2	32.00	32.50	
8	46	1.0	31.50	32.00	

The scope of work includes planning, designing, detailed engineering, drawing, construction, supply, erection, testing, commissioning, trial run, DLP for two years and operation maintenance of the SUGRs complete with inlet, overflow and scouring arrangement. The finished ground level of SUGRs shall be as per the table given above.

The SUGR shall be of two compartments with a facility for cleaning and maintenance of any one compartment without resorting to any shut down of the pump house as well as depressed sump. There shall be dividing wall between two compartments as well as depressed sump and compartments. To maintain minimum dead storage within the reservoir near the dry pit, a depressed sump at floor level shall be provided adjoining the dry pit pump floor having floor level 1.20 m below the reservoir floor level or as prescribed by the pump manufacturer whichever is higher. The suction pipe of designed diameter from each individual pump along with the bell mouth shall be placed in the sump. The pipe line, the bell mouth and puddle collar at prescribed level of the suitable size are also under the scope

of work. The sump floor will gently dip from the reservoir floor level with 45-degree slope. There shall not be any constriction/column in the suction sump area. One dewatering sump of suitable size shall be provided in each compartment of reservoir for dewatering purpose and shall be marked properly at the top of reservoir. One manhole shall be provided just above the sump. The full water depth should be at least 4.0 m or more at the time of reservoir full condition. The foundation of pump house and reservoir will be of direct mud circulation bored pile. The pile should have adequate strength to take tension for uplift due to subsoil water assumed at the existing ground level when the reservoir is empty and also for vertical loads in worst condition. The construction of pump house shall be completed earlier to facilitate the erection work of electrical/mechanical equipment. The free board in reservoir shall be of 0.5 m. There shall be proper overflow arrangement and ventilation arrangement in the reservoir and depressed sump. Prior approval shall be taken by the Agency for overflow and ventilation arrangement. There shall be a park with well-designed landscaping arrangement and walkway over the roof of SUGR. The roof is to be designed for a live load of 400 Kg/m^2 and a superimposed load of saturated compacted earth of 500 mm depth. No relief shall be allowed due to this super impose load of saturated earth while computing the uplift on the pile of SUGR. The roof slab shall be flat slab designed based on IS: 3370 and shall have minimum 300 mm projection on all sides and the parapet wall of the SUGR roof shall be of 200 mm thick RCC. The Agency shall provide proper roof treatment and drainage arrangement over the roof of SUGR. The site of SUGR shall be camouflaged with surrounding landscaping. The top of SUGR roof slab shall be one meter above the finished GL. Agency shall construct three stairs to reach top of the SUGR/Park from FGL. The reservoir shall have 1.0m wide plinth protection along with proper overflow and storm water drainage arrangement surrounding it. The plinth protection shall be constructed with 100 mm thick PCC (M15 grade) over single brick flat soling finished with 25 mm thick artificial stone flooring. There shall be 3.5 m road surrounding the SUGR and pump house. Agency shall provide proper lighting arrangement, internal storm water drainage, landscaping, internal road etc. for entire WDC compound. Agency shall also provide decorated framed boundary wall with ornamental gates made of MS angle, flat, square bar, sheet. Agency shall provide one security cabin of size 10 sq.m at the entry gate.

The total work includes civil construction work of reservoir, pump house and pump sump and inlet connection to the reservoir from nearby clear water trunk main. The inlet pipe of

suitable dia given herewith shall be laid by the Agency from the pipeline already laid under nearest road. The inlet pipeline shall be bifurcated before entering to the SUGR and enter into two compartments. Electrical operated actuator controlled SCADA compatible valve of same size of pipeline shall be installed on both the lines in front of the SUGR, so that the reservoir could be completely separated/controlled as and when required.

- ***Pumping Stations for SUGRs at WDCs***

As per the scope of work, there are eight (8) number of pumping stations at the 8 SUGRs area. The details of these 8 pumping stations are given in the table below

S No	WDC No	No. of pumps	Capacity		Remarks
			Discharge for each pump (LPS)	Head (m)	
1	18	2W+1S	72.11	33.0	
2	23	2W+1S	68.75	40.0	
3	24	2W+1S	81.83	35.0	
4	42	2W+1S	67.94	33.0	
5	43	2W+1S	72.81	37.0	
6	44	2W+1S	38.20	36.0	
7	45	2W+1S	54.29	32.0	
8	46	2W+1S	44.10	33.0	

The scope of work includes planning, designing, detailed engineering, drawing and construction, supply, erection, testing, commissioning and O&M of pumping station at each of 8 SUGRs. The work includes proper ventilation system, firefighting system in entire pumping station as well as air conditioning system in the control room. The pump house at each SUGR shall be planned for hosing 5 No (3W+2S) of VFD control pumps and motors with same capacity specified herewith in the above table along with valves (along with electrical actuators and SCADA compatible), piping arrangement and all other necessary equipment and accessories. Construction of control room for VFD control panel, SCADA room, battery room, operators room, toilet and bathroom etc. are also under this scope of work. The depth of dry pit pump house shall be compatible with the sump level of adjacent SUGR. RCC staircase to access pump floor from MCC room shall be provided by the Agency.

Height of the pump house building shall be minimum 5.0 m from FGL. There shall be walkway of 1m width surrounding pump room inside the pump house.

It is proposed to install 3 (2W+1S) horizontal split case centrifugal pumps at each SUGR directly coupled with drive motor by flexible coupling. The capacity of the electro-mechanical component shall be as per the above table. The positive suction pumps shall be connected to the reservoir through suction pipes of designed diameter/diameter supplied by the manufacturer along with electrical actuator operated valves compatible with SCADA & specials. The pumps & motors must be of continuous duty type.

The individual pump delivery pipe lines shall be connected to a common delivery manifold of designed diameter but **not less than 200 mm plus diameter** of delivery pipe placed outside the pump house 1.2 m below G.L. The individual delivery line should have a Duck Foot bend inside the pump house. The delivery manifold shall be equipped with actuator operated SCADA compatible Butterfly valves, electro-magnetic flow meter, flow meter chamber, valve chamber, blank flange if necessary (details of which are given in Technical Specification in Schedule D). The vertical portion of the delivery line shall be covered with proper cladding as approved by the Engineer-in-Charge. All the design of the pipelines should be such that so as to ensure streamline flow.

Apart from these, Agency shall also consider the following points:

i. The vibration & noise should be within the acceptable limit as per ISO 10816 code (latest revision) or as per existing norms for all equipment.
ii. The dimension and centre line of pedestals for supporting the Pumps as well as the valves should strictly be in line for both Civil & Electromechanical works.
iii. The minimum centre-to-centre distance of the pumps, clearance from the walls should be as per CPHEEO manual and Latest relevant IS code.
iv. The clearance for installation of all H.T. & L.T. electrical equipment should be strictly as per I.E. Rules.
v. The minimum distance from the pump impeller centre to suction sump wall is to be maintained in such a level so that no vortex formation takes place in the entry of pump i.e. the flow should be maintained streamlined at the entry point of pump.
vi. The elevation of pump centre line should be designed in such a manner to maintain adequate clearance between the bell mouth and the floor of the suction sump to avoid choke or vortex formation.

vii. The Agency has to submit parallel operation curves for pumps & the same is to be matched with the system resistance curve of the delivery grid. Pump selection should be based upon that. Family curves for individual and multiple operations at all possible consequences depending upon the variation in % opening of the PDV are to be submitted.

viii. The Agency has to consider all sluice valves, PDVs, dismantling joints in individual pump suction & delivery pipe lines as per detail technical specification.

ix. The puddle collars are needed to be fixed into the wall for entry & exit of suction and delivery pipelines.

x. The Agency shall work out the natural frequency analysis for the structural work and the same shall be verified with the RPM & critical speed of the rotating equipment to eliminate any chance of vibration to such a level so that no vortex formation takes place in the entry of pump i.e. the flow should be maintained streamlined at the entry point of pump.

xi. The puddle collar needs to be fixed on the suction and delivery sides inlet and outlet on the concrete wall and are to be supplied and fixed as per specification/requirement.

xii. All the cabling work required to operate the equipment at all the WDCs has to be considered and accordingly sizing of each LT cable has to be done. Power cables must be 1100 V, AL, 3.5 core armored XLPE for LT loads.

The design of pump house shall be made on the basis of the Static load as prescribed and Dynamic loading and vibration level supplied by the manufacturer that will be generated due to operation of each pump motor set or as per relevant IS code.

The Agency, whose tender is accepted in due course will have to furnish details of the design of the pump house and sump with all levels to connect the reservoir considering all the parameters as supplied by the pump manufacturer within the dimensions of the pumping station provided by them for housing the pumping machinery, compact substation equipment/appliances. The inlet connection will be made at a level as shown in the obligatory data in Schedule D. The Agency shall undertake soil investigation studies of their own and thereby formulate the design criteria for structural works which will be subject to approval of the Engineer-in-Charge.

- ***Cushion Tanks for WDCs:***

The scope of work includes design, detailed engineering, construction of decorated boundary wall with ornamental gates made of MS angle, flat, square bar, sheet, security cabins, operators room & SCADA control rooms, approach road, drainage network, compound lighting, Bypass Management System etc. in all the 51 sites of cushion tanks complete in all respect. The agency shall also design, detail engineering and construct Cushion tanks (ELSRs) of different capacities and staging height as given below. The specification for ELSRs is given in Schedule D.

S No	WDC No	EGL (m)	FGL (m)	Capacity (KL)	Staging Height (m)
1	3	18.69	20.88	2000	22.0
2	11	20.67	21.81	1250	21.0
3	20	22.22	22.86	1750	23.0
4	30	19.71	20.62	2400	26.0
5	41	26.55	27.50	1850	27.0
6	59	29.41	29.40	2150	23.0
7	37	20.65	20.65	1600	22.0

The agency shall design and construct unique ELSR structure and shall have decorative artefacts which gives pleasant look to its surroundings and resembles a signature structure in Amaravati capital city. The contractor shall submit different types of design & elevation of ELSRs to the EIC for approval. Each ELSR shall have different elevation and look. The specification for ELSRs is given in Schedule D.

The Agency shall provide inlet arrangement from nearest clear water main to the cushion tank compound, bypass management system and outlet arrangement. Agency shall provide tee connection with electrical actuator control and SCADA compatible sluice valves and blind flange before and after bypass management system. Outlet pipe shall be extended from bypass management system to nearest road. Diameter of inlet pipe and outlet pipe, tees are given below.

Cushion tank/WDC No	Inlet pipe dia	Material	Dia of Tees & valves	Outlet pipe dia	Material	Dia of Tees & valves
1	700	DI K9	700	700	DI K7	700
2	600	DI K9	600	600	DI K7	600
3	600	DI K9	600	600	DI K7	600
4	600	DI K9	600	600	DI K7	600
5	700	DI K9	700	700	DI K7	700
6	600	DI K9	600	700	DI K7	700
7	600	DI K9	600	600	DI K7	600
8	700	DI K9	700	700	DI K7	700
10	600	DI K9	600	600	DI K7	600
11	600	DI K9	600	500	DI K7	500
12	600	DI K9	600	600	DI K7	600
14	600	DI K9	600	600	DI K7	600
15	600	DI K9	600	700	DI K7	700
16	600	DI K9	600	600	DI K7	600
17	600	DI K9	600	600	DI K7	600
19	600	DI K9	600	700	DI K7	700
20	600	DI K9	600	700	DI K7	700
21	600	DI K9	600	600	DI K7	600
22	600	DI K9	600	600	DI K7	600
25	600	DI K9	600	600	DI K7	600
26	600	DI K9	600	600	DI K7	600
27	700	DI K9	700	700	DI K7	700
28	600	DI K9	600	600	DI K7	600
29	600	DI K9	600	600	DI K7	600
30	700	DI K9	700	700	DI K7	700
31	600	DI K9	600	600	DI K7	600
32	600	DI K9	600	600	DI K7	600
33	600	DI K9	600	600	DI K7	600
34	600	DI K9	600	600	DI K7	600

35	600	DI K9	600	600	DI K7	600
36	600	DI K9	600	600	DI K7	600
37	600	DI K9	600	600	DI K7	600
38	600	DI K9	600	600	DI K7	600
39	500	DI K9	500	500	DI K7	500
40	600	DI K9	600	600	DI K7	600
41	700	DI K9	700	700	DI K7	700
47	500	DI K9	500	500	DI K7	500
48	600	DI K9	600	600	DI K7	600
49	600	DI K9	600	700	DI K7	700
50	800	DI K9	800	800	DI K7	800
50A	800	DI K9	800	800	DI K7	800
51	600	DI K9	600	600	DI K7	600
52	700	DI K9	700	700	DI K7	700
53	600	DI K9	600	600	DI K7	600
54	600	DI K9	600	600	DI K7	600
55	700	DI K9	700	700	DI K7	700
56	700	DI K9	700	700	DI K7	700
57	600	DI K9	600	600	DI K7	600
58	700	DI K9	700	700	DI K7	700
59	700	DI K9	700	700	DI K7	700
60	700	DI K9	700	700	DI K7	700

- ***Laying of Clear water pumping main in WDC with SUGR***

  The scope of work includes laying of different diameter SWMS pipe & DI-K9 pipe from common manifold of clear water pumping station upto nearest road and making connection with distribution system. Details of inlet and outlet pipes are given below.

SUGR/WDC No	Inlet pipe dia	Material	Outlet pipe dia	Material	Remarks
18	600	DI K9	600	DI K7	
23	600	DI K9	600	DI K7	
24	600	DI K9	600	DI K7	

42	600	DI K9	600	DI K7	
43	600	DI K9	600	DI K7	
44	500	DI K9	500	DI K7	
45	600	DI K9	600	DI K7	
46	600	DI K9	500	DI K7	

i. Survey, Geo-technical Investigation, Detailed Engineering of the pipeline system based on the design principle provided by the Authority for civil structures (pipe diameter, pipe material, valves and specifications as provided in Schedule D). For SWMS pipes, recommended in-lining is 406-micron food grade fusion bonded Epoxy and out-coating is 3-layer polyethylene/polyolefin.

ii. Provide detailed plans, preparation of L section, Cross Sections etc., GFC's of pressurized potable pipeline system without deviating the design concept considered and provided in Schedule D. Agency shall also provide as-built drawing indicating all assets related to water supply in GIS format.

iii. Submission of plans, designs and engineering drawings for further approval of the authority.

iv. Construction of Water Supply Network as per approved design and drawings

v. Loading, Unloading, Transporting and handling of DI-K9 Ductile Iron pipes and laying of Ductile Iron Pipe and special.

vi. Supplying, fabricating, loading, unloading, transporting and handling of SWMS pipes, specials etc.,

vii. Loading, Unloading, Transporting and handling of PLB HDPE ducts and laying of ducts along with MS Pipes & DI-K9 pipeline and accessories for laying of OFC.

viii. Neoprene gaskets, tyton gaskets for maintaining proper alignment shall be supplied by the Agency.

ix. Lowering, placing and laying such pipe specials, valves etc., properly in trenches, jointing by proper neoprene gasket (Push on joint/ tyton joint etc.,), submerged arc welding to the MS pipes including de-rusting, scraping, brushing and applying heat shrink sleeves as per specification and hydraulic pressure testing.

x. Supplying of all labour, tools & tackles, plants, instruments, equipment, machinery, accessories as are needed to complete the job in the manner as specified to the entire satisfaction of the Engineer in Charge.

xi. Construction of supporting arrangements for pipes.

xii. Construction of thrust blocks.

xiii. Earth work in excavation in trenches

xiv. Pumping out sub-soil water and water from other sources accumulated in excavated trenches.

xv. Erection, Testing, Commissioning and O&M of the Potable Water System

xvi. Any other work related to laying of water supply pipe which is not mentioned above shall be executed by the Agency.

xvii. The Agency shall construct the water supply pipelines for the pressurized water supply system on continuous running basis, along with installation of scour valves, thrust blocks and Isolation valves etc. as required.

xviii. The Agency shall supply, install, test and commission of SCADA compatible electro-magnetic flow meters of same size of outlet pipeline at proper location inside WDC campus.

The Agency shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid. Size of all valve chambers shall be considered for electrically actuated valve & compatible to SCADA connectivity except scour and air release valves as per the valve data sheet and location provided in drawings.

- **Electrical Works**

A. <u>General:</u>

Agency shall design and supply all electrical equipment in accordance with the Specification, Data sheets and the enclosed Single Line Diagrams (SLD). The scope covers design, manufacture, supply, testing at Manufacturers works, packing and forwarding, delivery to site, inland transit insurance, unloading at site, handling and safe storage of materials at site, installation, testing and commissioning of Electrical system/Equipment for the pro-

posed works of Intake well cum raw water pumping station of 196MLD for Phase-I development and future provision of 196 MLD for Phase-2 development, considering the total capacity of the unit is 392 MLD. For the proposed works of WTP of 190 MLD for Phase-I development and future provision of 190MLD for Phase-2 development, considering the total capacity of the plant is 380 MLD.

B. Scope of work:

The scope of work for Intake and WTP is as follows:

i. Supply, Installation, testing and commissioning of the complete Electrical Distribution System inside the plant as per Specifications, Data Sheets & Single Line Diagram provided in Schedule D. Following electrical items shall be considered and provided by the Agency accordingly:

   a. 33KV supply from two sources
   b. 33KV Ring main unit
   c. 33kV Switchgear Panel
   d. 6.6KV switchgear panel
   e. 33/6.6kV Oil Filled Power Transformers (1W+1S).
   f. 6.6/0.415kV Dry type indoor Transformers for station auxiliaries
   g. 33/0.415KV CSS for WTP
   h. 6.6kV Neutral Earthing Resistors
   i. 6.6kV Pump Panels
   j. Main LT PCC Panel
   k. Pump Motors
   l. Pump MCC Panels
   m. Fresh air & Exhaust Panel
   n. AC Panel for cabin air condition
   o. Main Lighting & Power Panel DB
   p. Lighting Panel for Admin Building
   q. Variable Frequency Drive for Pumps (VFD)
   r. Capacitor and APFCR panel to maintain Power factor greater than 0.90
   s. UPS - 2 Nos with Battery Banks & Battery chargers
   t. DC Distribution Board

u. UPS DB - 1 & UPS DB - 2

The above-mentioned panels shall be SCADA compatible including all metering and protection devices.

ii. Design, supply, installation, testing and commissioning of complete electrical distribution system as per the designed load. Provide protection tripping matrices and tripping logics for SCADA during the design stage.

iii. Design, Supply, installation, testing and commissioning of the complete lighting system as per technical specification mentioned in Schedule D, approved data sheets and single line diagram including following items:

a. Indoor Lighting Fixtures with necessary accessories for Minimum Average Lux Level of 200Lux.
b. Outdoor lighting fixtures with poles, junction boxes & necessary accessories for Minimum Average Lux Level of 40Lux.
c. Conduiting.
d. Point Wiring.
e. Lighting Control switches.
f. Receptacle Units/Socket Outlets for Indoor & Outdoor installations.

iv. Design, Supply, installation, testing and commissioning of the complete HT & LT cabling system as per technical specification mentioned in Schedule D, approved data sheets & single line diagram including following items:

a. HT Power Cable & Termination kit
b. LT Power & Control cables & terminations with necessary glands & lugs.
c. Testing equipment's for checking the healthiness of cables.
d. Cable trays and conduits.

v. Design, Supply, installation, testing and commissioning of Earthing grid system in the proposed water-work sites like Intake well, WTP, WDCs, connection of earthing leads of equipment to main grid, Transformer neutral & body earthing etc. with necessary earthing pits, including necessary clamps, nuts, bolts, etc all including welding, bolting and associated civil works as per layout diagram, technical specification & data sheets provided in Schedule D.

vi. Design, Supply, installation, testing and commissioning of Plant Lightning Protection in the proposed water-work sites like Intake well, WTP, WDCs, connection of

Lightning Arrestor leads to main grid with necessary Earthing pits, including necessary clamps, nuts, bolts, etc all including welding, bolting and associated civil works as per approved layout diagram.

vii. All civil construction associated with the Electrical Works shall be in the Agency's scope of works as per Technical Specification mention in Schedule D.

viii. Scope of work also includes lesioning and getting approval of all Electrical installation works from the competent authority of the Govt. of Andhra Pradesh.

- **Boundary Wall & Security Cabins**

The Agency shall design, construct and maintain RCC framed 250 mm thick brick filled decorated boundary wall with ornamental gates made of MS angle, flat, square bar, sheet. Security cabins of floor space 10 sq.m shall be provided in all the water work sites like Intake well, WTP, WDC compounds.

The height of the boundary wall shall be 1.8 m above the finished ground level. Height of the MS gates shall be of 1.8 m. There shall be atleast two ornamental covered gates sufficient to provide access to heavy vehicular trucks in Intake well & WTP compound. There shall be at least one ornamental covered gates sufficient to provide access to heavy vehicular trucks in WDC compound. The gates shall preferably be made of MS bars, flats and plates welded together. The design of the entire work shall be submitted to the Engineer in charge for approval. The location of the gates shall be as instructed by the Engineer in charge. The Agency shall also provide plaster finish over both the sides of boundary wall and two coats of decorative weather coat exterior paint on the surface of the entire boundary wall.

- **Access Roads and internal roads**

The Agency shall design, make detailed engineering, construct and maintain approach roads of not less than 6 m wide and cross roads of 4 m wide made of cement concrete with minimum reinforcement over single brick flat soling over 400 mm thick sand filling. The approach road shall connect the gates and all the main units, such as, clear water pump house, annexe building, alum godown, chlorine electric storage room, chemical house, administrative building, staff quarters, bungalows, electric substations, etc. The cross roads shall connect the approach roads and the ancillary units. Access road to all WDCs shall be

of 6 m wide and internal road shall be of 4 m wide. All roads shall have raised kerb & channels with proper 1.2 m wide footpath. The approach road shall be designed for Class A loading as per IRC. The Agency shall submit layout and design of road network to the Engineer-in-Charge for approval. The technical specification for road development is given in Schedule D.

- **Storm Water Drains**

  The Agency shall design, make detailed engineering, construct and maintain storm water drains for disposal of rain water from the compound of all water work sites like Intake well, WTP & WDCs. The Agency shall also connect the internal drains with the city storm water drain outside the premises at suitable location. The storm frequency shall be one in five years. The Agency shall submit layout and design of storm water drainage network to the Engineer-in-Charge for approval. The technical specification for storm water drainage development is given in Schedule D.

- **Site Development and Landscaping**

  Wherever necessary, the agency shall develop all the sites by filling with locally available earth for installation of water supply infrastructure as per specification given in Schedule D. The agency shall also provide RCC retaining wall wherever the filling is more than 1.0 m. The agency may consider the retaining wall as a foundation of boundary wall. The Agency shall design, detailed engineering, provide, maintain gardening/beautification & landscaping in the entire campus area of Intake well, WTP, over the roof of SUGRs & WDCs. Agency shall also develop all the sites as per the EGL & FGL given in Schedule D

  The Agency shall design, make detailed engineering and construct appropriate irrigation system (combination of sprinkler and drip irrigation) for the entire landscaping/gardening area. The Agency shall submit layout and design of landscaping to the Engineer-in-Charge for approval. The technical specification for landscaping the area development is given in Schedule D.

- **Integration of entire water supply scheme of Amaravati capital city**

  The agency shall design, supply, installation of all control valves, electromagnetic flow meters, air valves, sluice valves, butterfly valves, pressure transmitters, RMS, BMS at

strategic locations, OFC etc. required for integration of entire water supply system of Amaravati capital city. The agency shall undertake all necessary works for integration of entire water supply system.

- **Testing, commissioning and performance of water supply system**

  The scope of work includes testing of all electro-mechanical equipment like pumps & motors, panels, transformers, UPS, SCADA as per the detailed specification given in Schedule D. Arranging water, power, tools & tackles and other consumables is under the Agency scope.

  The scope of works also includes commissioning all electro-mechanical equipment, demonstrate and provide the performance data as per the approved QAP and data sheet.

- **Operation & Maintenance (O&M)**

  The scope of work includes testing, commissioning, trial run of 3 months, DLP for 2 years and O&M for 8 years period.

  After the water supply system is deemed to be ready and to be put into normal use, the Agency shall provide commissioning procedure document, O&M manual and accordingly they shall operate and maintain the system for a period of three months trial run, thereafter 2 years of DLP and thereafter 8 years of O&M by engaging his own personnel under the overall supervision of the Agency. The agency shall provide biometric attendance system for all staff at all installations i.e. Intake well cum pump house, WTP, WDCs, Admin building, Clear water pump house created under this scope of work. The specification for biometric system has provided in Schedule D. Biometric system will be connected with SCADA for attendance report generation. All consumables, tools and tackles, spares and all other necessary stores required for the operation of the water supply system shall be supplied by the Agency at his cost. The Employer shall bear the cost of electrical charges to the extent it is required. During the aforesaid period of operation of the water supply system, the Agency's supervisory staffs shall train and instruct technicians and other staffs to be deputed by the Employer about the correct method of operation and maintenance of the water supply system as a whole and its various mechanical and electrical components. The training shall be such as would enable the Employer's staffs to take over the water

supply system from the Agency for its operation and maintenance independently. The Agency's training personnel shall give special attention to this.

During the period of operation and maintenance, the Agency shall arrange to take regular samples as given here above/as directed by the Engineer-in-Charge and shall have such samples tested at Agency's cost in the WTP laboratory or any other laboratory nominated by the Engineer-in-Charge, to determine the quality of the samples and the performance of the water supply system. Such tests shall be continued upto the penultimate week prior to the end of the O&M period and the water supply system shall be taken over by the Employer subject to the final performance tests being certified as satisfactory by the Engineer-in-Charge. O&M includes carrying necessary repairs of all equipment and machineries to meet the original specifications, replacement of any component, required for smooth running of the system etc. including breakdown maintenance, preventive maintenance, predictive maintenance and conditional monitoring. Supply of minimum inventory spare is under this scope of work. The detailed specifications of O&M are given in Schedule D.

The tenderers shall submit with their offer a list of technical and non-technical staffs they propose to engage for operation and maintenances of the water supply system for ten years including two years of DLP.

- **Handing over of water supply system of Amaravati Capital City**

The agency shall handover the entire water supply system in good working condition after completion of 10 years O&M period including 2 years DLP to the authority. All electro-mechanical equipment shall be in good working condition at the time of handing over to the authority. All laboratory instruments shall function properly at the time of handover. Control Command Centre (C3), Instrumentation & SCADA of entire system shall be functionally fully automated condition without any fault while handing over to the authority. There shall be no sign of leakages in the entire pipeline and water retaining structures of the water supply system. The agency shall maintain and handover minimum spares and consumables (Alum, PAC, chlorine, oil & lubricants etc.) for 3 months usage. The agency shall maintain sufficient quantity of laboratory chemicals for 3 months usage at the time of handing over. The agency shall maintain stock register and handed over to EIC for physical verification. The condition monitoring of major electromechanical

equipment like pumps and motors, blowers, compressor, VFD, MCC panels etc. has to be done by the agency and vetted by the 3rd party before handing over to the authority for submission to the EIC. All instruments with valid calibration certificate has to be submitted at the time of hand over. There shall not be any sign of splashing of concrete, worn out of plaster and/or damage to any civil structures while handing over. The Engineer-in-Charge shall inspect all electro-mechanical, instrumentation as well as civil installations and verify stock registers for his satisfaction prior to taking over the water supply system from the agency. Decision of EIC regarding non-functionality of any electromechanical, instrumentation and civil installations is final and binding by the agency.

Appendix B-III(b) – Pipeline Network
Potable Water Supply Network

General

Water supply system is planned for the Amaravati capital city on continuous water supply (24x7) to meet the water demand of the projected population and other civic services by the year 2050. For the greenfield city, projected population of 38,33,120 is arrived based on the proposed Land Use Plan and Floor Space Index (FSI) method. Water demand of 931 MLD by the horizon year 2050 is estimated by adopting unit norms of water supply for various service categories, recommended by CPHEEO. Source of water supply is Krishna river near Undavalli for Phase-I and Proposed Vaikuntapuram barrage for Phase-II.

Scope of Work

As part of the proposed water supply scheme for Amaravati capital city, the following works are needed to be executed in this project.

The scope of work includes construction of water supply pipe lines with appurtenances and civil works required along the Roads. In general, this work shall include supply, lowering, laying, jointing and testing of all MS, DI (K7 and K9) pipes, specials, appurtenances, PLB HDPE duct and civil structures required for the water supply network along the roads.

The Scope of Work shall include:

- Survey, Geo-technical Investigation, Detailed Engineering of the pipe line system based on the design principle provided by the authority for civil structures (the pipe diameter, pipe material, valves and specifications is provided below)
- Provide Detailed plans, Preparation of L section, Cross Sections etc., GFC's of pressurized potable system without deviating the design concept considered and details given below. Contractor shall also provide as built drawing indicating all assets related to water supply in GIS format.
- Submission of plans, designs and engineering drawings for further approval of the authority.
- Construction of Water Supply Network as per approved design and drawings
    - Loading, Unloading, Transporting and handling of Ductile Iron pipes and laying of Ductile Iron Pipe and special.

- Supplying, fabricating, loading, unloading, transporting and handling of Mild Steel pipes, specials etc.,
- Loading, Unloading, Transporting and handling of PLB HDPE ducts and laying of ducts along with MS & DI K9 Pipes and accessories for laying of OFC.
- Tyton gaskets, DI specials required for maintaining proper alignment shall be supplied by the contractor.
- Lowering, placing and laying such pipe specials, valves etc., properly in trenches, jointing by proper rubber gasket (Push on joint/ tyton joint etc.,), submerged arc welding to the MS pipes including derusting, scraping, brushing and applying heat shrink sleeves as per specification and hydraulic pressure testing.
- Installing the pipe at RCC box section/Utility duct in bridges. Design and detailed engineering of saddle for pipe support at RCC box section in bridges shall be submitted for EIC approval before proceeding to work.
- Supplying of all labour, tools & tacklets, plants, instruments, equipment, machinery, accessories as are needed to complete the job in the manner as specified to the entire satisfaction of the Engineer-In-Charge.
- Construction of supporting arrangements for pipes.
- Construction of thrust blocks.
- Earth work in excavation in trenches
- Pumping out sub-soil water and water from other sources accumulated in excavated trenches.
- Erection, Testing, Commissioning of the Potable Water System
- Any other work related to laying of water supply pipe which is not mentioned above has to be executed by the contractor.

The contractor shall construct the water supply pipelines for the pressurized water supply system on continuous running basis, along with installation of scour valves, thrust blocks and construction of valve chambers for TCMS (Tapping control management system) and Isolation valves etc. as required.

The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this

bid. Size of all valve chambers shall be considered for electrically actuated valve & compatible to SCADA connectivity except scour and air release valves as per the valve data sheet and location provided in drawings.

1.0 Details of Pipe lines in E3 Road

This contract package includes providing, laying, jointing, testing and commissioning of water supply pipe lines of various diameters as provided in Table-1 for roads including appurtenances and construction of Valve chambers and allied works.

Table-1 Water Supply Network details in E3 Road

Road Nomenclature	Pipe Material	E3
Diameter of Pipe (mm)		Diameter wise Length (m)
2400	MS / 20mm	1125.0
2000	MS / 16mm	5974.0
1900	MS / 16mm	4742.0
800	DI K9	2814.0
600	DI K9	3032.0

2.0 Encasing at Road Crossings

Encasing is proposed for pipe lines under the carriage way of the road and storm water drains for E3 road. The details are provided in **Table-2** as well as in the drawings:

Table-2 Road wise Water Supply Pipes with Encasing details for Road

Road Nomenclature	Pipe Material	E3	Remarks
Diameter of Pipe (mm)		Diameter wise Length (m)	
2500	MS / 20mm	58.25	MS pipe encasing with HDD
1900	MS / 16mm	60	RCC encasing
1900	MS / 16mm	25 (Karakatta bund crossing)	MS pipe encasing with HDD
1500	MS / 14mm	58.25	MS pipe encasing with HDD
800	DI K9	58.25	MS pipe encasing with HDD
700	DI K9	58.25	MS pipe encasing with HDD
600	DI K9	58.25	RCC encasing

600	DI K9	58.25	MS pipe encasing with HDD
300	DI K9	58.25	MS pipe encasing with HDD
500	DI K7	60	MS pipe encasing with HDD
450	DI K7	60	MS pipe encasing with HDD
400	DI K7	60	MS pipe encasing with HDD

3.0 Pipe Material

The type of pipe shall be MS pipe above 1000mm and DI K9 / DI K7 class pipes for diameter upto 1000mm. The details of DI K7 & DI K9 locations are provided in Table-1. The type of pipe shall be MS, DI K9 for water supply trunk network and DI K7 for water supply distribution network.

4.0 Pipe Cover

The pipeline shall be buried with minimum cover of 1.20 m from Finished Road Level (FRL), however pipeline shall be laid as per detailed Engineering approved by Engineer In-charge. In case of required cover is more than 1.20 m at different locations, contractor has to lay the pipeline accordingly as directed by the Engineer in Charge.

No pipe shall be laid in position until the bedding/foundation has been approved by the Engineer in charge. If two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450mm.

5.0 Specials

MS Pipes: All Specials, such as tees, Y-pieces, bends (single or composite), tapers, etc. shall necessarily be fabricated at site from same pipe sections used in straight reach and shall be manufactured as per standards and tested and laid in the same manner as the pipes.

DI Pipes: All types of DI fittings shall be manufactured and tested in accordance with IS: 9523.

- flanged socket
- flanged spigot

- double socket bends (90^0, 45^0, 22.50^0, 11.25^0)
- double socket branch flanged tee
- all socket tee
- double socket taper
- blind flange/dummy flange

The road wise specials/fittings for **E3** road are given in Table-3.

Table-3 Road wise Specials/Fittings details for Road

DI Specials/Fittings	E3
DI Pipe Bends	Number
22.50º	
150	-
250	-
300	4
350	-
400	4
450	4
500	2
600	22
700	-
800	11
900	-
45º	
150	-
250	-
300	-
350	-
400	-
450	-
500	-
600	4
700	-
800	6
900	-
90º	
150	-
200	-
250	-
300	-
350	-
400	1
450	-
500	-
600	4

DI Specials/Fittings	E3
700	-
800	3
MS Bends	
22.50º	
1600	-
1900	27
2000	24
2500	2
45º	
2500	-
90º	
2400	1
DI Tees	
200 x 200 x 200	-
300 X 300 X 300	-
350 X 350 X 350	-
400 X 400X 400	-
500 x 500 x 500	-
600 x 600 x 600	-
800 x 800 x 600	-
800 x 800 x 800	1
900 x 900 x 900	-
DI Reducers	
200x150	-
250x200	-
450x150	-
450x250	-
450x350	-
450x400	-
300x200	-
350x150	-
350x200	-
350x300	-
400x200	-
400x300	-
500x150	-
500x250	-
500x300	-
500x350	-
500x450	-
600x300	-
600x350	-
600X400	-
600x450	-
600x500	-
800x600	1

DI Specials/Fittings	E3
800x700	1
900x700	-
MS Tees	
2400x2400x1900	-
MS Tapers	
2400x1900	-

Note: Specials to be considered as per requirement based on the design subjective to the minimum numbers defined above.

6.0 Permanent lubricant based HDPE Duct (PLB)

For laying of the fibre optic cable, 1 No. of PLB HDPE Ducts of 40 mm (OD) / 33 mm size all along the length of MS & DI K9 pipe line with required accessories with appropriate spacing approved by Engineer-in-Charge.

7.0 Civil Structures

Design and Construction of Thrust Blocks at bends and Valve Chambers to house isolation valves, scour valves and Tapping Control Management System as per the locations provided in the GAD. All the structures related to water supply pipe line i.e., valve chambers, thrust blocks are to be designed considering the ground water table at ground level with M25 grade concrete. The design and drawings shall be submitted to the Engineer-in-Charge for approval.

8.0 Cross Drainage Structures (If any as per the table below)

Water supply pipe lines crossing the canals/vagus are categorized into two types. Pipe lines of sizes 1000mm and below are to be in the utility ducts provision on the east side of the road bridge as shown in the drawings. Pipe lines of sizes above 1000mm diameter are to be provided with a separate pipe carrying bridge and as per the GA drawings. The material of water supply pipe line is MS in both utility ducts and pipe carrying bridges. PLB HDPE duct runs along with the MS Pipe in both utility ducts and pipe carrying bridges. The details of canal crossing are given in the table below:

S. No	Road Nomenclature	Canal	Road Chainage (m)	Length of Crossing (m)	Dia of Pipe (mm)	Type of Crossing

1	E3	Pala Vagu	3950	105.00	2000 mm	Pipe carrying Bridge
3		Canal	8740	42	1900 mm	Pipe carrying Bridge
4		Konda-veeti Vagu	18290	175.00	800 mm	Utility Duct provided in Road bridge

9.0 Backfilling

The space around the foundations in trenches or sites shall be cleared of all trash and loose debris. After laying of pipe lines on 150mm thick sand bedding, the pipe lines shall be covered with 300mm sand filling and the rest filled with approved earth (all clods being broken up to the finished G.L.) as per the instructions of the Engineer-in-charge.

10.0 As Built Drawings

The Contractor shall submit "As Built" drawings to the Engineer-in-charge; these Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Engineer-in-Charge. The completion drawings shall be grouped into two categories (i.e.) Plan and L-section to be submitted both in Auto cad and GIS format.

- Plan with scale 1:1000 (A1 Size) showing the roads along with other details such as property width, storm water drains, footpaths, location of electrical / telephone poles along with all the dimensions wherever possible shall be prepared. The type of road, footpath details etc., shall be further elaborated in terms of their dimensions and material used. Finally, exact alignment of water supply line and appurtenances, alignment shall be marked on the plan. Nomenclature of network shall be same as given in the network design drawing furnished to the Contractor during execution.
- L-Section & Cross Section: The L-Section should show the water supply profile, bends and appurtenances ie., Air valve, Scour valve, Isolation valve details (X, Y, Z Coordinates), PLB HDPE duct profile. Cross Section of the pipe line shall be provided at an interval of 500m and also at junctions. The other details such as ground level, pipe invert level, pipe cover, pipe material, diameter, hydraulic gradient line (as per data provided by authority), chainages, etc. shall be shown in the L-section.

The scale for L-section shall be decided as per the directions of Engineer-in-Charge. Also, plan of the water supply line with roads of concerned length and other important feature should be shown above the L-section profile along with all utility services encountered during execution.

- **Pressure testing**

  After laying/installation of the pipe, pipe network need to be tested as per the specifications given in Schedule-D. After successful completion of erection, testing and commissioning, entire pipe network to be hand over to main contractor of WTP system (Head Works)

Appendix B-III(c) – Valves & Integration of entire Water Supply System

Potable Water Supply Network

Scope of Work

As part of the proposed water supply scheme for Amaravati capital city, the following works are needed to be executed in this project.

The scope of work includes installation, testing and commissioning of required Valves and civil works required along the E3 Road and also Valves along the other Roads for entire Water Supply System. The scope of work also includes integration of entire water supply system starting from Intake well to WDCs of Amaravati capital city for smooth operation and maintenance of the entire system. It includes integration of Instrumentation & Control through SCADA for the entire water supply system. The agency shall also construct RCC valve chambers & RCC chambers for electromagnetic flow meters where ever necessary.

The agency shall provide QAP, Data Sheets and Detailed drawings for Engineer in charge approval. Supply, delivery and installation of valves properly in valve chambers already constructed and integrating the valves with SCADA as per approved design and drawings. The agency shall provide shop testing & in-situ testing of valves as per specification.

The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid. Size of all valve chambers shall be considering for electrically actuated valve & compatible to SCADA connectivity except scour and air release valves as per the valve data sheet and location provided in drawings.

Appurtenances

The minimum requirements for the provision of valves are given below. Prior to the procurement of valves, the agency shall obtain the Engineer in charge approval for the materials to be used as per specified MoC and types of Valves. General applicable Standards to be applied to the works under this Section shall be Indian Standards and British Standards or other approved International Standard.

Isolation Valves

In Water Supply Pipe lines, Isolation valves are provided as line valves or sectionalizing valves to divide the pipe line into suitable sections so that in the event of damage or defect in the pipe line or for providing new fixture etc.

In Isolation valves, Sluice valves and Butterfly valves are generally used. In this project, Sluice valves are provided where there is a requirement for control of flow upto 1200 mm dia and for isolation upto 600 mm dia. Butterfly valves are provided for isolation of pipelines above 600mm dia. All the valves are provided with SCADA compatible Electric Actuators and shall be controlled through SCADA. There shall also be provision for local operation of the valves.

Table-1 Isolation valve details in E3 Road

Road Nomenclature	Size of Valve (mm)	Type of Valve	Quantity
E3	600	Sluice Valve	2
	1900	Butterfly Valve	4
	2000	Butterfly Valve	4

Table-2 Isolation valve details in other Roads

Road Nomenclature	Size of Valve (mm)	Type of Valve	Quantity
N14	600	Sluice Valve	1
N9	1900	Butterfly Valve	5
E8	600	Sluice Valve	3
	500	Sluice Valve	1
	1900	Butterfly Valve	1
E10	1900	Butterfly Valve	1
	800	Butterfly Valve	1
	700	Sluice Valve	1
	600	Sluice Valve	1
E14	1500	Butterfly Valve	2
	600	Sluice Valve	1
E6	2000	Butterfly Valve	1
	700	Sluice Valve	1
	600	Sluice Valve	2

E12	600	Sluice Valve	2
E4	600	Sluice Valve	2
	1900	Butterfly Valve	1
	2400	Butterfly Valve	1
E15	700	Sluice Valve	1
	800	Butterfly Valve	1
	1100	Butterfly Valve	1
E9	500	Sluice Valve	1
	800	Butterfly Valve	1
	1600	Butterfly Valve	3
N10	600	Sluice Valve	1
N15	1800	Butterfly Valve	1
	2000	Butterfly Valve	2
N6	700	Sluice Valve	1
	1900	Butterfly Valve	3

Air Valves

In pressure pipe lines, Air valves are used to protect the pipe line by filling air during draining, venting air during filling and Continues venting of entrapped air during operation. Details are given in table below:

Table-3 Air valve details in E3 Road

Size of Air Valve (mm)	Number of Valves
200	20
100	10

Table-4 Air valve details in other Roads

Road Nomenclature	Size of Valve (mm)	Quantity
N14	100	2
N9	200	17
N4	100	1
E8	100	9
	200	1
E10	100	5
	200	1
E14	200	5
	150	1

	100	3
E6	100	12
	150	1
E12	100	1
E4	100	4
	200	6
E15	100	1
	150	1
N1	100	5
N18	100	2
N2	200	1
E1	200	1
E9	100	7
	150	1
	200	11
N8	100	1
N15	200	14
E5	100	1
N6	100	2
	200	16

Scour Valves

In pressure pipe lines, scour valves are provided at low points above line valves situated in the line on a slope such that each section of the line between valves can be emptied into a natural or storm water drainage channel. Details are given in table below:

Table-4 Scour valve details in E3 Road

Size of Scour Valve (mm)	Number of Valves
600	1
500	4
200	1
150	1

Note: Valves to be considered as per requirement based on the design subjective to the minimum numbers defined above.

Control Valves

Control Valves at TCMS are provided at Tapping points on Ring main at specified locations mentioned and located in the drawing. These are provided with Electrically Actuated Sluice valve, Electromagnetic Flow meter and Pressure transmitter with SCADA connectivity. These are to be provided with Valve chambers.

Road Nomenclature	Control Valve (TCMS) Size (mm)	Quantity
E3	800	2
E10	900	1
E15	1100	1
	800	1
E14	1100	1
E6	800	1
E12	800	1
N7	800	1
N15	800	5
	900	1
E9	900	1
	1000	1

Electromagnetic Flow Meters

Electromagnetic flow meters are to be provided at all the locations of TCMS with electrically actuated Scada compatible sluice valve, all WDC locations near Reservoir management system for SUGRs and near Bypass management system at Cushion tank location. These are to be provided with necessary protection of valve chambers.

Integration of Entire Water Supply System

The agency has to integrate the entire water supply system from Intake well (source) to WDC integrating all components i.e., Headworks, Pipe lines in E3 road as well as pipelines constructed in other roads, appurtenances etc., to operate and maintain the entire water supply system for 2 years DDLP and 8 years ADLP.

Appendix-B IV

Recycled Water Supply Network

General

Reuse water supply system is planned for the Amaravati capital city on recycled reuse water supply to meet the water demand of the projected green spaces and District Cooling application by the year 2050, for the greenfield city. The entire capital city area is divided into 13 sewerage zones with 12 STP's and 1 CETP for industrial area. Source of reuse water supply is from the STP/CETP serving with in the respective sewerage zone through pumping with Reuse water supply pumping and reservoir system located within the STP of the respective zone. Reuse water supply network comprises of a Trunk network followed by distribution network running on either side of the entire road network under the green zone or multi-function zones further connected to drip irrigation laterals.

Scope of Work

As part of the proposed reuse water supply scheme for Amaravati capital city, the following works are needed to be executed in this project.

The scope of work includes construction of reuse water supply pipe lines with appurtenances and civil works required along the Roads. In general, this work shall include supply, lowering, laying, jointing and testing of all DI (K7) and HDPE (PE100 PN10) pipes, specials, appurtenances, and civil structures required for the reuse water supply network along the roads.

The Scope of Work shall include:

- Survey, Geo-technical Investigation, Detailed Engineering of the pipe line system based on the design principle provided by the authority for civil structures (the pipe diameter, pipe material, valves and specifications is provided in Tables-1, 2, 3, 4, 5 & 6 of this section.
- Provide Detailed plans, Preparation of L section, Cross Sections etc., GFC's of pressurized treated reuse water system without deviating the design concept considered and details given below need to be submitted for EIC approval before installation. Contractor shall also provide as built drawing indicating all assets related to reuse water supply in GIS format.

- Submission of plans, designs, and engineering drawings for further approval of the authority.
- Construction of Reuse Water Supply Network as per approved design and drawings
  - Loading, Unloading, Transporting and handling of Ductile Iron pipes and laying of Ductile Iron Pipe and special.
  - Supplying, fabricating, loading, unloading, transporting and handling of HPDE pipes, specials etc.,
  - Tyton gaskets, DI specials required for maintaining proper alignment shall be supplied by the contractor.
  - Lowering, placing and laying such pipe specials, valves and air valves etc., properly in trenches, jointing by proper rubber gasket (Push on joint/ tyton joint etc.,).
  - Supplying of all labor, tools & tacklets, plants, instruments, equipment, machinery, accessories as are needed to complete the job in the manner as specified to the entire satisfaction of the Engineer-In-Charge.
  - Construction of supporting arrangements for pipes.
  - Construction of thrust blocks.
  - Earth work in excavation in trenches
  - Pumping out sub-soil water and water from other sources accumulated in excavated trenches.
  - Erection, Testing, Commissioning of the Reuse Water System.
  - Any other work related to laying of reuse pipe which is not mentioned above has to be executed by the contractor.

The contractor shall construct the reuse water supply pipelines for the pressurized water supply system on continuous running basis, along with installation of scour valves, thrust blocks and construction of valve chambers air valves and Isolation valves etc. as per the Drawings.

The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., any and everything necessary for construction of the works, whether such items are specifically stated elsewhere in this bid. The valve shall be a butterfly valve manually operated and also be compatible for motorized

operation. Size of all valve chambers shall be considering for electrically actuated valve & compatible to hSCADA connectivity except scour and air release valves as per the valve data sheet and location provided in drawings.

1.0 Details of Pipe lines in E3 Road

This contract package includes providing, laying, jointing, testing and commissioning of reuse water supply pipe lines of various diameters as provided in Table-1 for **E3** road including appurtenances and construction of Valve chambers and allied works.

Table-1 Reuse Water Supply Network pipe details in E3 Road

Road Nomenclature	E3
DI-K7	**REUSE TRUNK NETWORK**
Diameter(mm)	**Dia. Wise Length in (m)**
TRUNK-150	0
TRUNK-200	0
TRUNK-250	69.072
TRUNK-300	0
TRUNK-350	0
TRUNK-400	421.077
TRUNK-450	996.437
TRUNK-500	1104.997
TRUNK-600	149.171
Sub-Total	**2740.754**

Road Nomenclature	E3
HDPE-PE100-PN10	**REUSE DISTRIBUTION NETWORK**
Diameter(mm)	**Dia. Wise Length in (m)**
DISTRIBUTION -50	13769.884
DISTRIBUTION-75	6828.52
Sub-Total	**20598.4**

Road Nomenclature	E3
DI-K7	**REUSE DISTRIBUTION NETWORK**
Diameter(mm)	**Dia. Wise Length in (m)**
DISTRIBUTION-100	3527.666

DISTRIBUTION-150	1294.647
DISTRIBUTION-200	599.605
DISTRIBUTION-250	0
DISTRIBUTION-300	0
DISTRIBUTION-350	0
DISTRIBUTION-400	0
Sub-Total	**5421.918**
Total Length in (m)	**28761.08**
Total Length in (km)	**28.76**

2.0 MS Encasing Pipe at Road Crossings

MS encasing pipe is proposed for pipe lines under the carriage way of the road and storm water drains. The details are provided in Table-2 as well as in the drawings.

Table-2 Reuse Water Supply Network MS Encasing Pipe details in E3 Road

Road Nomenclature	E3
Diameter(mm)	**MS Pipe ENCASING Length**
	Dia. Wise Length in (m)
TRUNK-150	0
TRUNK-200	0
TRUNK-250	0
TRUNK-300	0
TRUNK-350	0
TRUNK-400	105
TRUNK-450	0
TRUNK-500	0
TRUNK-600	35
DISTRIBUTION-50	140
DISTRIBUTION-75	35
DISTRIBUTION-100	210
DISTRIBUTION-150	70
DISTRIBUTION-200	140
DISTRIBUTION-250	0
DISTRIBUTION-300	0
DISTRIBUTION-350	0

Road Nomenclature	E3
DISTRIBUTION-400	0
Total Length in (m)	**735**
Total Length in (km)	**0.735**

3.0 Pipe Material

The type of pipe shall be DI K7 class pipes for 100mm & above and HDPE-PE100-PN10 class pipes for diameter below 100mm. The type of pipe shall be DI K7 for reuse water supply trunk network and DI K7/ HDPE-PE100-PN10 for reuse water supply distribution network. The details of DI K7 & HDPE pipes are provided in Table-1.

4.0 Pipe Cover

The pipeline shall be buried with minimum cover of 1.00 m at top, however pipeline shall be laid as per detailed Engineering approved by Engineer In-charge. In case of required cover is more than 1.00 m at different locations, contractor has to lay the pipe-line accordingly as directed by the Engineer in Charge.

No pipe shall be laid in position until the foundation has been approved by the Engineer in charge. If two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450mm.

5.0 Specials

DI Pipes: All types of DI fittings shall be manufactured and tested in accordance with IS: 9523.

- flanged socket
- flanged spigot
- double socket bends (90^0, 45^0, 22.50^0, 11.25^0)
- double socket branch flanged tee
- all socket tees
- double socket taper
- blind flange/dummy flange

HDPE Pipes: Laying and jointing of HDPE pipes and fittings by butt fusion welding as per IS:7634-Part-II/1975 as amended from time to time to the alignment and gradient and testing the pipe line to the required pressure.

The road wise specials/fittings for roads are given in Table-3.

Table-3 Reuse Water road wise Specials/fittings details for E3 Road

Road Nomenclature	E3
DI-PIPE	DI Pipe Bends 22.6
Diameter(mm)	Road wise numbers of units
100	0
150	0
200	0
250	0
300	0
350	0
400	0
450	0
500	0
600	0
Total	0
DI-PIPE	DI Pipe Bends 45
Diameter(mm)	Road wise numbers of units
50	4
100	0
200	0
300	0
450	4
500	4
Total	**12**
DI-PIPE	DI Pipe Bends 90
Diameter(mm)	Road wise numbers of units
50	1
100	1
200	0
300	0
400	0
450	0
500	1

600	0
Total	**3**
DI-PIPE	**DI Pipe TEEs**
Diameter(mm)	**Road wise numbers of units**
50X50X50	9
100X100X100	6
150X150X150	3
200X200X200	2
50X50X100	1
75X75X50	9
75X75X100	1
100X100X50	8
150X150X50	2
150X150X75	3
150X150X100	3
200X200X50	2
200X200X100	1
450X450X250	1
500X500X300	1
Total	**52**
DI-PIPE	**DI Pipe Reducers**
Diameter(mm)	**Road wise numbers of units**
75X50	6
100X50	6
100X75	3
150X50	2
150X100	2
200X50	1
200X100	2
450X400	1
500X450	1
Total	**24**

Note: Valves and specials to be considered as per requirement based on the design subjective to the minimum numbers defined above.

6.0 Appurtenances

The minimum requirements for the provision of valves are given below. Prior to the procurement of valves, the Contractor shall obtain the Engineer in charge's approval

for the materials to be used as per Specified MoC and types of Valves. General applicable Standards to be applied to the Works under this Section shall be Indian Standards and British Standards or other approved International Standard.

6.1 Scour Valves

In pressure pipe lines, scour valves are provided at low points above line valves situated in the line on a slope such that each section of the line between valves can be emptied into a natural or storm water drainage channel.

Scour valve arrangement of sizes 150mm to 600mm.

Table-4 Scour valve details in E3 Roads

Road Nomenclature	E3
DI-PIPE	**Scour Valves DI-Pipes**
Diameter(mm)	**Road wise numbers of units**
100	0
250	0
400	1
450	1
Total	**2**

6.2 Air valve

Air valves are considered on the pipeline at suitable location. Air valves is necessary for effective working of system as the chock air will leads to water hammer and less flow. Air valves of sizes 100mm to 250mm.

Table-5 Air valve details for E3 Road

Road Nomenclature	E3
DI-PIPE	**Air Valves DI-Pipes**
Diameter(mm)	**Road wise numbers of units**
200	0
300	0
400	1
450	1
Total	**2**

6.3 Butterfly Valve

Supply, Installation, and Commissioning of butterfly valves which should be able to control and isolate the flow as per demand to facilitate uniform distribution of reuse

water to serve the green spaces. The butterfly valve should be as per the specifications defined in schedule D.

Table-6 Butterfly valve details in E3 Road

Road Nomenclature	E3
DI	**RWMS-Numbers**
TRUNK-200	0
TRUNK-250	0
TRUNK-300	0
Sub-Total	**0**

7.0 Civil Structures

Design and Construction of Thrust Blocks at bends and Valve Chambers to house isolation valves, scour valves, air valves and butterfly valves as per the locations provided in the GAD with M25 grade concrete. The design and drawings shall be submitted to the Engineer-in-Charge for approval.

8.0 Backfilling

The space around the foundations in trenches or sites shall be cleared of all trash and loose debris. After laying of pipe lines on 150mm thick sand bedding, the pipe lines shall be covered with 300mm sand filling and the rest filled with approved earth (all clods being broken up to the finished G.L.) as per the instructions of the Engineer-in-charge.

9.0 As Built Drawings

The Contractor shall submit "As Built" drawings to the Engineer-in-charge; these Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Engineer-in-Charge. The completion drawings shall be grouped into two categories (i.e.) Plan and L-section to be submitted both in Auto cad and GIS format.

- Plan with scale 1:1000 (A1 Size) showing the roads along with other details such as property width, storm water drains, footpaths, location of electrical / telephone poles along with all the dimensions wherever possible shall be prepared. The type of road, footpath details etc., shall be further elaborated in terms of their dimensions and material used. Finally, exact alignment of water supply line and appurtenances,

alignment shall be marked on the plan. Nomenclature of network shall be same as given in the network design drawing furnished to the Contractor during execution.

- L-Section & Cross Section: The L-Section should show the water supply profile, bends and appurtenances i.e., Air valve, Scour valve, Isolation valve details (X, Y, Z Coordinates), PLB HDPE duct profile. Cross Section of the pipe line shall be provided at an interval of 500m and also at junctions. The other details such as ground level, pipe invert level, pipe cover, pipe material, diameter, hydraulic gradient line (as per data provided by authority), chainages, etc. shall be shown in the L-section. The scale for L-section shall be decided as per the directions of Engineer-in-Charge. Also, plan of the water supply line with roads of concerned length and other important feature should be shown above the L-section profile along with all utility services encountered during execution.

Appendix- B V

Domestic Sewerage Collection Network

1. General

Waste water system for Amaravati capital city will cover entire 217.23 sq.km area with 100% collection, conveyance and safe disposal. Waste water generation of 600 MLD by the horizon year 2050 is estimated by adopting unit norms of waste water for various service categories, recommended by CPHEEO. Decentralized sewerage system is proposed in tune with topography, land use and development plans, accordingly ,12 STPS and 1 CETP proposed for Amaravati Capital city area. Treated wastewater shall discharged (after recycle & reuse) into navigational canals after meeting discharge standards.

Scope of Work

The scope of work includes, but not limited to, providing sewerage collection system including Gravity network pipe lines and Manholes required in Package Road. In general, this work shall include supply, lowering, laying, jointing and testing of all DWC-HDPE, , Inner HAC lined DI K7 & K9 pipes with outer polyethylene sleeves, Inner HAC lined RCC NP4 pipes for gravity network and HAC lined DI K9 pipes for pumping mains and Precast RCC manholes required for the sewerage collection network in the road. The work should be executed as per the details given in the drawing and the detailed scope of works includes:

- Survey, Geo-technical Investigation, Detailed Engineering of the pipe line system based on the design principle provided by the authority for civil structures (the pipe diameter, pipe material and specifications is provided below)
- Provide Detailed plans, Preparation of L section, Cross Sections etc., GFC's of wastewater pipe network without deviating the details given below. Contractor shall also provide as built drawing indicating all assets related to waste water in GIS format.
- Submission of Network plans, structural designs & engineering drawings of manholes for further approval of the authority.

2. Design Period

Sewerage projects are designed to meet the future requirement of a stipulated design period. The design period considered for Sewer Network system is 30 years.

3. Details of Sewerage Network in Package-XV Road

This contract package includes providing, laying, jointing, testing and commissioning of Sewerage collection pipe lines of various diameters in the above-mentioned roads as per the details furnished in the Table-1.

Table-1 Sewerage Collection Network details

Road Nomenclature	E3
DWC HDPE	**Dia. Wise Length in (m)**
200	2074
250	0
300	430
400	65
490	0
Sub-Total	**2569**

Road Nomenclature	E3
DI K7 & K9	**Dia. Wise Length in (m)**
600	0
700	611
800	0
900	149
1000	0
1100	20
1200	1922
Sub-Total	**2702**

Road Nomenclature	E3
RCC NP4	**Dia. Wise Length in (m)**
1400	0
1600	1298
1800	3106
Sub-Total	**4404**
Total Length in (m)	**9675.0**
Total Length in (km)	**9.675**

** Length means effective network length excluding manholes*

4. Details of Sewer Manholes in Package-XV roads

The Manholes shall be RCC construction with Sulphate Resistant Cement with M-30 Grade Concrete. The Manholes may be Precast or Cast in-situ as per design and detailing submitted by the contractor and subsequent approval by the Engineer In-Charge. The Manhole shall be plastered internally with SRC mortar (1:3) and neat cement finish over the same. Manholes shall be provided with CI rung ladder with epoxy painting having diameter 16mm at a spacing of 300mm. Providing drop connections wherever mentioned in drawing. Providing and fixing SFRC manhole frames and covers over manholes as per the Table-4 given below. Construction of Manholes includes all civil works, like excavation, dewatering, backfilling, RCC works etc. The Manhole details are furnished in Table 3. Datasheet for manholes is provided in Schedule D.

Table-2 Sewerage Manhole details(Tentative)

Road Nomenclature	E3
Type of Manhole	**Road wise Manholes**
Type-A	12
Type-B	11
Type-C	75
Type-D	5
Type-E	77
Total No. Manholes	**180**

5. Pipe Material

The type of pipe shall be DWC HDPE up to 490mm diameter and Inner HAC lined DI K7 & K9 pipes with outer polyethylene sleeves up to 1200mm diameter for gravity network and HAC lined RCC NP4 pipes for diameters above 1200mm. Inner HAC lined DI K9 for pumping mains. The total length of Sewerage collection network is around 9.961 km.

6. Bedding

6.1 Bedding for RCC pipes

For RCC (NP4 class) pipes bedding shall be of plain cement concrete of grade M-10. Contractor shall provide bedding design as per CPHEEO Manual considering Superimposed loads (concentrated and distributed), back fill load and Uplift pressure for approval.

6.2 Bedding for HDPE DWC pipes

As per IS 7634 (Part 2): 2012 clause no. 6.2, Polyethylene pipe requires no special bed preparation for laying the pipe underground, except that there shall be no sharp objects around the pipe. However, while lying in rocky areas suitable sand bedding should be provided around the pipe and compacted. Be noted that all the HDPE DWC pipes shall be provided with minimum 200mm of uniform river natural graded sand bedding free from any foreign /sharp etc. material to avoid the damage of the outer surface of the HDPE DWC pipes.

No pipe shall be laid in position until the bedding/foundation has been approved by the Engineer in charge. If two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450mm.

7. Manhole size, depth, and type

The channels in manholes at junctions and bends shall be smooth with gradual transitions to avoid turbulence and deposition of solids. Manholes will be constructed directly over the line of the sewer. They are circular, rectangular or square in shape. Manholes should be of such size that will allow necessary cleaning and inspection. As per IS-4111: 1986 “Circular type manholes are much stronger than rectangular and arch type manholes and thus these are favored over rectangular as well as arch type manholes”. Therefore, circular manholes are provided on all sewer lines for all depths starting from 1.2m. Diameter of manhole varies with change in depth of manhole & internal diameter of Sewer. Manholes are provided as per the space requirements given in the CPHEEO Manual, 2013 and at necessary locations like change in alignment, bends and junctions.

Table-3 Manhole Sizing

Type of Manhole	Internal Diameter of Manhole (mm)	Depth Range (m to m)
Type-A	900	0.9 to 1.65
Type-B	1200	1.65 to 2.29
Type-C	1500	2.29 to 5
Type-D	1800	5 to 8
Type-E	2400	5 to 8

8. Cover Frame

- As per IS-4111: 1986, the size of manhole covers should be such that there should be clear opening of not less than 560 mm diameter for all manholes.
- Manhole cover and frame with SFRC (Steel Fiber Reinforced Concrete) conforming to the IS 12592 as per the Table 4.

Table -4 Manhole cover details as per IS 12592

Manhole Type	Load withstanding capacity	Suitable Locations
M.D (Medium Duty)	10.00 MT	Footpaths, cycle tracks, Two wheelers & Light four wheelers
H.D (Heavy Duty)	20.00 MT	Heavy vehicles
E.H.D (Extra Heavy	35.00 MT	Heavy traffic roads

9. Pipe Cover

The pipeline shall be provided with minimum cover depth of 1.0 m as per the details furnished in the drawing. The pipe shall not be laid in position, until the foundations are approved by the Engineer In-charge.

Appendix-B VI

Power Conduits and Concrete duct for power cables

1.1 General

Power Supply in the proposed capital city Amaravati is to make quality and reliable power available for 24/7 supply with Smart Grid & Smart Metering with energy efficient transmission and automation in distribution. The power supply system will be underground cables which will not be vulnerable to surges from lightning, earthquakes, wind storms, cyclones and have the system be able to 'heal' itself when outages occur, isolating problem areas .and minimum electrical losses to improve overall efficiency.

1.2 Scope of Work:

As part of the proposed power supply system in Amaravati capital city, following works shall be executed in this project.

i. Design, Detail Engineering, Supply, lowering, laying, jointing and testing of HDPE pipe conduits and RCC manholes required for 33kV Power cables along and across the roads.

ii. Design, Detail engineering and Construction of 220KV RCC ducts and junctions with shafts/openings for cable access, emergency exits and MEP services.

iii. RCC Ducts and junction including shafts/openings shall be RCC M30 grade (Sulphate Resistant Cement Concrete) and Manhole chambers for Pipe Conduits shall be RCC M25 grade.

iv. RCC NP4 encasing pipes shall be given for 33kv pipe conduits with spacer arrangement for road crossing as indicated in drawings.

v. RCC Ducts should have MS plates inserts with min 10mm thickness as per the IS 2062 embedded in the structure where ever necessary for 220/33KV cable tray supports, MEP services and hooks/rollers (cable installation) as indicated in the drawings.

vi. Wherever slopes of more than 15 degrees are provided in RCC Ducts, steps shall be provided in access way for movement of maintenance personal.

vii. Construction of Exhaust shafts in RCC Duct at 500m intervals should have provision for future installation of ventilation equipment such as exhaust fans, sound attenuator, dampers, louvers, filters, bird screens etc., as shown in drawings.

viii. Construction of Fresh air/cable access shafts in RCC Duct at 500m intervals should have fresh air louvers, precast RCC cover and MS plates inserts embedded in shaft for rollers as shown in drawings.

ix. Construction of Control room for MEP services with controlled access from road including steps from road level and with access into the RCC duct as per the drawings.

x. All pipes entering/exiting the RCC duct should have puddle flange embedded in RCC Duct.

xi. Pipe Conduits shall be laid in groups with uniform spacing arrangement with spacers (made of ABS) to sustain the loads.

xii. Manhole chambers for Pipe conduits should have sufficient space inside for cable laying, bending (20D) and jointing as well as for future maintenance as given in drawing.

xiii. Procurement and laying of RCC ducts and HDPE inner ribbed layer of solid permanent lubricant (PLB) i.e. Silicore pipe conduits as defined in schedule-D.

xiv. The size, length and numbers for pipe conduits and the size and length for RCC ducts are provided in table-1 & 2 respectively. Accordingly, contractor shall furnish the structural design and GFC drawing based on IS 3370 & IS 456 after conducting geotechnical investigation and construct based on relevant IS standards conforming to water tightness for electrical RCC ducts & Pipe Ducts including manholes.

xv. 3D modelling & Clash Analysis shall be done using a standard software by the contractor considering the sequence of the utility crossings like storm water, water supply, sewer, ICT etc.

xvi. Contractor shall connect his work with the other adjacent contractor's electrical RCC duct/Pipe Conduit based on the details provided by the Authority.

xvii. Contractor shall design proper ventilation system for RCC duct by taking inputs from the Authority and making provisions/openings for MEP provisions.

xviii. Contractor shall design the drainage & dewatering facilities in the RCC duct along with the sump at each junction or the lowest point with 2 No's submersible pumps each with a capacity of 10 lps flow with 20m head necessary pumping systems to the nearby storm water drains with puddle flange embedded in RCC Duct. Detailed design of dewatering system shall be submitted for authority engineer's approval.

xix. Contractor shall provide reinforced HDPE grating arrangement for drain channels and dewatering sumps.

xx. Contractor shall submit data sheet, QAP of pump, and layout showing connectivity to the nearby storm water drain for EIC approval before proceeding for procurement.

xxi. Power cable laying, MEP works will be done by a separate contractor and is not part of this contract except for lighting arrangement inside RCC Duct.

xxii. Any other works required for the above but not mentioned elsewhere.

In addition to the standards provided in the schedule-D, Contractor shall also observe the latest editions of the following standards, specification or requirements. In case of any conflict, technical advice from EIC shall be obtained.

Power conduit sizes:

In table-1, 2 & 3, Road wise power conduit sizes and length for roads are provided.

Table-1 Number of Conduit Details in E3 Road

225mm HDPE Duct Configuration (mm)	Length (m)
2-Conduits	909.108
3-Conduits	2242.676
4-Conduits	1771.7
6-Conduits	3054.602
8-Conduits	2192.127
10-Conduits	433.539
12-Conduits	429.588
14-Conduits	135.845
16-Conduits	869.039
18-Conduits	41.111
20-Conduits	213.092
22-Conduits	84.539
23-Conduits	553.772
29-Conduits	283.922
31-Conduits	41.975
Total	**13256.6**

Table-2 MS Encasing Pipe with HDD method in E3 Road

Encasing Pipe Dia (mm)	Pipe Encasing Length (m)
800	540
1200	162
1600	270
Total Length (m)	**972**

Table-3 Manhole Details for E3 Road

Road no.	Manhole Locations	Chainage	Type of Manhole	Position X	Position Y
E3	Side of the road	150	2.5 x 2.5	440001.564	1829309.574
		449		440304.160	1829311.167
		1305		441176.745	1829317.075
		3478		443347.276	1829318.418
		3580		443450.238	1829311.244
		3930		443797.697	1829307.753
		4350		444238.253	1829308.440
		4560		444429.923	1829307.753
		5005		444876.658	1829310.002
		5372		445234.504	1829310.113
		5596		445461.569	1829309.815
		5715		445584.373	1829309.570
		5865		445735.274	1829310.254
		8445		448068.870	1828381.166
		9682		449209.445	1827806.812
		11858		451142.379	1826807.414
		12125		451382.811	1826690.398
		12370		451585.789	1826574.144
		12560		451776.533	1826477.719
		4140	3.0 x 3.0	444010.526	1829318.419
		4276		444115.440	1829307.600
		6848		446690.942	1829100.517
		7621		447404.391	1828717.707
		9017		448599.404	1828108.851
		10660		450075.294	1827350.053
		10965		450359.833	1827215.880
		11953		451224.759	1826759.596
		6472	4.5 x 4.0	446339.373	1829257.680
		10073		449546.475	1827623.299
	Junctions	E3 x N9	4.5 x 4.0	448855.576	1828020.364
				448815.906	1828003.097
				448900.895	1827958.364
				448806.246	1827931.363
				448797.175	1827964.830
				448891.549	1827995.324
		E3 X N16		440753.126	1829352.832
		E3 X N7		450891.143	1826970.950
		E3 X N14		442853.572	1829340.981
		E3 X N10		447799.990	1828554.711

E3	Junctions	E3 X N10		447813.042	1828514.706
		E3 x N15	3.0 x 3.0	442003.510	1829344.113
				442028.999	1829314.574
		E3 x N8		449838.140	1827484.903
				449824.791	1827524.027
		E3 X N11	2.5 x 2.5	446101.180	1829313.582
		E3 X N11		446098.852	1829261.608
		E3 X N10		447769.932	1828575.956
		E3 X N10		447729.379	1828567.093
		E3 X N12		445027.326	1829348.043
		E3 X N12		444953.879	1829317.201
		E3 X N11		446072.698	1829235.734
		E3 X N12		445053.606	1829318.180
		E3 X N8		449787.441	1827540.206
		E3 X N16		440786.737	1829311.783
		E3 X N6		451947.578	1826389.744
		E3 X N16		440684.489	1829316.519
		E3 X N16		440715.548	1829349.807
		E3 X N7		450905.617	1826936.190
		E3 X N8		449746.617	1827527.693
		E3 X N7		450814.754	1826979.725
		E3 X N7		450856.713	1826994.958
		E3 X N14		442813.522	1829346.308
		E3 X N14		442889.301	1829313.536
		E3 X N12		444982.156	1829348.043
		E3 X N14		442783.495	1829316.718
		E3 X N15		441933.160	1829316.990
		E3 X N15		441962.366	1829346.990
		E3 X N14		442886.816	1829266.615
		E3 X N14		442851.203	1829230.778

Construction Requirement for Ventilation system & Access staircase

Provision of ventilation shaft & Access staircase is shown in drawings. Contractor shall provide detailed construction drawing & design for approval by EIC and construct ventilation system and access staircase as per the location road-wise.

Lighting Arrangement

Contractor shall design the lighting system for the entire RCC duct considering 20 Lux. Contractor shall submit data sheet, QAP of lighting fixtures, schematic and SLD of lighting circuit including control panel for EIC approval before proceeding for procurement and

constructions. All lighting designs, drawings and proposed materials/equipment shall be submitted to Engineer-in-Charge for approval before installation. The Engineer-in-Charge will not take over any completed lighting arrangements without prior approval.

Appendix B VII

ILLUMINATION SYSTEM

1.0 Design

The public lighting installations shall be designed to appropriate lighting levels in an energy efficient and environmental-friendly manner. In this Document, there are requirements on lighting level, uniformity etc. for different types of roads and highway structures. Lighting designers shall prepare the lighting scheme strictly according to the specified limits or values in this document for approval by the EIC.

Illumination system shall be designed as per the design parameters defined in CEI129, Indian standards and state electricity rules. The required LUX levels as per areas are defined in the table 1.0 below.

Scope of work:

- Design of the street lighting system as per the lux levels provided in the Table1.0 below and as per lighting arrangement given in the drawing.
- Fabrication, supply, erection & Commissioning of smart poles, ordinary poles and post top lanterns including all civil works.
- Supply, installation & Commissioning of luminary system along with smart controlling provisions along with street light central management software for monitoring and controlling of lights with all necessary accessories.
- Supply, erection along with installation and commissioning of Distribution boards used for incoming power supply and distribution to the poles with all necessary accessories like cables, fuses, MCB's, bus bars, etc.
- Incoming power source cables shall be routed underground from the nearest source available or as per the instruction given by EIC. Procurement, laying of the HDPE conduits along with necessary cables for incoming power supply source where ever required.
- Supply, excavation, laying, crimping & termination of the cables within the ducts with all necessary accessories for the above said lighting system.
- The bidder must also provide a detailed operation and maintenance manual specific to the installed systems.
- Supply and installation of control equipment's required for the system.

- Training to the user for operation and maintenance of the system after 2 years.
- Civil work for all the above mentioned works shall be done.

Any additional works not covered above, but necessary for the functioning of the system and required as per specification incorporated. The works of minor nature, which are not mentioned, shall be incorporated by the bidder.

Any other work required for complete illumination of Arterial/Sub-arterial roads along with footpath and cycle track but not mentioned elsewhere.

Road and Open Area Lighting

It is proposed that roads and street shall be illuminated by using Smart Lighting Poles/High Masts. Each Lighting pole shall be supplied with LED based luminaries to Be connected and monitored by Streetlight Central Management Software, Collect and forward streetlight information, including power, voltage, current, power factor, alarms, and metering etc. The Smart pole shall have inbuilt junction boxes (for looping with other poles). However, other open areas like park/Green belts shall be illuminated by fancy Post Tops with LED.

Luminaire System Requirements:

Luminaires Street Light/ Post top should be a Class I luminaire with good Impact Resistance IK 08 necessary to resist Vandalism, System Efficacy: ≥ 110 lm/W, CCT to be 4000K for natural and eco-friendly lighting, P.F > 0.95, Driver Efficiency >85%, The Upper light output Ratio (ULOR) should be 0%* to avoid glare and light pollution, should have inbuilt NEMA Socket for supporting Lighting Management System. Must have internal 6KV and external surge protection 10/10KV (in both CM and DM modes), Ingress Protection: IP66 tightness for both Optical and Control Gear, Dimmable Driver.

Smart Pole Details:

Smart Pole with Smart City Management Cloud having Smart Street light controller (having IPV6 addressing, NEMA compliance with Advance encryption standard, Secure hash algorithm) be connected and monitored by Street Light Central Management Software and shall have following smart features like Having Laser PM environmental Sensor, RF Wi-Fi (Supporting dual band concurrent 802.11ac(5.8GHz), WLAN RF Capacity upto 1200 Mbps, Ethernet port(10/100/1000 Base-T 802.3, 802.3 u, 802.3 at/af POE input), provide wireless intrusion detection and endpoint GPS location services, Crowd Camera with 30 X optical zoom, 16 X digital zoom(support H.265 coding, Ultra-low streaming transmission, Horizontally rotate 360

degrees, continuous monitoring rotating to 180 degree, no blind spot, Support facial detection-single view/ multiple view and full view settings, support standard protocols(Onvif, CGI, GB/T28181), with LED panel for Advertisement (Max. brightness>= 5500 cd/m2, Max visible angle 150 degree, Display Color: 16.7M, Video input: Cable, USG, LED Lifetime:100000 hrs, Continuous working hours>72 hrs, IP65, Synchronized cycle play up to 1000 panels for word messages), Public service platform(IP55, Resolution: 1920*1080, Visible angle:178 degree Hor/Ver, Max Power:330W, Temperature Control, Android System, Touch Screen and Internet browsing), SOS Button(GB/T15279-94 Standard, IP65, Pulse dialling, M-B Ratio: 1.6+-0.2:1:0, Embedded sim card, Pre-set SOS service, allow real time video call and GPS location, SOS message to Smart City Management Platform), Street light+ EV charger(Charging Stations can charge vehicles display charging mode, time, electricity consumption and cost and support various payment platforms), Electrical Charger(charging Mobile, Laptop), Pole Height: 10-12 Meters, Made of Hot dip galvanized with PU paint double coat designed Aesthetically .

The type, location and spacing between two lights shall be decided based on the LUX requirements, Smart poles shall be located at all junctions and rest of the poles shall be normal one with same look of Smart pole. The poles both smart & normal shall be of architectural design for aesthetic purpose. Design & details of poles shall be submitted by the bidder to EIC for approval prior to procurement. The minimum height of the poles for street lighting & footpath lighting shall be 10mtr & 3mtrs respectively.

Design Requirement for Road Lighting

a. Visibility of road and its surrounding.
b. Visual guidance of the shape of road. Motorist should be able to clearly identify bends and curves in roads.
c. Identification of obstacle.
d. The visual comfort of the driver. The visual field comprises carriageway, surrounds to the road including road sign, the sky and bright luminaire.
e. Light should appear continuous and uniform.

Illumination levels

Taking into account consideration of principles of vision, criteria of quality and characteristics of sources and luminaries, Table-1 given below gives for the desirable level of illumination which are recommended as per IUT (Institute of Urban Transport) & uniformity from IS:1944.

Table-1 Illumination Level

S. No	Type of Road	Remarks	Illuminance Criteria					
			E avg (IS standard)	**E avg (Proposed)**	**E min: E avg (IS standard)**	**E min: E avg (Proposed)**	**E min: E max (IS Standard)**	**E min: E max (Proposed)**
1	**Arterial Roads**	High speed, high density traffic and mixed Traffic	30	**40**	0.4	**0.6**	0.3	**0.4**
2	**Sub-Arterial Roads**	Medium speed, High Density traffic	15	**40**	0.4	**0.6**	0.3	**0.4**
3	**Conflict Areas**	Medium speed, high density traffic and pedestrian zone	50	**50**	0.4	**0.6**	0.2	**0.4**
4	**Pedestrian Pathways, jogging tracks and cycle tracks**			5-10		0.6		0.4

*Lux level mentioned above shall be uniform average luminance level measured at road surface.

Junctions: -

Lighting provision at a junction should reveal its configuration, positions of kerbs and road markings, directions of roads, presence of pedestrians or obstructions and movements of vehicles in the vicinity of the junction.

The provision should also meet the needs of drivers approaching the junction to see vehicles approaching from other directions. The lighting level on the carriageway throughout a junction shall not be lower than that provided on the main roads leading to the junction. Road lights shall not be placed at the curved corner of a road junction as this will reduce the

effectiveness of the main beams from all on-coming traffic at different branches of the junction

Roundabouts: -

The lighting provision at a roundabout should enable drivers to see clearly any traffic at the preceding entry and the traffic already in the roundabout. When in the roundabout, the lighting provision should also enable drivers to have adequate forward vision to see traffic entering from the left and to decide whether it is safe to proceed. It should reveal the form, direction and edges of the carriageway all the way round the roundabout.
Lighting columns shall not be installed on the central traffic islands as they would confuse the visual guidance required above and increase the possibility of vehicle collisions. They shall be placed behind the outer kerb at appropriate spacing.

Power Supply for Lighting System

Power distribution scheme for lighting shall be designed in coordination with the service area. The street lighting system shall be fed from their respective lighting distribution board.

For street lighting poles, the power supply shall be received from nearby substation. For this purpose, a dedicated main lighting distribution board shall be provided in the substation, which shall further feed the power supply to lighting small distribution board or high mast Feeder Pillar.

Each small distribution board shall be capable of feeding power to maximum 1000W or 10No.of light fixtures, whichever is lesser.

The location of small distribution boards for street lighting shall be strategically decided as per site actual conditions. To avoid the tempering, all the small distribution board shall be located away from public areas.

While deciding the location of small distribution board, the Voltage drop shall be kept in consideration. The voltage drop in lighting system should be less than 5% as per National Electrical Code.

SUBMISSIONS FOR APPROVAL: -

All lighting designs, computer simulations, drawings and proposed materials/equipment shall be submitted to the EIC for approval before installation. The EIC will not take over any completed lighting installations without prior approval.

HANDOVER OF LIGHTING SYSTEM: -

Handover Inspections: -

After the completion of installation work, the Contractor shall arrange the first inspection for staff of departmental authorities and corresponding EIC to inspect the lighting installation. In general, a list of defects and outstanding items list shall be agreed by all relevant parties and the EIC. The EIC shall highlight those major defects. After the Contractor has rectified all the major defects, a handover inspection shall be arranged.

Provision of Spare Parts: -

The exact quantities and types of spare parts for the road lighting installations shall be confirmed with the EIC at design stage. Spare parts shall be provided and delivered to the EIC before handing over the lighting installations for maintenance, 100% of the installed luminance meters and 1 set of controller shall be provided as spare parts. For more complicated installation, the EIC shall be consulted at design stage. For lighting installations at other types of structures such as covered public transport interchanges, covered pedestrian routes and high mast lights, 10% of each type of the installed luminaires shall be provided as spare parts if typical luminaires are used. The exact quantities of spare parts for non-typical luminaires shall be confirmed with the EIC at design stage.

As-built Drawings and Other Required Documents: -

On completion of the lighting installations, the Contractor shall provide soft copies of as-built drawings in Autocad format in appropriate size and also in GIS format to the EIC to facilitate the handover inspection.

For the final handover, the Contractor shall provide the EIC with 2 sets of CD ROMs each containing the following documents in editable format and 2 sets of hard copies:
(a) As-built drawings including lighting layouts, schematic drawings, circuit diagrams and conduit routes layouts;
(b) Lighting measurement results (pdf format);
(c) Electrical test reports (pdf format);
(d) Equipment database in required format; and
(e) Operation and maintenance Document.

For as-built drawings, 1 more set of CD ROM containing the drawings in shall be provided. For lighting systems with software/electronic control, the design logic flow chart and associated software protocols of the controller shall be submitted to the EIC after commissioning and testing.

2.0 Lighting Small Distribution Board (DB's)

Each indoor Distribution board shall be with minimum IP-42 protection, dead front, front operated and shall be designed as per IEC-61439. The outdoor lighting distribution boards shall be with minimum IP65 protection. The number of ways of lighting DB's shall be decided based on the number of the circuit and the spare MCB's for future use.

The type of lighting distribution board shall be provided as per the location of lighting poles.

1) **Lighting Distribution Board (Type-1) for street lighting poles**: : In this type of distribution board 40Amp ELCB for incomer is considered. 18no.of outgoings (6no.on R-Phase, 6no.on Y-Phase, 6no.on B- Phase) of 16 Amps SP shall be controlled by 32 Amp (3No.) DP MCBs.

3.0 Lighting Management System

The lighting will be designed to illuminate the entire areas with the minimum necessary luminaires in an efficient manner, through directing the light to the areas to be illuminated through minimizing the tilt angle and appropriate aiming of the luminaries thereby minimizing the

wasteful use of light, reducing required power and ensuring that the surrounding environment is not subject to obtrusive lighting of the site.

Therefore, Utilizing controllable streetlights as a communication link and smart poles as a carrier to build a smart city management platform, Maximizing the platform friendliness, compatibility and scalability, and utilizing reliable network to sense, collect and analyze key data that can help cities make efficient and smart respond to improve city management on infrastructure, public service and safety.

Lighting system shall be controlled via Smart Street Light Controller for the luminaires mounted on each lighting pole.

8.1 Smart Lighting Controller:

IPV6 addressing, opening standard, NEMA compliance, 868MHZ,915-928MHz, 902-928 MHz/2.4GHZ

Advanced encryption standard. Secure hash algorithm to secure from hackers.

Each Node in the luminaire Collect and forward streetlight information, including power, voltage, current, power factor, alarms, and metering etc.

Smart Lighting Diagnosis individually, the defect luminaire to pin point location on a GPS remotely by LMS for necessary actions.

Be connected and monitored by Streetlight Vision Central Management Software.

LMS shall be pre-programmed/ re-programmed as per the requirement for automatic switch 'on' and 'off' the luminaries remotely. The dimming option in the luminaries will give the LMS to program lighting levels based on traffic and weather conditions remotely at SVCMS.

The successful contractor shall submit lighting design, layout & calculations (generated by reputed software like DIALUX) based on the lighting design standards and LUX levels mentioned in the table 1.0 here in this section for client's approval.

Utilizing controllable streetlights as a communication link and smart poles as a carrier to build a smart city management platform.

Maximizing the platform friendliness, compatibility and scalability, and utilizing reliable network to sense, collect and analyze key data that can help cities make efficient and smart respond to improve city management on infrastructure, public service and safety.

4.0 Standards and Codes

The illumination system shall be designed, installed and tested in accordance with the latest editions of the standards - IS-2149, IS-3646, CIE129.

In addition to this Document, lighting designers shall also observe the latest edition of the following standards, specifications or requirements mentioned in schedule-D and, in case of any conflict, technical advice from the EIC shall be obtained.

Table-3 (Street Light- Standard for installation)

Code	Standard for installation
IS: 1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
IEC:60947	Switchgear Protective Components.
IEC: 60598 – 2 – 3 IUT (Institute of Urban Transport)	Particular requirements luminaries for road & street lighting.
IS: 2309	Code of practice for Lightning Protection.
IS: 3043	Code of practice for Earthing.

Table-4 (Street Light- Design Standards)

Code	Standard for installation
IS: 7098 (Part-II& Part-III) 2003 IS: 8130	Standard for XLPE Cables, Part – II up to 3.3 kV to 33 kV and Part– III from 33 kV to 220 kV). Specification for conductors for insulated electric cables & flexible cords.
IS 1554 (Part I & Part – II)	Specification for PVC insulated (Heavy Duty) electric cables • Part 1 For working voltages up to and including 1100 • Part 2 For working voltages from 3.3 kV up to and including 11 kV
IEC: 61439 IEC:60947	Feeder Pillar & Switchgear (Totally Type Tested Assembly TTTA).

• IEC: 60598 – 2 – 3 • IUT (Institute of Urban Transport) • CIE (Industrial commission of illumination)	(a) Particular requirements luminaries for road& street lighting (b) Standard for road lighting (c) Road Transport Lighting for Developing Countries
IS: 2309	Code of practice for Lightning Protection
IS: 3043	Code of practice for Earthing
IS: 1944	Code of practice for lighting of public thoroughfares

Appearance

For daytime appearance, the design and siting of road lighting and other road equipment can make a great difference to the overall street scene. At locations such as a processional way, monumental bridge and roads abutting onto heritage buildings, the design and placing of lighting columns shall match with the architectural setting, in order to make a positive contribution to the street scene.

For the selection of luminaire, in urban centres, shopping streets, boulevards, promenades and other places that are the hubs of social activities, decorative road lights are highly desirable. In general, proposals using decorative road lights should be agreed by the EIC and all relevant parties such as the APCRDA.

Lighting designers should also consider whether the lighting scheme could make a positive contribution to the night environment, especially for areas of civic importance. A higher colour rendering index (Ra ≥ 60) of the light source is paramount to the nighttime appearance of the street scene and can enhance the sense of nighttime security.

Luminaires

Lanterns shall be of sound and robust construction to BS EN 60598-2-3. The IP rating for decorative and conventional lanterns shall not be less than 65 and 66 for decorative and conventional lanterns respectively. They shall be for use on 220V, 50Hz single phase mains supply. To ensure high energy efficiency of public lighting system, the overall efficacy of the whole lantern for new road projects shall not be less than 100lm/W.

In addition to above, LED luminaires shall comply with IEC 62471 hazard class Group 1 or Exempt Group and shall have a correlated colour temperature at 4000K. The luminaire shall

be in modular type so that replacement of parts such as drivers, LED circuit boards and other components can be carried out as necessary. LED luminaires shall have a minimum of 50,000 hours of lifetime at 70% lumen maintenance.

Luminaires installed on a bridge deck shall be capable of withstanding the effects of vibration from structures, passing vehicles and prevailing winds. Vibration studies/analyses and tests shall be carried out on the proposed luminaires beforehand in order to illustrate that no premature failure of lamps would occur under the structural vibration of the bridge. Studies/analyses/test reports and any proposed vibration reduction measures on the luminaires shall be submitted to the EIC for approval.

Light Sources

The choice of light source depends on the number of lumen per watt, life time, flux maintenance, colour rendering, initial costs and lamp replacement costs. The luminous efficacy of a light source has a dominating influence on the energy consumption and consequent running costs of a road lighting installation. The requirement on minimum luminous efficacy for LED is 100lm/W with considering the standard IEC 62471.

Ballasts/Drivers

In general, electronic ballasts shall be used for road lighting for higher energy efficiency. The use of conventional magnetic ballasts shall be agreed by the EIC. An electronic ballast shall be a solid-state converter capable of converting single phase mains supply of 230V ± 6% and 50Hz ± 2% to a high frequency voltage output at its rated power to suit the lamps connected. Electronic ballasts shall conform to IEC 61000-3-2, IEC 61000-3-3, BS EN 55015 and IEC 61547.

The whole electronic ballast shall be housed in a single front-access enclosure with appropriate terminal blocks for easy connection of wires. Electronic ballasts shall be suitable to operate at an ambient temperature range of 0oC to 50oC and at maximum relative humidity of 95%. The electronic ballast shall go into a shutdown or lower power stand-by state when the connected lamp is failed or when overload occurs in the lamp circuit.

LED drivers shall comply with IEC 61347-1 and IEC 61347-2-13. For drivers with dimming function, they shall be capable of providing continuous dimming range of 10% to 100%. An external surge protection device capable of withstanding surges of 10kV shall be provided to

the driver. The driver and the surge protector shall be housed in a separated front-access enclosure to be installed at the column door level of the lighting column.

Power Cables

Cables shall be of 600/1,000V grade with cross-linked polyethylene (XLPE) insulation, galvanized steel wire armored and PVC outer sheath as per specification confirming to IS:7098 (Part - I)

Makes: Torent / Universal / Unicab / Havells / KEI / Gloster/ Polycab

Astronomical Time Switches and Digital Photoelectric Controllers

The on/off control of lighting circuits shall be by means of an astronomical time switch and a digital photoelectric controller as a backup. The astronomical time switch shall comply with IEC 60730-1. It shall have 2-channel, an accuracy of ± 0.5 sec/day and a battery reserve for at least 5 years. The digital photoelectric controller shall be of electronic fail-safe type, and have a LCD display showing the local time, on/off settings and measured illuminance level. It shall also have a plug-in and replaceable photo sensor, and an on/off adjustable setting from 1 to 2,000lux with adjustable time delay of 0-60 seconds. Both the switch and the controller shall be suitable for use in exposed weather conditions and shall function correctly at a temperature range of -5°C to +50°C at the local supply voltage and frequency.

Road Lighting Circuits

Road lighting shall be fed from PLCCs. For the security of road lighting circuit systems, 100% back feed capability is mandatory for road lighting along trunk roads or above including slip roads. The same arrangement shall be adopted for other roads as far as possible. Back feed will be needed when the power supply for a series of lights fed from one PLCC is suspended, faulted or affected and could not be immediately restored.

Cable Circuits

All road lights fed from the same circuit shall be looped together by turning in and out the lighting cables and terminating them with cable glands at the base section of lighting columns. Alternative connection means, such as teeing underground lighting cables in the proximity, are unacceptable.

To maximize the number of road lights that can be supplied by one circuit, the whole length of lighting cables shall be of the same size. Reducing the cable size or the number of cable cores at any section of the circuit shall not be allowed for consistent circuit design and for circuit backfeed. The maximum number of lights to be connected to an outgoing circuit shall be determined by wattage of the lamps and voltage drop of the cables. For circuits with back-feed, a two-stage approach shall be adopted:

Care must be taken to ensure that the voltage of the last light during the most critical backfeed condition shall be maintained at no less than 216V, i.e. a total voltage drop of the entire circuit be no more than 14V, assuming the supply voltage is 230V.

(ii) During normal operation, the minimum voltage of the last light up to the normal open (N/O) point, shall be no less than 216V by taking into account the ± 6% voltage fluctuation as specified by the respective Power Company.

A full ducting system for protecting road lighting cables is required. For all road projects including reconstruction of carriageways/footpaths, a full ducting system comprising either HDPE ducts and GI pipes and draw pits shall be specified to facilitate future maintenance of the cables.

Whenever possible, ducts/pipes shall be laid under footpaths instead of carriageways. On footpaths or carriageways where a minimum cover of 450mm from the finished surface of the footpath and 900mm from the finished surface of the carriageway could be provided, HDPE ducts shall be used. GI pipes of appropriate size shall be used. The GI pipes shall comply with BS EN 10255 and be of medium grade. The HDPE ducts shall comply with BSEN - 500 86/IS 14930 Part-II.

PLCCs

There are two different types of PLCCs, i.e. pole-mounted and ground-mounted PLCCs. Detailed construction of these PLCCs shall comply with the requirements as specified by the Lighting Division.

The locations of PLCCs and earth pits shall be chosen at places where they are practically accessible for maintenance and less obstructive to pedestrian flow. For the accurate operation of the photoelectric controller, the PLCCs shall not be sited in shaded areas, such as under trees and structures, in order to avoid mis-operation of the road lighting system. Wherever possible, especially at new developments, the respective Power Company shall be consulted at the early design stage for the availability of power supply.

Fuse and MCB

Incoming and outgoing circuits at a PLCC shall be protected by high rupturing capacity (HRC) fuses of an appropriate rating to BS EN 60269-2 and BS 88-2. Each lighting point shall be separately protected by an MCB unit to BS EN 60898-1. For double arm road lights, each lamp shall be supplied from a different circuit to avoid total loss of light in the event of fault. The rating of fuses and MCBs shall be properly designed according to circuit cable size and loading.

Earthing

The complete road lighting installations, including PLCCs, lighting columns, lanterns, control gear, conduits, cables fittings and other exposed conductive parts, shall be effectively earthed to the ground by means of copper conductors of appropriate sizes and shall comply with the recommendations as per standards. The results of the earth fault loop impedance test for each road light and PLCC shall be submitted to the EIC for acceptance.

A separate earthing system shall be provided at each PLCC. Earth electrodes of 16mm diameter copper bonded steel core rods shall be used. The electrode shall be driven into the ground and connected to a sufficiently sized copper earth terminal inside the PLCC. It may require more earth electrodes connected in parallel to achieve the required earth fault loop impedance value. The earthing of each outgoing circuit shall be bonded to the main earth terminal of the PLCC.

Appendix B VIII
Pipe Conduits for ICT cables

General

As a part of the Smart city concept in Amaravati capital city, the latest advanced technology of ICT (Information & Communication Technology) is proposed to be implemented. ICT will provide high speed internet as a core utility for delivery of services to citizens, cradle to grab digital identity that is unique, lifelong, online and authenticable to every citizen, mobile phone & bank account enabling citizen participation in digital & financial space and easy access to a Common Service Centre shareable private space on a public cloud safe and secure cyber-space, making financial transactions electronic & cashless and leveraging Geospatial Information Systems (GIS) for decision support & development.

Scope of Work

As a part of ICT implementation in Amaravati capital city, following works shall be carried out in this project.

i. Communication pipeline as an underground communications network will consist of DWC HDPE pipe and 7-way honeycomb ducts. DWC HDPE will be carrier for 220 Core ICT cables and 7-way Honeycomb duct will be carrier for 4 core ICT cables. The arrangement is shown in the drawing AG-1957-DDR-AM-ICT-SD-CS. 7-way Honeycomb ducts are hexagonal in shape readily available in the market.

ii. For E3 road, configuration of DWC duct and 7 Way Honeycomb ducts has been provided in the drawing along with tables.

iii. ICT bundle of cables will be residing inside the DWC-HDPE pipes and 7-way Honeycomb ducts. ICT cable laying and connectivity will be done by a separate contractor and is not part of this contract.

iv. This contract shall include supply, lowering, laying, jointing, and testing of all DWC-HDPE main ducts & honeycomb ducts and RCC manholes required for the ICT communication network along the E3 road. The work shall be executed as per the details shown in the drawings.

v. The sizes, length and number of DWC and 7-way Honeycomb ducts are given in table-1. Accordingly, contractor shall lay pipe ducts for ICT.

vi. Contractor shall construct RCC (M25 grade) manholes following relevant IS standards & considering the sequence of the utility crossings as given in the schedule-D.

vii. RCC NP4 encasing pipes shall be given with spacer arrangement for road crossing as indicated in drawing.

viii. Contractor shall consider end-to-end connectivity between adjacent contractor's ICT ducts based on the details provided by the authority.

Details of ICT Duct

In Table-1, length and diameter of DWC HDPE duct and 7-Way Honeycomb ducts are provided.

Table-1 ICT Roads Ducts length

Package-XV Roads ICT Ducts length & MH details		
Package-XV Roads	**E3**	
	TRUNK	**DISTRIBUTION**
ICT Ducts configurations (DWC(dia-160mm) +7way honeycomb (inner dia of each duct 40mm)	6+8	2+6
Length of the duct (m)	19856.76	715
Total length of DWC duct (km)	117.99	1.404
Total length of 7-way honey comb duct (km)	158.932	4.212

Details of ICT Communication Network

This contract package includes providing, laying, jointing, testing and commissioning of DWC HDPE ducts (IS: 14930 part-2) of 160 mm diameter as per the details furnished in the drawing. Double-wall corrugated pipe is a kind of pipe material with ring-structure external wall and smooth internal wall at a length of 6 m each piece as shown in figure-1.

The Contract package includes providing, laying, jointing, testing and commissioning of Communication Honeycomb pipe lines outer diameter 110 mm as per the details furnished in the data sheet provided in Schedule -D.

Honeycomb pipe is a kind of communications piping made mainly of HDPE pipes (IS) and molded into honeycomb shape with smooth internal wall for direct cable threading and laying as shown in figure -2 Thickness of Inner core and outer core

Figure-1 Double Wall Corrugated Pipes

Figure-2:7-way honeycomb ducts

In table-1, Road-wise number of manholes are provided. Total requirement of DWC HDPE ducts and 7-way honeycomb ducts road-wise will be provided by the authority for the E3 road.

Manhole for ICT duct

The ICT pipes are connected through the manhole, whose major functions are to provide maintenance and repair space for communication pipes as well as operation space for laying communication wires. In general, manholes shall be spaced at an interval of 100m. At junctions of road crossings, additional manholes shall be provided as per the drawing.

The precast manhole shall be designed and constructed with M25 grade concrete. The cover of manhole shall be removable RCC slab as per design thickness. A SFRC manhole cover of 560mm dia shall be provided in removable RCC slab.

ICT Manhole Details	
Road Nomenclature	E3
Type of Manhole	**Road wise Manholes**
4-way direction	18
3-way direction	122
2-way direction	174
Big hand hole	0
Small hand hole	0
Total No. Manholes	**314**

Type of Manhole & Hand holes	MH & HH Inner Dimensions (L x B x H) mm
2-Direction manhole	2200x1400x2030
3-direction manhole	3200x1550x2230
4-direction manhole	3200x1700x2230
Small hand hole	1200x900x1350
Big hand hole	1700x1200x1600

Number and Location of the manhole shall be decided based on manhole spacing and the road junctions and other site factors to be approved by the Engineer-in-Charge.
The manholes sizes for 2-way, 3-way & 4-way are 2m x 2m, 2m x 3m and 2m x 4m respectively. The contractor has to design the manholes duly considering the criteria as mentioned in Schedule-D and shall obtain approval from Engineer-in-Charge.

Trench:

In the trench where the ducts will be residing, the backfilling shall be done as follows:

1. Up to 20 cm above the top of the duct shall be filled with sand and the remaining space up to the road level shall be filled up by earth. (There shall not be any stone in the backfill)

2. To lay HDPE duct and 7-way honeycomb duct, spacers (ABS-HDPE make) shall be provided at an interval of 1.5 mts to sustain the loads.

3. Two-layer warning tapes (Orange and Yellow color) shall be provided along the ICT ducts route, one at 100mm below G.L and other one at a depth of 800mm below G.L.

4. Contractor shall furnish layout, Longitudinal Sections, Cross sections of ducts, details of manholes, GFC's, datasheets etc., and shall take approval from Engineer-in-Charge prior to execution of work. As Built Drawings (GIS compatible & AutoCAD Format) shall be provided by contractor.

Appendix B IX
Gas Crossings

1.0 MS Encasing Pipe at Road Crossings

MS encasing pipe is proposed for pipe lines under the carriage way of the road and storm water drains. The details are provided in Table-1 as well as in the drawings.

Table-1 Gas Network Crossings - MS Encasing Pipe details in E3 Road

Road Nomenclature	E3
Diameter(mm)	**Dia. Wise Length in (m)**
500	550
600	150
Total	**700**

Appendix B X
ITS

ITS Ducts and Chambers Requirements

ITS Ducts

The requirements for ducting along major arterial roads shall be 4 x 100 mm, High Density Polyethylene (HDPE) ducts running parallel to the arterial roads in the reserved location within the utility corridor on both sides of the major arterial roads. In a circumstance, whereby ducts cannot be provided on both sides of the major arterial roads due to space constraints or other conflicts, use an 6 x 100 mm configuration along one side of the roadway.

In 4-way configuration, the top two ducts shall be designated for communications cables of ITS, and the bottom two shall be designated for power cabling of ITS. In 6-way configuration, the top four ducts shall be designated for communication cables of ITS and the bottom two ducts shall be designated for power cabling for ITS. Ducts on both sides of the arterial roads in the 4 x 100 mm configuration is the standard requirement and shall be followed on all major arterial roads unless an exception is provided in writing from client.

Transverse arterial road ducts shall be 4 x 100 mm HDPE ducts with a maximum spacing of 125 m between road crossings and shall be encased in concrete.

All ducting shall be type HDPE with uniform plastic or rubberised clip spacers, placed evenly throughout the duct run to ensure duct banks keeps uniform shape and order. Spacer shall consist of one uniform component and ducting shall be tied together with the use of plastic or rubberised cable ties.

High Density Polyethylene (HDPE) ducts suitable for underground installation for both electric power and Telecommunications shall be provided and installed. Product data sheets and specifications shall be submitted for review and approval from the client. Ducts shall be designed to be parallel to the main carriageway and at all junctions, a ring shall be provided.

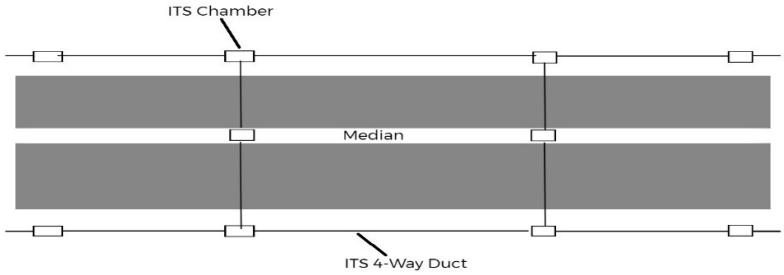
ITS Chambers

ITS chambers shall be located on both sides of all arterial road crossing locations. The maximum spacing of ITS chambers is 125 metres. Where significant changes of direction of ducting are required, this will be through a chamber. Typical dimensions of the chamber shall be 1m x 1m and 0.8 m deep.

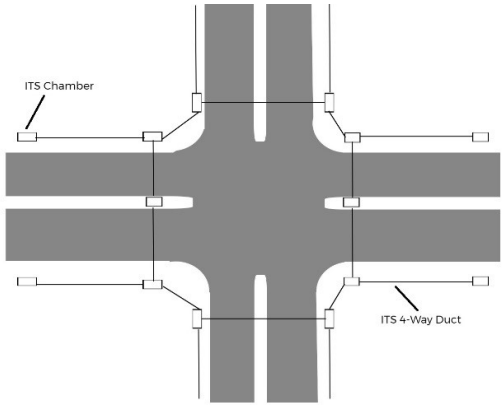
ITS chambers are to be installed at the following locations:

- along the ITS duct network at intervals of no more than 125 metres
- both ends of carriageway duct crossings
- at signalized junctions
- proposed locations of ITS elements
- at termination of duct bank / future connection to the longitudinal duct network.

A chamber shall be installed in the median where there is a planned or potential future need for the provision of communications and power cabling to ITS equipment in the median.
HDPE chambers and duct management boxes which can be easily handled, buried and have locking lids shall be used. Sufficient drainage shall be allowed for in the area surrounding each chamber, and each chamber shall have a sump to prevent flooding of the ITS network through the conduit system.



Typical arterial road dual 4-Way duct mid-block arrangement



Typical arterial road dual 4-Way duct junction arrangement

Appendix B XI
Utility Corridor/Clash Analysis

1. Introduction

The design of utility corridors involves a thorough understanding of the design of the new street families. In addition, a comprehensive understanding of the requirements of all utility providers and agencies is necessary.

There are different standards adopted by different countries based on their technological advances in laying and maintaining. Some of the standards are

- Indian Standards IS & IRC
- French Standard NF P 98-332
- Abu Dhabi Guidelines
- Vancouver Guidelines
- Chinese Guidelines

1.1 Type of Utilities

Utilities considered for this report include all the utilities that are currently used in urban local bodies of India as well as the utilities that may be considered in the future. In general, utilities that occupy part of roads ROW can be divided into two categories

- Road Utilities
- Building Utilities

Road utilities include the infrastructure systems that serve the road itself, such as storm water

drainage, street lighting, fiber optic systems and landscape irrigation systems. Building utilities include infrastructure systems that service the buildings located on the side of the road; these include the water supply, power supply, telecommunication system, gas network, district cooling system and wastewater collection system. These utilities fall under the responsibility of the respective utility providers in conjunction with Municipality.

Following utilities are considered for corridor requirements

- Water distribution system
- Wastewater collection system
- Landscape irrigation water supply system

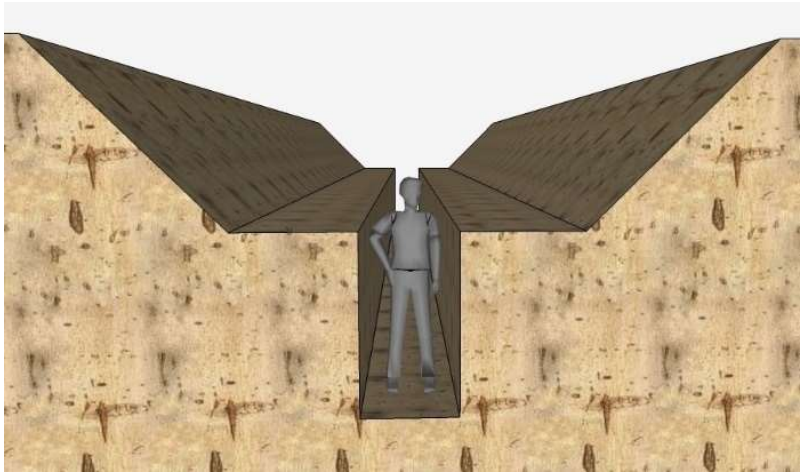
- Urban storm water drainage system
- Gas network
- Power supply, including extra high voltage (EHV), high voltage (HV) that supplies primary substations, medium voltage (MV), low voltage (LV)
- Telecommunication network
- Fiber optic networks, that include: The DoT's, (Intelligent Transportation System: ITS), Area Traffic Control: ATC),
- Street Lighting

In addition to the above, allocation of corridors for trees/ landscaping are accounted for, and guidelines for the arrangement of solid waste collection facilities/ bins, information/ advertisement boards, fire hydrants are provided for.

1.2 MANAGEMENT AND COORDINATION OF UTILITIES

Effective management and design of utility installations are imperative for the safe and expedient construction and maintenance of the road network. Close coordination with utility providers is essential to meet these objectives. This will necessitate that the ADC, CRDA, DoT, the Municipality and the utility companies' representatives meet regularly to exchange information to help avoid conflicts between utility companies' projects and

Municipal projects, in terms of location, construction or method of installation of utilities within the ROW of streets. Work within the public ROW by contractors and / or utility companies requires proper coordination between these companies and the authorities to ensure appropriate utilization of the ROW. Among the issues that need to be coordinated, public safety, pedestrians', cyclists and drivers' comfort, aesthetics and cost-effectiveness of the implemented reinstatement strategy are considered to be of utmost importance.



The operation and maintenance of the utilities will benefit from efficient and effective coordination. Inter-agency coordination during the installation and/ or operation and maintenance activities will maximize the benefits and ensure the following:

- Reduction in road maintenance costs
- Provision of smoother roads with fewer closures for maintenance/ rehabilitation activities
- Provision of cost effective engineered solutions which are suitable for the local conditions
- Promotion of consistent policies which eliminate disputes among stakeholders
- Expediting project delivery and avoidance of project delays in the preliminary engineering, preconstruction and construction phases.

2. Design Considerations and Requirements

Several factors affect the design of utility corridors. Some factors might differ depending on the utility in question; however, many factors are common and govern the design of corridors for almost any utility. Moreover, factors are divided into two major categories; factors which govern the corridor in terms of its width, and factors which govern the corridor in terms of its location.

The required corridor widths are normally governed by the minimum width needed to properly install the utility and this comprises proper excavation, laying, backfilling, compaction and reinstatement. The corridor width is also governed by the size/ width of the associated chambers and manholes that are installed along the corridor. Other factors also include operation and maintenance, repair and replacement requirements.

Factors governing the location of the corridor include clearance requirements from other utilities (mainly applicable between water and wastewater/ treated sewage effluent), clearance requirements from plot limits and connections to plots and inspection chambers, in addition to public safety considerations. Other important considerations in locating utilities are the factors which govern whether a utility can be installed under the carriageway or whether it should be placed under the sidewalk.

Utilities, which require frequent access, should not be placed under the carriageway because operation and maintenance requirements may cause frequent traffic interruptions and frequent asphalt cutting and repairs. Also, pressurized pipes such as water and irrigation water supply pipes might cause significant damage to asphalted roads if pipe failure occurs; consequently, these utilities are normally placed under sidewalks and/ or block paved surfaces. The utilities that can be accessed for repair through manholes are selected to be installed under the travel lanes/ carriageway.

In order to reduce the width of the ROW and optimize the location of each utility corridor width, the design of the utility corridor is done considering the concept of staggering, whereby appurtenances (chambers and manholes) are allowed to extend beyond the corridor limits to a shared corridor between adjacent utilities.

However, in all instances, the encroachment will respect the minimum clearance from the utility pipe/ cable and accordingly, no encroachment on the pipe/ cable corridor will be allowed. This is mainly applicable to utilities which require a wider corridor at the locations of the appurtenances/ chambers. Thus, a shared corridor is created between adjacent utilities to accommodate the appurtenances of the utilities. The shared corridor

will also be useful during operation and maintenance for accessibility space requirements. Each utility will have a dedicated corridor that accommodates the minimum pipe/ cable requirements, referred to as the pipe/ cable corridor.

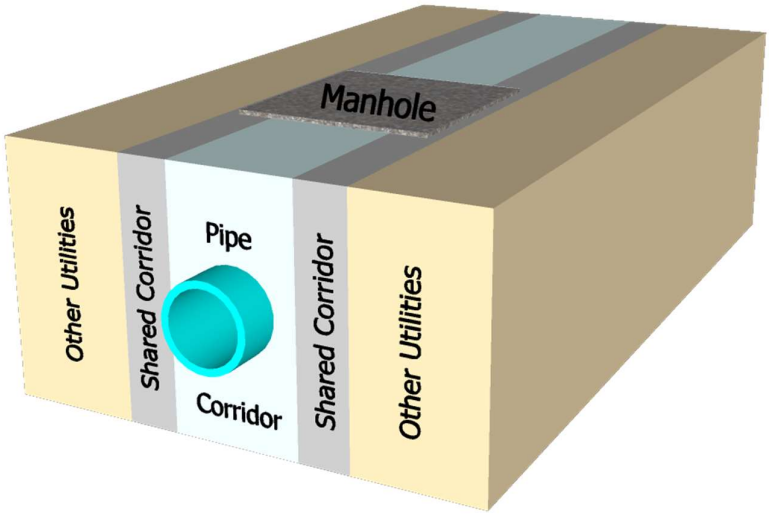


Figure 1: Sample Utility corridor with manhole in shared corridor

In addition, minimum clearance of 0.5m is maintained between the plot boundary and the first utility adjacent to it. Clearance next to the plot boundary shall be used for the installation of riders/ inspection chambers/ house connections. Consequently, the plot boundary wall foundation shall not be allowed to extend beyond the plot boundary limit into the ROW. All utilities shall be installed up to the plot boundary limit, whereby the pipe and/ or cable will be extended to the inspection chamber, valve box, etc. inside the plot boundary.

For utilities installed on one side of the ROW or under the carriageway, ducts for utility crossing to the opposite plots will be installed through riders along with primary system within the ROW. For spacing between utilities please see Schedule-D.

2.1 Water Supply Corridor

Two criteria govern the required corridor width for the water supply network. The first is the pipe corridor width determined by the pipe size/ diameter, and the second is the chamber corridor width determined by the width of appurtenance(s)/ chambers. While the former dictates the minimum width to house the pipe, the latter is normally required to house the outer width/ dimension of the chambers/ manholes, as required. Fire Hydrants are generally provided in multifunction zone.

2.1.1. Water Supply Pipe Corridor Width Requirements

Pipe corridor width requirements are based on the pipe material and/ or pipe diameter. Pipe diameters vary depending on the land use context as well as the street type, as larger streets are expected to contain larger pipes. Minimum pipe corridor width requirements were estimated based on best practices prevailing in India, the requirements for different pipe diameters are shown in Table 0-1.

Table 0-1 Water Supply Pipe Corridor Requirements

Size of Pipe	Corridor Width
150mm	350mm
200mm	400mm
250mm	450mm
300mm	500mm
350mm	550mm
400mm	600mm
450mm	650mm
500mm	700mm
600mm	800mm
700mm	900mm
800mm	1000mm
900mm	1100mm
1000mm	1200mm
1100mm	1300mm
1200mm	1400mm
1300mm	1500mm
1400mm	1600mm
1500mm	1700mm
1600mm	1800mm
1700mm	1900mm
1800mm	2000mm
1900mm	2100mm
2000mm	2200mm

2100mm	2300mm
2200mm	2400mm
2300mm	2500mm
2400mm	2600mm
2500mm	2700mm

Table 0-2 Water Supply Corridor Allocation

Street Family	Pipe Corridor Width	Chamber Corridor Width
Sub Arterial Roads	3.00m	4.20m
Arterial Roads	3.00m	4.20m
Major Arterial Roads	3.00m	4.20m

In addition to isolation valve chambers, water networks comprise other chambers/ appurtenances including washout valve chambers, air vent chambers, flow meter chambers, sector meter chambers and several others. All details will be in accordance with relevant standards. For valve chambers at intersecting pipes, it is recommended to utilize chambers with single valve installation for reducing the chamber dimensions. In instances where two valves are installed at a T connection, it is recommended that the valves are installed in separate chambers before the street intersection. However, if a common chamber for the valves is to be used, the chamber will be allowed to encroach on the adjacent corridor.

2.1.2.Water Supply Chamber Corridor

The minimum chamber corridor width will be equal to the width of the largest chamber required for the pipe installed and at no point is less than the required pipe corridor width. In instances where the street ROW is limited, the chambers are allowed to encroach on the corridor (shared corridor) of the adjacent utility provided the pipe corridor width of the adjacent utility is maintained. Based on the same principle, chambers/ appurtenances of adjacent utilities are allowed to encroach on the water chamber corridor provided the required pipe corridor width is maintained. The standard minimum pipe and chamber corridor widths required for the water pipes for the different street families

are presented in Table 0-2. In some instances, where the ROW is limited, and taking into consideration the land use context and expected demands, absolute minimum pipe and chamber corridor widths are also estimated and are included in Table 0-2.

2.1.3. Water Supply Special Arrangements

Although the corridor allocations, as summarized in Table 0-2, can accommodate most of the water appurtenances, a few specific appurtenances/ chambers might require special arrangements/ considerations. Accordingly, the necessary allocations are provided within development plan outside the ROW of the streets (away from footpaths and the furnishing zone) for the following appurtenances, whenever required

- District Meters (DMS) will be installed in open areas. In instances where the DMS need to be installed within the street ROW, a localized widening of the street ROW can be considered
- Washout chambers will be installed, whenever possible, within parks and open spaces
- House connections along with flow meters will be placed within the plot boundary

In addition, transmission water lines are accounted for as per transmission water corridor requirements, independently of the above required water corridors. Transmission water corridors will be installed based on one of the following guidelines on the approach adopted

- Increasing the ROW of the street where a transmission water main is installed;
- Introducing within the development a dedicated corridor for the transmission water main.

2.1.4.Water Supply System Pipe Depth

The depth of the water supply system will be in accordance with the requirements of CPHEEO/ IRC 98. The minimum depths for water pipes is 1.0m. consideration for varying the depth of water pipes is done so as to allow for the vertical clearance of pipe and other utilities, in particular at intersections and for house connection installation.

2.1.5.Water Supply System Horizontal and Vertical Clearances with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For other utilities international standards like, NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for water supply mains with other utility mains are given in Table 0-3.

Table 0-3 Minimum Clearances for Water Supply Mains with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.4	0.2
Sewerage	3.0	0.2
Reuse Water Line	0.6	0.2
Storm	0.6	0.2
Power 220KV	0.6	0.2
Power 33KV	0.3	0.2
Power 415V	0.3	0.2
Gas	0.6	0.4
ICT	0.6	0.2
District Cooling	0.6	0.3

In all instances, the water pipe will be installed above wastewater pipe with minimum vertical clearance as specified above. In case where a wastewater line crosses over a water pipeline, all pipes will be encased in concrete.

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Contamination of Sewage and reuse water with water supply water.
- Operation and maintenance issues during pipe bursts, leakages, etc.,
- Ultimately with age, pipelines corrode, leak and fail; adequate spacing to be provided as a barrier for separation

2.1.6. Location of the Water Pipe Corridor

The corridor adjacent to power corridor has been reserved for the water lines on both sides of the street. Whenever valve chambers are required, the chambers are allowed to encroach into the shared corridor between power and water supply. Whenever the corridor width for the primary main is not sufficient for the construction of the appurtenances, the chambers are allowed to encroach on adjacent utility corridors provided the encroachment does not extend into the pipe/ cable corridor reservation of the adjacent

utility. Similarly, adjacent utility appurtenances are allowed to encroach on the water supply main corridor, provided that such encroachment does not extend into the water main pipe corridor.

2.2 Reuse Pipe Corridor

As is the case for water, the same criteria dictate the required corridor width for reuse pipe network. The minimum corridor width will be that imposed by the pipe corridor requirements which is determined by the pipe diameter. The maximum corridor width allowed is based on the outer dimensions of the appurtenances / chambers used for reuse pipe systems.

2.2.1 Reuse Pipe Corridor Width Requirements

Pipe corridor width requirements are based on the pipe material and/ or pipe diameter. Generally, reuse pipes are either ductile iron pipes, PVC or HDPE pipes. Reuse pipe diameters vary depending on the landscape scheme which may vary from one land use context to another. Since irrigation systems within urban areas are generally decentralized, the maximum pipe diameter of these systems will be 600mm.

This report provides corridors for larger diameters in providing a primary supply / transmission main through the development. The larger corridors are only permitted on wider streets or in open spaces. The pipe corridor width requirements for the different pipe diameters are shown in Table 0-4.

Table 0-4 Reuse Pipe Corridor Requirements

Size of Pipe	Corridor Width
150mm	350mm
200mm	400mm
250mm	450mm
300mm	500mm
350mm	550mm
400mm	600mm
450mm	650mm
500mm	700mm
600mm	800mm

2.2.2 Reuse Pipe Appurtenances

Reuse water system appurtenances mainly include isolation valve chambers. However, other types may be used on primary supply mains, such as washout valve chambers, and air vent chambers. All details will be in accordance with Bureau of Indian standards and typical details, with the exception of surface finishes, which will be in accordance with the requirements of the street scape standards. For valve chambers on the main line at intersecting pipes, the chamber shall be designed for single valve installation so as to reduce the chamber dimensions. In instances where two valves shall be installed at a T connection, each valve shall be installed in a separate chamber before the street intersection.

2.2.3 Reuse Pipe Corridor

The minimum primary Reuse pipe corridor width will be equal to the width required for the pipe installation. The maximum allowed corridor width is determined by the outer dimensions of the largest chamber required for the pipe to be installed. In instances where the street ROW is limited, the reuse pipe chambers are allowed to encroach on the corridor of the adjacent utility provided the pipe / cable corridor width of the adjacent utility is maintained. In most cases, the reuse pipe chamber is allowed to encroach on the tree corridor. Based on the same principles outlined for other utilities, chambers / appurtenances of adjacent utilities will be allowed to encroach on the reuse pipe corridor provided the required pipe corridor width is maintained. The pipe and chamber corridor widths required for the primary irrigation system for the different street families are presented in Table 0-5.

Table 0-5 Reuse Pipe Corridor Allocation

Street Family	Pipe Corridor Width	Chamber Corridor Width
Local Roads	<=0.350m	1.50m
Collector Roads	0.50m	2.00m
Sub Arterial Roads	0.80m	2.20m
Arterial Roads	0.80m	2.20m
Major Arterial Roads	0.80m	2.20m

The number of Reuse pipe corridors per street is determined by the number of tree corridors required. With regard to secondary supply lines, these shall be installed within the tree corridor.

2.2.4 Reuse Pipe Depth

The depth of Reuse pipes will be in accordance with the CPHEEO/IS standards. The minimum depth of Reuse pipes is 1.0m for primary lines and 0.3m for secondary lines. In all instances, the Reuse pipe will be installed below water pipes with a minimum vertical clearance of 300mm. In cases where an irrigation pipe crosses over a water pipeline, especially at house connections and at intersections, all pipes will be encased in concrete or installed within a sleeve.

2.2.5 Special Arrangements

Although the foregoing corridor requirements can accommodate most Reuse pipe appurtenances, a few appurtenances/ chambers might require special arrangements/ considerations, such as washout chambers. It is recommended that such chambers be installed, whenever possible, within parks, landscaped areas and open spaces.

2.2.6 Location of The Reuse Pipe Corridor

A minimum clear distance of 1.0m shall be maintained between the reuse pipe corridor and any potable water corridor. This distance can be reduced to 0.8m if a third utility separates the water from the irrigation corridor. Irrigation corridors will not be allowed under the carriageway unless there is no available space under the sidewalk and / or block paved surfaces. However, it is placed as close as possible to any landscaping strip / tree corridors.

2.2.6.1. Reuse Pipe Horizontal and Vertical Clearance with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For other utilities international standards like Gainesville Regional Utilities - Utility Separation Requirement, NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for reuse mains with other utility mains are given in Table 0-6.

Table 0-6 Minimum Clearances for Reuse Pipe Mains with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.6	0.2
Sewerage	0.5	0.2
Reuse Water Line	0.5	0.2
Storm	0.5	0.2
Power 220KV	0.5	0.2
Power 33KV	0.3	0.2
Power 415V	0.3	0.2
Gas	0.5	0.4
ICT	0.5	0.2
District Cooling	0.5	0.3

In all instances, the reuse pipe will be installed below water supply pipe with minimum vertical clearance as specified above. In case where reuse line crosses over a water pipeline, all pipes will be encased in concrete.

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Contamination of reuse water with water supply water.
- Operation and maintenance issues during pipe bursts, leakages, etc.,
- Ultimately at ages, pipelines corrode, leak and fail; adequate spacing to be provided as a barrier for separation.

2.3 Wastewater Collection Corridor

Similar to the water supply system, two criteria dictate the required corridor width for the wastewater collection network. The first is the pipe corridor width as determined by the pipe diameter, and the second is the manhole width/ diameter. While the former imposes the minimum width required for the whole length of the corridor, the latter is normally required at connections and changes in direction or slopes at manhole locations.

2.3.1. Wastewater Pipe Corridor Width Requirements

Pipe corridor width requirements are generally based on pipe diameters. The required pipe diameter varies depending on the wastewater flow which in turn depends on the

land use context as well as the street type. In general, larger pipes are expected to run within the wider roads. The pipe corridor width requirements for the different pipe diameters are shown in Table 0-7.

Table 0-7 Waste Water Pipe Corridor Requirements

Size of Pipe	Corridor Width
200mm	600mm
250mm	650mm
300mm	700mm
350mm	750mm
400mm	800mm
450mm	850mm
500mm	900mm
600mm	1000mm
700mm	1100mm
800mm	1200mm
900mm	1300mm
1000mm	1400mm
1100mm	1500mm
1200mm	1600mm
1300mm	1700mm
1400mm	1800mm
1500mm	1900mm
1600mm	2000mm
1700mm	2100mm
1800mm	2200mm
1900mm	2300mm
2000mm	2400mm

2.3.2. Wastewater Manholes

Manhole dimensions and details will be in accordance with CPHEEO standards and typical details.

Additional space will be given wherever drop manholes are provided. For riders 0.80m diameter inspection chambers are provided at the edge of RoW

2.3.3. Wastewater Pipe Depth

The minimum depth of the wastewater pipe will be in accordance with the requirements of CPHEEO, and as per the design requirements. The minimum depth of wastewater pipe is 0.6m for wastewater riders and 1.0m for wastewater mainlines. Consideration for varying the depth of sewer lines is done so as to allow for vertical clearance of storm drains, in particular at intersections and for house service connection installation.

2.3.4.Wastewater Pipe Horizontal and Vertical Clearances with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For water supply clearance is in accordance with CPHEEO guidelines. For other utilities, international standards like NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for wastewater mains with other utility mains are given in Table 0-8.

Table 0-8 Minimum Clearances for Wastewater Mains with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	3.0	0.2
Sewerage	0.5	0.2
Reclaimed Water Line	0.5	0.2
Storm	0.5	0.2
Power 220KV	0.5	0.2
Power 33KV	0.3	0.2
Power 415V	0.3	0.2
Gas	0.5	0.4
ICT	0.5	0.2
Solid Waste Chute	0.5	0.3

In all instances, the wastewater pipe will be installed below water supply pipe with minimum vertical clearance as specified above. In case where a wastewater line crosses over a water pipeline, all pipes will be encased in concrete. For wastewater riders, the clearance with ICT and power distribution is reduced to 0.3m.
Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Contamination of ground water, water supply.
- Extensive damage caused to neighborhood streets by the collapse of a sewer line.
- All piped utilities suffer damage, aging and wear.

2.3.5.Wastewater Corridor

The minimum corridor width will be equal to the width/ diameter of the largest manhole along the pipe and will not be less than the required pipe corridor width. In instances where the street ROW is limited, the manholes will be allowed to encroach on the adjacent space, which is defined as a shared corridor between adjacent utilities. The shared corridor will under no circumstances extend into the dedicated pipe/ cable corridor of the adjacent utility. Based on the same principle, chambers/ appurtenances of adjacent utilities will be allowed to encroach on the wastewater corridor provided the required pipe corridor width for wastewater pipes is maintained. The standard minimum pipe and manhole corridor widths required for the wastewater system for the different street families are presented in Table 0-9.

Table 0-9 Wastewater Corridor Allocation

Street Family	Pipe Corridor Width	Manhole Corridor Width
Local Roads	<=0.80m	1.80m
Collector Roads	1.40m	2.30m
Sub Arterial Roads	2.00m	3.16m
Arterial Roads	2.00m	3.16m
Major Arterial Roads	2.00m	3.16m

In some instances, where the ROW is limited, and taking into consideration the land use context and expected discharges from the various buildings/ dwellings along the streets, the pipe and manhole corridor widths may be eliminated and only riders with inspection chambers are provided.

2.3.6. Location of The Wastewater Corridor

A minimum clearance of 3.0m will be maintained between the wastewater pipe and any potable water pipe. Wastewater corridors are provided under the carriageway to avoid the clearances with potable water supply pipes. And wastewater riders are provided at the edge of RoW for house service connections.

2.3.7. Wastewater Force Mains

Wastewater force mains will be installed in accordance with design requirements as per CPHEEO standards. Based on the design of the wastewater system, the force main shall be installed within a dedicated corridor under the carriageway in accordance with corridor widths for force main requirements.

2.4 Storm water Drainage

The corridor widths for the storm water collection system are determined by the requirements for drain and appurtenance installation. The corridor width is determined by the drain widths.

2.4.1. Storm Water Drainage Corridor Width Requirements

Corridor width requirements are generally determined by the minimum requirements for drain installation and hence depend on the drain size and the type of soil. Drain sizes vary depending on the street type and its ROW since in general, storm water is drained from smaller streets to larger streets provided the gradient allows for such gravity flows in order to optimize the storm water corridor width. The corridor width requirements for the different sizes are shown in Table 0-10.

Table 0-10 Storm water Drain corridor requirements

Size of Drain (mm)	Corridor Width (mm)
450x450	700mm
600x600	1000mm
750x750	1250mm
900x900	1400mm
1000x1000	1500mm
1500x1500	2000mm
2000x2000	2600mm
2400x2400	3000mm

2.4.2. Special Arrangements

Although the foregoing corridor requirements can accommodate most drains, few chambers might require special arrangements/ considerations, such as Silt, Floating debris/grease removal chambers. It is recommended that such chambers be installed, whenever possible, within parks, landscaped areas along roads and open spaces.

2.4.3.Storm water Drain Horizontal and Vertical Clearances with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For water supply clearance CPHEEO guidelines are maintained. For other utilities international standards like Sydney water, NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for storm water drains with other utility mains are given in Table 0-11.

Table 0-11 Minimum Clearances for Storm water Drain with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.6	0.2
Sewerage	0.5	0.2
Reuse Water Line	0.5	0.2
Storm	0.5	0.2
Power 220KV	0.5	0.2
Power 33KV	0.3	0.2
Power 415V	0.3	0.2
Gas	0.5	0.4
ICT	0.5	0.2
District Cooling	0.5	0.3

In case where a storm water line crosses over a water pipeline, water lines will be encased in concrete.

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Obstruction to runoff discharge.
- Structures life may be reduced due to wear & tearing effect/abrasion during the floods.

2.4.4. Storm water Drainage Corridor

The storm water corridor width will be greater of the width of the largest drain along the road or the required corridor width. In instances where the street ROW is limited, the storm water drains will be allowed to encroach on the corridor of the adjacent utility, provided the pipe/ cable corridor width of the adjacent utility is maintained. Similar to other utilities, chambers / appurtenances of adjacent utilities shall be allowed to encroach on the storm water corridor provided the required corridor width is maintained. The corridor widths required for the storm water pipes for the different street families are presented in Table 0-12.

Table 0-12 Storm water corridor allocation

Street Family	side 1	side 2
Local Roads	1.25m	1.25m
Collector Roads	2.00m	2.00m
Sub Arterial Roads	3.00m or swale	3.00m
Arterial Roads	3.00m or swale	3.00m
Major Arterial Roads	3.00m or swale	3.00m

2.4.5. Location of the Storm Water Corridor

Local storm water corridors are located at the edge / curb of the carriageway with catch pit arrangement. The main storm water corridor will be located under the NMT zone/sidewalks, as shown in the proposed utility disposition drawings. Where ever possible, green buffer zones adjacent to roads were proposed for swales. In instances where a subsurface drainage system is needed to lower the groundwater table, the system shall be located within the same corridor allowed for the main storm drains.

2.5 Power Supply Corridor

The power supply comprises EHV, HV, MV, LV and street lighting. The following subsections define the corridor width and location for each of these installations.

2.5.1. Extra High Voltage and High Voltage Corridors

All HV trenches, joint pits and corridors shall conform to, and be in accordance with, AP Transco requirements and typical details. The maximum external chamber widths are 4.5m for EHV and HV Corridors respectively. The EHV and HV corridors will be located under the median/walkway. The allowed corridor width will accommodate the

EHV/HV cables, joint pit, link box including joint and route markers. All the lines are taken through accessible concrete duct. The power cables are placed with a horizontal spacing of 330mm (3 x dia of cable) between each other and vertical spacing of 500mm between each other. AP Transco cables are generally installed with a minimum cover of 1.2m.

The typical arrangement of HV lines inside accessible RCC duct is shown in Figure 2.

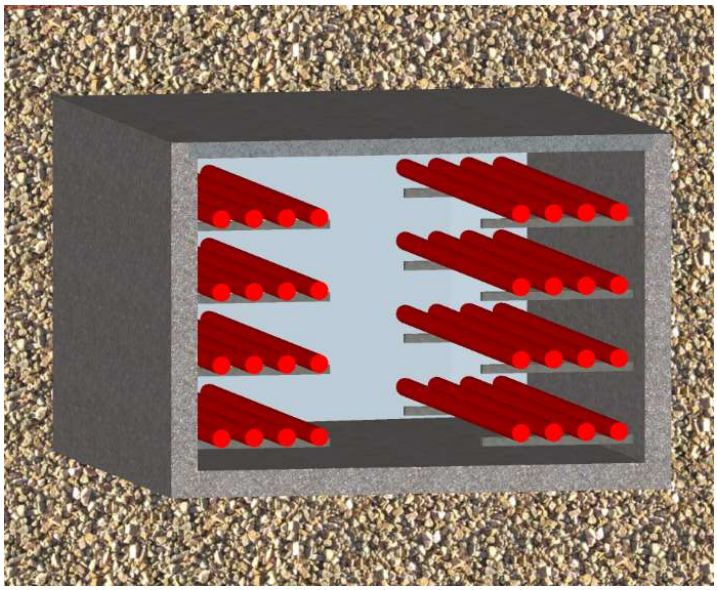


Figure 2 : Typical EHV cable arrangement inside accessible RCC duct

2.5.2. Medium and Low Voltage Corridors

According to the current practice worldwide, fiber optic cables (FOC) are installed alongside the power cables. All MV pipe conduits/manholes, FOC conduits/manholes and corridors will be installed within the same allocated corridor. The FOC will be laid through separate PVC conduit(s) at the same depth as and adjacent to the power cable conduit(s), and in the same trench. All LV trenches and corridors will conform to the requirements and typical details. In order to allow for more flexibility in installation, combined corridors will be allocated for both MV and LV cables. The number of cables,

and consequently Conduits / corridor width for both MV and LV, varies between land use contexts and street types depending on the electrical loads and the number of storeys per building. The spacing between MV cables (33Kv) will be 150mm. Whenever necessary, the spacing can be reduced to 100mm, subject to approval. Similarly, LV cables will be installed with a spacing of 100mm and the spacing can be reduced to 50mm whenever necessary, also subject to approval.

Table 0-13 provides the corridor width for LV / MV / HV, for guidance only. All LV / MV conduits will be located under sidewalks and / or NMT corridors. LV / MV cables are generally installed at depths varying between 0.75m and 1.05m respectively.

Table 0-13 Power corridor allocation

Street Family	Side 1	Side 2
Local Roads	1.10m	0.85m
Collector Roads	1.10m	1.10m
Sub Arterial Roads	6.00m	-
Arterial Roads	6.00m	-
Major Arterial Roads	6.00m	-

Power Distribution networks comprise chambers for connections to/from feeder pillars and house service connections. All details will be in accordance with relevant standards. External chamber dimensions for different pipe conduit types are shown in Table 0-14. For chambers at intersections, it is recommended to have chambers before and after the bends for reducing the chamber dimensions as the cable required minimum of 20 times the diameter as bending radius. However, if a common chamber is to be used, the chamber will be allowed to encroach on the adjacent corridor.

2.5.3. Power Cables Horizontal and Vertical Clearances with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For other utilities international standards like NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for power cables with other utility mains are given in Table 2.5.4 1.

In all instances, the Power conduit will be installed below gas pipe with minimum vertical clearance as specified below. In case where a power conduit crosses over a gas pipeline, all conduits will be encased in concrete.

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Increased magnetic fields.
- Increased risk of Short circuits through other utilities (metal pipes).

2.5.4. Special Arrangements

The Compact substations within residential developments will be strategically located in the middle of the block of buildings/ villas within a street / access lane, to the extent possible, so as to distribute the load in two directions and thus optimize availability of adjacent corridors for LV cables. EHV substations will be strategically located on 50m/60m roads with access. 33KV switching stations are strategically located along 25/50m roads. Duct banks may also be used to distribute the load from a EHV substation to reach the first junction on major roads. Wherever grid stations(400/220KV) are proposed, a dedicated corridor for the EHV lines connecting grid stations are given in accordance with APTRANSCO requirements. In Distribution Feeder pillar will be placed along the edge of the RoW and with a provision of 0.6m width and the sidewalks and nmt zones at those locations will encroach into the multifunction zones.

Utility	EHV / HV Cables (<=220KV)		MV/LV Cables (>=33KV)	
	Horizontal Clearance (m)	Vertical Clearance (m)	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.6	0.2	0.3	0.2
Sewerage	0.5	0.2	0.3	0.2
Reclaimed Water Line	0.5	0.2	0.3	0.2
Storm	0.5	0.2	0.3	0.2
Power 220KV	0.2	0.2	0.2	0.2
Power 33KV	0.2	0.2	0.25	0.2
Power 415V	0.2	0.2	0.15	0.15
Gas	1.0	0.5	0.3	0.3
ICT	0.5	0.4	0.3	0.2
Solid Waste Chute	0.5	0.3	0.3	0.3

Table 0-14 Minimum Clearances for Power with other Utility Mains

Where RCC ducts are used the Verticle and Horizontal clearences shall be 0.1 m from the edge of the duct subject to the clearances given in the table above for the cables.

Where HDPE ducts are used the Vertical and Horizontal clearances shall be 0.2 m from the edge of the pipe subject to the clearences given in the table above for the cables.

2.5.5. Location of the (MV/LV) Corridor

MV / LV corridors shall be located under the sidewalk, NMT Zones so as to facilitate maintenance operations. The allocated corridor width for MV / LV corridors shall be maintained and no encroachment by other utilities is allowed into this corridor.

2.5.6. Street Lighting Corridors

Street lighting (SL) cables / trenches shall be installed in accordance with the requirements and will follow the same configuration required for LV cables. Street lighting poles shall be in accordance with relevant standards. The street lighting corridor will be shared with the corridor allocated for trees/multifunction zones. The power supply to street lights shall be provided from the feeder pillars located on the edge of the RoW and fed from the LV cables installed adjacent to streel lights in tree zones/multi-function zone. The SL cable arrangement shall be in accordance with design requirements. At the tree pit, the cables shall be installed in conduits and arranged at the corridor edge. The SL corridor width shall be 1.0m depending on space limitations. Street lighting corridors shall be provided on one or both sides of the road and on the median, depending on road width and street lighting design.

Table 0-15 summarizes the street lighting corridor requirements depending on the different street types.

Table 0-15 Streetlight corridor requirements

Street Family	side 1	Median	side 2
Local Roads	1.0m	-	1.0m
Collector Roads	1.0m	1.0m	1.0m
Sub Arterial Roads	1.0m	1.0m	1.0m
Arterial Roads	1.0m	1.0m	1.0m
Major Arterial Roads	1.0m	1.0m	1.0m

2.6 ICT Corridors

The Fiber Optic lines generally pertain to the following requirements:

- Telecom operators
- Intelligent Transportation System (ITS)
- Police

- Area Traffic Control (ATC)
- Safety and security
- Disaster Management.
- Public Utilities operation and control systems (SCADA)

Fiber optic lines are grouped in three main categories, as follows:

- High security fiber optic lines, which include Safety and security lines, Police lines.
- Regular fiber optic lines, which include Intelligent Transportation System lines, and Police, traffic police related communication lines, public utilities control lines, other public services lines.
- Telecom fiber optic lines

High Security fiber optic lines, regular fiber optic lines and telecom fiber optic lines are installed in the same corridor. But separate manholes are being provided for each category on all major roads. For local roads, only regular fiber optic lines and telecom fiber optic lines are installed. ICT and power distribution corridors are combined for distribution systems.

2.6.1. ICT Duct Corridor Width Allocation

The duct corridor width of the installations is governed by the number and size of ducts to be installed, the spacing between ducts.

In order to accommodate the various utilities sharing the corridor and their requirements, the fiber optic duct corridor dimension shall be based on the formation comprising 40mm dia each 7-way conduits and 110mm diameter conduits. The minimum spacing between conduits is maintained at 100mm for spacers.

Table 0-16 ICT corridor allocation

Street Family	side 1	side 2
Local Roads	0.30m	0.30m
Collector Roads	0.60m	0.60m
Sub Arterial Roads	1.00m	-
Arterial Roads	1.00m	-
Major Arterial Roads	1.00m	-

Similar to other utilities, if allocated space is not sufficient for the installation of the telecom manhole, the designer is allowed to use the shared corridor. In this instance, the manhole is allowed to encroach on the corridor of adjacent utilities provided the minimum pipe / cable corridor width of the adjacent utility is maintained. Similarly, other utility appurtenances are allowed to encroach on the telecom corridor provided the encroachment does not extend into the telecom duct corridor. The minimum cover requirement for ICT line is 0.75m.

2.6.2. ICT Manhole Corridor Width Requirements

As stated previously, the manhole corridor width is determined by the outer dimensions of the manholes used. Based on the currently used manhole sizes of both utility providers, the maximum outer width of manholes is 2.0m for major roads. For local roads, common manholes are provided for power distribution and ICT conduits. Manhole corridor width requirements for telecom cables in distribution are indicated in Table. Similar to other utilities, if allocated space is not sufficient for the installation of the telecom manhole, the designer is allowed to use the shared corridor. In this instance, the manhole is allowed to encroach on the corridor of adjacent utilities provided the minimum pipe / cable corridor width of the adjacent utility is maintained. Similarly, other utility appurtenances are allowed to encroach on the telecom corridor provided the encroachment does not extend into the minimum telecom duct corridor.

2.6.3. Special Arrangements

Security camera poles for the Falcon Eye system, where required, shall be located along the corridor dedicated for street lighting / trees. The locations of the poles will be given priority / precedence over trees and lighting poles. When placed within the street lighting / trees corridor, a minimum of two pass-thru conduits shall be provided within the manhole and pile foundation of the pole of the FE system to secure passage for the street lighting cables.

2.6.4. ICT Horizontal and Vertical Clearances with Other utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For other utilities international, standard NF P 98 – 332 (French Guidelines) are taken. Minimum Clearance's for ICT lines with other utility mains are given in Table 0-17.

Table 0-17 Minimum Clearances for ICT pipes with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.6	0.2
Sewerage	0.5	0.2
Reclaimed Water Line	0.5	0.2
Storm	0.5	0.2
Power 220KV	0.5	0.4
Power 33KV	0.3	0.2
Power 415V	0.3	0.2
Gas	0.2	0.2
ICT	0.2	0.2
District Cooling	0.3	0.4

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- will not have enough space for overhaul & Maintenance.

2.6.5. Location of the ICT Corridor

ICT Corridors will be located under the parking lane, Sidewalks and NMT Zones so as to facilitate maintenance operations.

2.7 Gas Corridors

Gas pipes and valve chambers, as well as all related gas supply network elements, will be in accordance with APGDC Distribution general requirements and standard details. Similar to the other piped systems, two criteria dictate the required corridor width for the gas network. The first is the pipe corridor width as determined by the pipe diameter, and the second is the manhole width/diameter. While the former imposes the minimum width required for the whole length of the corridor, the latter is normally required at control valves.

2.7.1. Gas Pipe Corridor Width Requirements

Pipe corridor width requirements are generally based on pipe diameters. The required pipe diameter varies depending on the gas flow which in turn depends on the land use

context as well as the street type. In general, larger pipes are expected to run within the wider roads. The pipe corridor width requirements for the different pipe diameters are shown in Table 0-18.

Table 0-18 Gas Pipe Corridor Requirements

Size of Pipe	Corridor Width
150mm	350mm
200mm	400mm
250mm	450mm
300mm	500mm
350mm	550mm
400mm	600mm

2.7.2. Gas Manholes

Manhole dimensions and details will be in accordance with APGDC standards and typical details.

2.7.3. Gas Pipe Depth

The minimum depth of the Gas pipe will be in accordance with the requirements of IS:15663, and as per the design requirements. The minimum depth for gas pipe in residential industrial and commercial areas is 1.0m and for road crossings it is 1.2m.

2.7.4. Gas Pipe Horizontal and Vertical Clearances with Other Utilities

The minimum clearance with power distribution will be in accordance with the requirements of IS:1255. For other utilities, international standards like NF P 98 – 332 (French Guidelines), GB50289 (Chinese Guidelines) were followed. Minimum Clearance's for gas lines with other utility mains are given in Table 0-19.

Table 0-19 Minimum Clearances for Gas mains with other Utility Mains

Utility	Horizontal Clearance (m)	Vertical Clearance (m)
Water supply	0.6	0.4
Sewerage	0.5	0.4
Reclaimed Water Line	0.5	0.4
Storm	0.5	0.4
Power 220KV	1	0.5

Power 33KV	0.3	0.3
Power 415V	0.3	0.3
Gas	0.15	0.6
ICT	0.2	0.2
District Cooling	0.5	0.4

In all instances, the gas pipe will be installed above power lines with minimum vertical clearance as specified above. In case where a gas line crosses below a power line, gas pipe joints will be away from those crossings.

Risks that might arise due to noncompliance of minimum horizontal and vertical clearances are as follows

- Increase in risk due proximity with power lines.
- will not have enough space for overhaul & Maintenance.
- All piped utilities suffer damage, aging and wear.

2.7.5. Gas Corridor

The minimum corridor width will be equal to the width/ diameter of the largest manhole along the pipe and will not be less than the required pipe corridor width. In instances where the street ROW is limited, the manholes will be allowed to encroach on the adjacent space, which is defined as a shared corridor between adjacent utilities. The shared corridor will under no circumstances extend into the dedicated pipe/ cable corridor of the adjacent utility. Based on the same principle, chambers/ appurtenances of adjacent utilities will be allowed to encroach on the gas corridor provided the required pipe corridor width for gas pipe is maintained. The standard minimum pipe and manhole corridor widths required for the gas system for the different street families are presented in Table 0-20.

Table 0-20 Gas Corridor Allocation

Street Family	Pipe Corridor Width	Manhole Corridor Width
Local Roads	0.40m	1.20m
Collector Roads	0.45m	1.30m
Sub Arterial Roads	0.60m	1.50m
Arterial Roads	0.60m	1.50m
Major Arterial Roads	0.60m	1.50m

To facilitate house connection crossings with other utilities, ducts shall be installed to allow for gas pipe crossings during the installation of gas pipes.

2.7.6. Location of the Gas Corridor

Gas corridors are provided under the NMT Zones/Sidewalks.

- Minimum proximity distance from buildings to PE gas mains is 5.0m for pipe diameters of up to 315mm (MOP 4 barg);
- Minimum proximity distance from buildings to PE gas mains is 8.0m for pipe diameters of more than 315mm (MOP 4 barg);
- Minimum proximity distance from buildings to steel gas mains of MOP 16 barg is 13.0m.
- Minimum clearance between gas mains and low voltage electrical cables is 300mm in any direction; and
- A minimum clear distance of 500mm will be maintained between gas pipeline corridors and any electrical / power cables (MV/HV), other than low voltage electrical cables.

3. Utility Installation Overview

Installation of all utilities shall be carried out in accordance with the specifications and concerned authority.

All utilities shall be installed prior to the final finishing of roads and sidewalks in order to avoid the breaking up of finished surfaces. Similarly, all house connections shall be installed up to the plot limit, to avoid cutting the surfaces for utility connections.

All utilities crossing the carriageway shall be encased in concrete if the minimum depth requirements cannot be achieved to protect the utilities from damage due to traffic loads. Also, any utility which is required to be placed under the sidewalk, but instead is placed under the carriageway due to space limitations, shall also be encased in concrete if the minimum depth requirement cannot be achieved.

Root barriers and / or root-directors shall be used in all tree pits, so as to direct the growth of the roots in downward direction. During paving, the backfill surrounding the root barrier / root director must be compacted sufficiently to support the paved surface material and discourage roots from reaching back up to the surface layers. The barrier must be installed from the surface level to a minimum of 1.0m below surface level with joints overlapped by 300mm.

4. Utility Corridor Arrangement

The typical utility corridor sections were prepared, taking into consideration all the requirements discussed in previous chapters. All plot connections are provided through collector and local roads as specified in master plan. The allocated corridor for each utility is the maximum allowed for each utility, unless otherwise stated.

The number and width of utility corridors for each utility have been allocated based on the expected demands / discharges taking into consideration the context type, the street category, and ultimate capacity calculations and the same have been given in Annexure I. The type / nature of connections to the plots, and the crossing requirements were also maintained. All spacing requirements as given in Schedule-D are maintained while preparing Typical cross sections. To avoid conflicts near junctions/ crossings and for making decision whenever a conflict occurs between utilities, a conflict mitigation matrix has been prepared and presented in Schedule-D.

Annexure I

Utility Corridor Allocation in Street Family

Road / Item	Water supply	Sewerage	Reuse	Storm	Power 220KV	Power 33KV	Power 415V	ICT	Gas	District Cooling
Sub arterial	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	-
Sub arterial @ Govt Complex	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	4.5
Arterial	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	-
Arterial @ Govt Complex	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	4.5
Major Arterial	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	-
Major Arterial @ Govt Complex	2.5	2.4	0.6	3+3	6.0	2.4		0.8	0.5	4.5

Schedule C - Project Facilities

(See Clause 2.1)

Contents

1.0 Project Facilities

The Contractor shall design and construct the Project Facilities in accordance with the provisions of this Schedule C. Such Project Facilities shall include;

1.1 Project Facilities

Each of the Project Facility is briefly described below;

Road Side Furniture / Road Markings & Signage

Road Side furniture and Road markings & signage shall be provided in accordance with the provisions as per **Schedule D**.

The road side furniture shall include the provision of the:

i) Traffic Sign:

Traffic signs include roadside signs and curb mounted signs along the entire road network in scope. Signage shall be provided as per IRC Standards.

ii) Pavement markings:

Pavement markings shall cover road marking for the entire road network in scope as per IRC standards.

iii) Pedestrian facilities:

The Pedestrian facilities shall include the provision of the;

Pedestrian crossing facilities at intersections and mid-block locations required by the Employer.

iv) Street Lighting

Street lighting within the scope of work in the Right of Way shall be as per road plans in drawings volume. This work comprises of poles & fixtures, lighting cables, optical fibre cables, controllers etc.

S. No.	Element	Proposed Minimum Illumination Level (Lux)
1	Roads (BRT lane)	In accordance with the Standards and specifications
2	Cycle track and side walk	
3	Junctions and Pedestrian Crossings	

Street lighting shall be provided in accordance with the Standards and Specifications as referred in **Schedule-D**.

Schedule D - Specifications and Standards

(See Clause 2.1)

Technical Specifications and Standards:

Contents

1.0 Construction

The Contractor shall comply with the Specifications and Standards set forth in Annex-I of this Schedule-D for construction of the Project Road.

2.0 Design Standards

The Project Road shall conform to design requirements set forth in Annex-I of this Schedule-D.

Annexure – I (A)

Specifications and Standards for Construction of Roads

1.0 Roads

Standards and Specifications of following project components are given in this section;

- Road works: road furniture, road markings, road signage, traffic control devices, safety works, pedestrian facilities, median plantation, etc.
- Structures: storm water drainage structures etc.

1.1 The Codes, Standards and Technical Specifications applicable for the design and construction of project components are:

i. Indian Roads Congress (IRC) Specifications, Standards, Design Codes

ii. IRC Special Publications

iii. Ministry of Surface Transport Publications (Now Ministry of Shipping, Road Transport & Highways)

iv. IRC Seminar Publications

v. Policy circular/Advisory letters issued to all states/UTs on the matter pertaining to urban transport April 2008 – October 2014

vi. Geometric Design standards for Urban roads in Plains i.e. IRC: 86-1983

vii. Any supplement issued with the bid document

Latest version of the Codes, Standards, Specifications, etc., notified/published at least 60 days before the last date of bid submission shall be considered applicable.

1.2 Where the Contractor intends to use an alternative to these Standards/Guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

He shall demonstrate that the proposed alternative conforms to any of the following International Standards, Codes of Practice, Specifications, Guidelines, etc.

i. American Association of State Highway and Transportation Officials (AASHTO)
ii. American Society for Testing of Materials (ASTM)
iii. Euro Codes
iv. National Standards of any of the following countries: United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, Netherlands, Spain, Australia, New Zealand, Japan and South Africa

In case the Contractor intends to use any alternative material/ technology/ method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar projects (similar in category of road, traffic and climatic conditions) as the Project Road, he would be permitted, its use on certification by the owners of such similar projects regarding the continued successful performance of such materials, technologies, methods, procedures or processes for at-least 5 years of the service life of the project. Such a certification shall be supported with details of critical performance parameters.

1.3 Standards and Specifications for Construction

The Contractor shall comply with the Standards and Specifications for Construction of roads and utilities / services as given below.

All materials, works and construction operations shall conform to the Specifications for Road and Bridge Works (Fifth Revision, April 2013), issued by the Ministry of Road Transport & Highways (MoRT&H). Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

1.4 List of Standards

List of Standards are given in Table: 1, Table: 2, Table: 3 and Table: 4.

Latest revision of codes shall be referred.

Table-1

S. No.	Description	Code/ Document No
1	Recommended Practice for the Design and Layout of Cycle Tracks	IRC:11
2	Space Standards for Roads in Urban Areas	IRC:69
3	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas	IRC:70
4	Geometric Design Standards for Urban Roads in Plains	IRC:86
5	Guidelines on Accommodation of Underground Utility Services Along and across Roads in Urban Areas (Second Revision)	IRC:98
6	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads	IRC:99
7	Guidelines for Pedestrian Facilities	IRC: 103
8	Guidelines for Capacity of Urban Roads in Plain Areas	IRC: 106
9	Guidelines for the use of Interlocking Concrete Block Pavement	IRC: SP: 63
10	Tentative Recommendations on the Provision of Parking Spaces for Urban Areas	IRC: SP: 12
11	Code of Practice for Road Markings (with Paints) (First Revision)	IRC:35
12	Code of Practice for Road Signs (Third Revision)	IRC:67
13	New Traffic Signs	IRC: SP:31
14	Vertical Curves for Highways	IRC: SP:23
15	Guidelines for the design of curves for Highways & Design tables (First Revision)	IRC:38
16	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas	IRC: SP: 41
17	Highway Safety Code	IRC: SP: 44
18	Guidelines on Urban Drainage	IRC: SP: 50
19	Tentative Guidelines for the Design of Flexible Pavements	IRC:37
20	Dimensions and weights of Road Design Vehicles	IRC:3
21	Guidelines for the Design and Construction of Cement Concrete pavements for Low Volume Roads	IRC: SP: 62

Table-2

Element of roads/services	Design Standards/Guidelines used for design	
	Code No.	**Description**
Ground improvement	HRB SR No.14	State-of-the-Art-Report: High Embankments on Soft Ground, Part B – Ground Improvement
Embankment filling	HRB SR No.3	State-of-the-Art-Report: Compaction of Earthwork and Subgrades
Pavement design	IRC: 37	Tentative Guidelines for the Design of Flexible Pavements
	IRC: 58	Guidelines for the design of plain jointed rigid pavement for highways
	IRC: SP:62	Guideline for the design and construction of cement concrete pavements for low volume roads
Road markings	IRC: 35	Code of Practice for Road Markings (First Revision)
Signage	IRC:67	Code of Practice for Road Signs (Third Revision)
Landscaping	IRC: SP:21	Guidelines on Landscaping and Tree Plantation
Pedestrian facilities	IRC:103	Guidelines for Pedestrian Facilities (First Revision)
Cycle tracks	IRC:11	Recommended Practice for the Design and Layout of Cycle Tracks
Safety features	IRC: SP: 44	Highway Safety Code
Traffic lights	IRC: 93	Guidelines on Design and Installation of Road Traffic Signals
Junctions / Median openings	IRC: SP:41	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
Kerb and separator	IRC:86	Geometric Design standards for Urban roads in plains
Drains	CPHEEO, IRC SP-42 IRC SP-50	Guidelines for Road Drainage Guidelines for Urban Drainage

Table -3 (Street Light- Standard for installation)

Code	Standard for installation
IS:1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
IEC:60947	Switchgear Protective Components.
IEC:60598 – 2 – 3 IUT (Institute of Urban Transport)	Particular requirements luminaries for road & street lighting. Standard for road lighting.
IS:2309	Code of practice for Lightning Protection.
IS:3043	Code of practice for Earthing.

Table-4 Street Light- Design Standards

Code	Design Standards
IS:7098 (Part- II & Part-III) 2003 IS:8130	Standard for XLPE Cables, Part – II up to 3.3 kV to 33 kV and Part– III from 33 kV to 220 kV). Specification for conductors for insulated electric cables & flexible cords.
IS 1554 (Part I & Part – II)	Specification for PVC insulated (Heavy Duty) electric cables ✓ Part 1 For working voltages up to and including 1100 • Part 2 For working voltages from 3.3 kV up to and including 11 kV
IEC:61439 IEC:60947	Feeder Pillar & Switchgear (Totally Type Tested Assembly TTTA). Switchgear Protective Components.
IEC: 60598 – 2 – 3 • IUT (Institute of Urban Transport) • CIE (Industrial commission of illumination)	✓ Particular requirements luminaries for road & street lighting • Standard for road lighting • Road Transport Lighting for Developing Countries
IS:2309	Code of practice for Lightning Protection
IS:3043	Code of practice for Earthing
IS:1944	Code of practice for lighting of public thoroughfares
IS: 1367 • BS EN ISO 1461 • BS EN 10025-1:2004	Standards for Poles & Masts (1) Recommended practice for hot-dip galvanizing of iron & steel Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods (a) Hot rolled products of structural steels. General technical delivery conditions

Annexure – I (B)

Storm Water Drainage

Standards and Specifications for the Design & Construction of Storm Water Drainage are given in this section.

The Scope of Work shall include:

- Detailed design, plans, L sections and construction drawings of storm water drainage system;
- Submission of SWD design calculations, plans and drawings for approval to the client;
- Construction of storm water network as per approved design and plans; and
- Erection, Testing, Commission of the System and,
- Integration of main road trunk drains with the connecting LPS storm water drainage network.

The contractor shall design and construct the storm water drainage network and shall furnish all required tools, plant, instruments, materials including water, electricity, labour, consumables, etc., any and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid.

The primary objective of drainage design is to protect the area from flooding and efficient operation of systems during the design storm events. The drainage system is designed to collect storm water run-off from roadway surface and right-of-way along with runoff from LPS lots drainage network and convey it along and through the storm water network and discharge into a receiving body above the design HFL without causing adverse site impacts.

Storm water collection systems shall be designed to provide adequate surface drainage. Surface drainage is a function of transverse and longitudinal pavement roughness, inlet spacing and inlet capacity.

The discharge design facilities for storm water collection and conveyance systems include consideration of storm water quantity and quality. The general considerations in design of storm water drain shall be:

- Drains shall be design for appropriate design frequency/return period depending on importance of development and economic considerations.

- Drains shall be planned taking into consideration the ground levels, slope of the ground, valley and ridges and also the land uses planned for urban development.

- Drains shall be planned to get good longitudinal slope, considering the nature of soil and subsoil water level. Drainage of large area can be better achieved by subdividing it into small grids to avoid a long main drain. Aim should be to get a high velocity for the dominant flow.

- Efficiency in maintenance of drainage system is an important consideration in selecting the size, shape and the location. The specification of the drain shall also aim at preventing the possibility of ingress of other extraneous materials, debris, vegetation etc. where grating are provided on drains, they shall be so located as to attract attention of maintenance staff, easy to approach, inspect and clean it.

1.0 Catchments

Catchments shall be divided based on the topography and road layout. The outfalls shall be proposed considering the topography and location of Trunk Drains /primary channels within the area.

1.1 Storm Frequency/ Return Period

The components of proposed storm water drainage system shall be designed for the following design standards based on the national and international best practices:

- Once in 5year event flows for storm water drains;

The average intensity of rainfall for the above return period (t) event will be calculated from rainfall data for the derived time of concentration of the catchment.

1.2 Rainfall Intensity

As no hourly rainfall data is available within proposed Capital City area, hourly rainfall data for Gannavaram Airport has been considered in order to derive the Intensity-Duration-Frequency curves. Hourly rainfall data for 47 years (1969 to 2015) is available

from meteorological department. Rainfall intensity derived by analyzing the rainfall data with rainfall Intensity-Duration-Frequency (IDF) curves for once in 2-year, 5- year and 10-year criteria. Based on above data/information, Intensity-Duration-Frequency (IDF) Curves for 2,5 and 10 years return period to estimate the design rainfall intensity of various durations has been worked out and given below:

						a	n						
Table for Intensity -Duration	2 Yr Return Period					346.065014	0.516199						
Duration (t) in min	5	10	15	20	25	30	40	45	50	60	80	100	120	180
Intensity (i=a/t^n) in mm/hr	150.78	105.43	85.52	73.72	65.70	59.80	51.54	48.50	45.94	41.81	36.04	32.12	29.23	23.71
						a	n						
Table for Intensity -Duration	5 Yr Return Period					564.644562	0.569814						
Duration (t) in min	5	10	15	20	25	30	40	45	50	60	80	100	120	180
Intensity (i=a/t^n) in mm/hr	225.68	152.04	120.68	102.43	90.20	81.30	69.01	64.53	60.77	54.77	46.49	40.94	36.90	29.29
						a	n						
Table for Intensity -Duration	10 Yr Return Period					619.267437	0.561687						
Duration (t) in min	5	10	15	20	25	30	40	45	50	60	80	100	120	180
Intensity (i=a/t^n) in mm/hr	250.77	169.90	135.30	115.11	101.55	91.66	77.99	72.99	68.80	62.10	52.84	46.61	42.08	33.51

Table-1 - IDF Table for Gannavaram Airport (Hourly Rainfall Data 1969-2015)

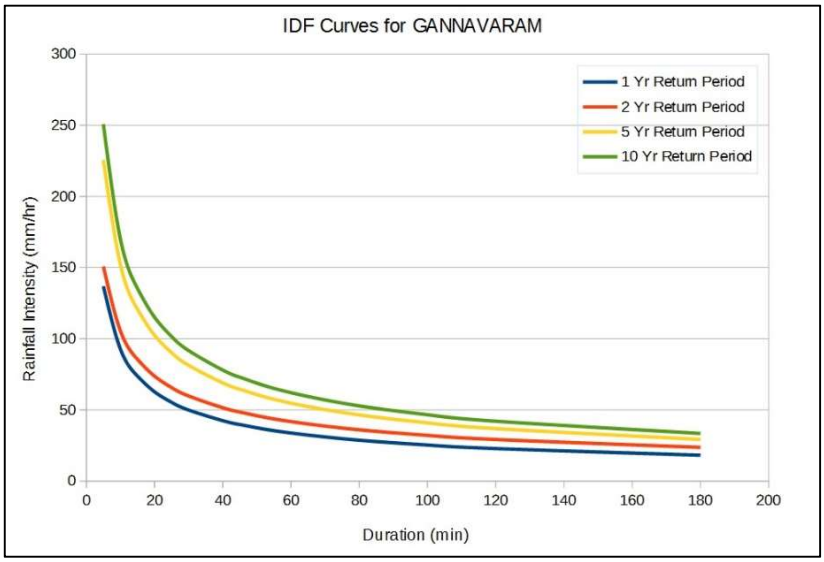


Figure-1 IDF Curves at Gannavaram Airport (Hourly Rainfall Data 1969-2015)

1.3 Other Design Parameters

1.3.1. Minimum and maximum velocity within drains

To ensure self-cleaning of the drain, a minimum velocity of 0.6 m/ s may be desirable. (Ref: CPHEEO manual). The velocity of flow in a drain shall not be too great to cause excessive scouring or hydraulic jumps. Hence maximum velocities shall be limited to 3.0m/sec within concrete drains.

1.3.2 Inlet Spacing

The spacing of inlets depends on condition of road surface size and type of inlet and rainfall. They shall be provided at closer intervals near junctions and valley curves; however maximum spacing shall not be more than 20 m.

1.3.3 Freeboard

Freeboard refers to the depth from the top of the drain (cope/bank) to the top of the water surface in the drain at design flow condition. Sufficient freeboard shall be provided to prevent waves or fluctuation of the water surface from overflowing the cope/bank. Free board shall be as per IRC SP 50 as below:

Table-2 Minimum Free Board

S. No.	Drain Size	Free Board
1.	Beyond 300 mm bed width	10 cm
2.	Beyond 300 mm & upto 900 mm bed width	15 cm
3.	Beyond 900 mm & upto 1500 mm bed width	30 cm

Table-3 Design Basis Parameters

Parameter	Expert Committee Recommendation
Design Storm Frequency	1 in 5 year
Check for Extreme Storm	1 in 100 year (for Hazardous Index)
Bridges	1 in 100 year

Method	Rational
Time of Concentration	Overland Flow (IRC SP 42) + Time in Drain
Runoff Coefficient	Land Use Based (weighted)
Minimum Velocity	0.6 m/s
Maximum Velocity	3.0 m/s
Minimum slope	0.1% (Others-Min Velocity)
Minimum size	450mm for Box Drain
Minimum Freeboard	Varies with Width of Drain
Preferred type of Drain	Box 0.45 x 0.45 (minimum)
Maximum spacing of Manholes	30 m
Minimum Tc	5 min
IDF curves	Gannavaram Airport 1-hour Rainfall data and Using the CPHEEO step Method
Manning's n	As per industry standard

1.4 Design Methodology

1.4.1 Rational Method

Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff is dependent on the intensity and duration of rainfall, characteristics of tributary area and the time required for such flow to reach the drain. The usual case for urban drainage system, the Rational method is widely used for estimating the peak runoff rates. The formula is:

Q = 0.278 CIA

Where:

Q = flow, m3/s

C = weighted runoff coefficient

I = rainfall intensity in mm/hr

A = drainage area in square kilometres

Assumptions

Assumptions inherent in the Rational Formula are that:

- Peak flow occurs when the entire watershed is contributing to the flow.
- Rainfall intensity is the same over the entire drainage area.
- The frequency of the computed peak flow is the same as that of the rainfall intensity,
- The coefficient of runoff is the same for all storms of all recurrence probabilities.

1.4.2 Time of concentration

The storm duration chosen for design is equal to the time of concentration. Maximum discharge in drainage system occurs when the entire catchment is contributing to the flow. The time of concentration, (t_c) is the time required for a given drop of water from the most remote part of watershed to reach the point of interest.The concentration time depends on the distance from the critical point to the inlet t_e and the time of travel in drain t_d.

1.4.3 Critical Intensity

The critical intensity for a catchment is that maximum intensity which can occur in a time interval equal to the concentration time t_c of the catchment during the severest storm (in the region) of a given frequency I_c

Overland flow equations are to be considered to calculate the time of entry in to storm water drainage system inlets. The most popular equation used around the world for overland flow is Kerby equation. For Indian conditions, The IRC SP:42-2014 sheet flow equation as below is to be considered for the time of entry for the storm water designs.

$$\mathbf{T_{sf} = 0.092*((n*L)^{0.8}/((P2)^{0.5} *(S)^{0.4}))}$$

Where, T_{sf} = Travel time in hours; n= Manning's roughness coefficient; L = Flow length in m;

P_2 = 2 year, 24-hour rainfall in mm/hr; S = Slope of catchment area (m/m)

1.4.4 Runoff Coefficient

The runoff coefficient, C, in Equation is a function of the ground cover and a host of other hydrologic abstractions. It relates the estimated peak discharge to a theoretical maximum of 100 percent runoff. Typical values for C are given in table below based on land use pattern. If the basin contains varying amounts of different land cover or other abstractions, a composite coefficient can be calculated through area weighing using Equation below:

Weighted C = $\Sigma(C_x * A_x)/A_{total}$

Where: x = subscript designating values for incremental areas with consistent land cover**.**

1.4.5 Hydraulics

The size of the drains shall be determined using Manning's formula. The Manning's equation is given below:

$Q = (A\ R^{2/3}\ S^{1/2})/n$

Where,

Q = discharge capacity of the drain in m3/s

N = manning's roughness coefficient

A = flow area in m^2

R = A/P = hydraulic radius in m

P = wetted perimeter in m

S = channel slope

Table-4 Runoff Coefficients for Rational Formula

Zone	Land Use	I value	Runoff Coefficient C
C1	MIXED USE ZONE	70	0.7
C2	GENERAL COMMERCIAL ZONE	74	0.74
C3	NEIGHBOURHOOD CENTRE ZONE	78	0.78
C4	TOWN CENTRE ZONE	80	0.8
C5	REGIONAL CENTRE ZONE	80	0.8
C6	CENTRAL BUSINESS DISTRICT ZONE	80	0.8
	CANALS	10	0.1
	DRAINS	10	0.1
	HILLS	10	0.1
I1	BUSINESS PARK ZONE	70	0.7
I2	LOGISTICS ZONE	80	0.8
I3	NON-POLLUTING INDUSTRY ZONE	80	0.8
	OPEN LAND	15	0.15
P1	PASSIVE ZONE	20	0.2
P2	ACTIVE ZONE	20	0.2
P3	PROTECTED ZONE	10	0.1
P3-HILLS	PROTECTED ZONE	10	0.1
R1	VILLAGE PLANNING ZONE	35	0.35
R2	LOW DENSITY ZONE	50	0.5
R3	MEDIUM TO HIGH DENSITY ZONE	60	0.6
R4	HIGH DENSITY ZONE	75	0.75
	ROADS	90	0.9
S1	GOVERNMENT ZONE	60	0.6
S2	EDUCATION ZONE	60	0.6
S3	SPECIAL ZONE	60	0.6
	EXISTING SETTLEMENTS	25	0.25
	STREAMS	10	0.1
U1	RESERVE ZONE	15	0.15
U2	ROAD RESERVE ZONE	90	0.9
	WATERBODIES	10	0.1
	UPSTREAM PROTECTED CATCH-MENT ZONE (KONDAVEEDU HILLS)	10	0.1
	REST OF THE SUB-CATCHMENT AR-EAS	15	0.15
	EXISTING VILLAGES	25	0.25

1.5 Network for Storm Water System

Collection Network shall be planned considering natural topography and planned grade levels. The network is designed on the assumption that although silting might occur at minimum flow, however it should be flushed out during peak flows.

The source controlled and volume restricted storm water from the roof and open area of developed residential, commercial, and industrial LPS plots gets into the system though downspouts and catch basins. The road drainage is catered through horizontal gratings at a specified interval along the road kerbs. The type of material for the inlet gratings decided considering the factors of vehicular loading, non-clogging, easy maintenance, and anti-theft.

The SuDS measures should come into picture and detain/ intercept/ clean runoff and convey to the nearest storm drains. Topographic survey of site and proposed plot levelling plan shall be utilized for hydraulic gradient of storm drains, for fixing invert levels, HGL, drain top levels, etc. The storm drains run along the roads within a block collecting the storm water and conveys it to the tertiary collector storm drains running on all the major arterial/ sub-arterial roads. Tertiary network consisting of box drains eventually discharge in the vagu directly or through the secondary network of box drains.

The tertiary drains are to be box type and to withstand the expansive soil pressures, minimization of cover due to flat terrain and for easy maintenance regime later. The access for maintenance in to precast box drains shall be from short depth precast chambers and covers at a specified interval. The tertiary drains are in turn connected to box drains as **secondary drains**, and these drains shall outfall into primary channels i.e., vagus above the HFL within the Capital city. Secondary and Tertiary storm water drainage network is to be designed using an industry standard storm water analysis design software (ex: Sewer GEMS) with an in-built storm water design module to arrive at size, capacity, nodes/ junction points and outfall points etc., for each planning zone.

1.6 Access Inspection Manhole Covers

- As per IS-4111: 1986, the size of manhole covers should be such that there should be clear opening of not less than 560 mm diameter.
- Manhole cover and frame will be SFRC (Steel Fiber Reinforced Concrete) conforming to the IS 12592.

Table-5 Access Manhole Cover Details as per IS 12592

Manhole Type	Load withstanding capacity	Suitable Locations
M.D(Medium Duty)	10.00 MT	Light four wheelers, NMT, walkways
H.D (Heavy Duty)	20.00 MT	Heavy vehicles
E.H.D (Extra Heavy Duty)	35.00 MT	Heavy traffic roads

1.7 List of Standards and Specifications

The design and Construction of storm water drainage network and the outfalls shall conform to design requirements and Construction specifications set out in the following Indian and International Standards.

- IS - 456 Code of practice for Plain & Reinforced concrete;
- IRC SP-50-1999 - Guidelines on Urban Drainage
- IS - 458 Pre-cast Concrete Pipes (with and without reinforcement);
- IS 783 -1985 Width and depth of trench for R.C.C. Pipes;
- IS 1726 Specification for Cast Iron Manhole Covers and Frames;
- IRC SP-42-1994 - Guidelines on Road Drainage
- IS 4985-2000 Un-plasticized PVC pipes for potable water supplies - specification;
- IS 12235- (Parts 1 to 19) Thermoplastics pipes and fittings - methods of test; and
- IS 12592 Pre-cast Concrete Manhole Covers and Frames – Specifications.
- Schedule of specifications of Govt. Of Andhra Pradesh and C.P.W.D. specifications (Govt. of India) 2009 with all latest amendments issued from time to time;

- CPHEEO Manual for Sewerage and Drainage -2014 - MoUD, GoI
- SP 35:1987 - Hand book of Water Supply and Drainage, Bureau of Indian Standards;
- Manual on artificial recharge of ground water by Central Groundwater Board Ministry of Water-Resources Government of India;
- Rain water harvesting and conservation Manual by consultancy services organization CPWD, New Delhi, India;
- Code of Practice on Surface Water Drainage by Public Utilities Board, Singapore; and
- Managing Urban Runoff Drainage Handbook by Public Utilities Board, Singapore.

Annexure – I (C) - i
Potable Water Supply
Standards & Technical Specifications

SECTION - I
GENERAL TECHNICAL SPECIFICATION

1. SITE CONDITION

The sites of the intake well-cum-raw water pumping station, water treatment plant, clear water reservoir and pumping station, water distribution centers and pipelines are on plain to undulated lands. The Tenderer shall verify the location of the above installations by inspection of the sites and shall apprise himself of the local condition before submitting the Tender.

2. SUB-SOIL REPORT

Sub-soil investigation was carried out by the ADC/APCRDA mostly along the arterial and sub-arterial roads. Sample soil data are presented in Appendix-1.

These soil data can be referred for design of pipeline layout and for road. The Tenderer shall satisfy himself about the adequacy of these data for design of pipelines and roads under this Tender. For structures like intake well-cum-raw water pumping station, water treatment plant, clear water reservoir-cum-pumping station, electrical sub-stations and other ancillary structures, pile foundation is strongly recommended. The tenderer shall carry out detailed geotechnical investigation by drilling bore holes at these work sites for foundation design, before submission of his tender, tenderer may visit these work sites and assess quantum of geotechnical investigation at his own cost for his own satisfaction. After getting the L.O.I., it is mandatory that the successful Tenderer shall have to undertake fresh geotechnical investigation of soil at the exact locations of the structures to design the foundation properly. At each work site, at least four bore-holes shall be drilled for proper investigation and records of such sub-soil investigation such as bore hole logs, soil samples, SPT values etc., shall be done by the Agency duly witnessed and authenticated by the Engineer-in-Charge- in- Charge or his competent authorized representative.

In the event of variation in preliminary soil data put up in NIT and those obtained by the Agency during execution, the more conservative values obtained from the two sets of reports shall be adopted for design without any extra claim over the quoted price as accepted by the Authority.

3. TENDER DRAWINGS

3.1 Site Layout Plan including alignment of the trunk pipelines, general arrangement of the Intake Well-cum-Raw Water Pumping Station, Water Treatment Plant, Clear Water Reservoir -cum- Pumping Station are shown in Tender Drawings. These drawings are meant for giving the Tenderer a general idea of the proposed water-work components. The various levels and dimension of these structures are to be fixed by the Agency according to the guidelines provided by the Authority. All levels are to be approved by the Engineer-in-Charge before execution. The effective capacity of the Clear Water Reservoir excluding free board, columns, baffle walls and any other civil structures in the reservoir, volume of water in depressed sump, 0.15m dead storage will be 64 million litre. If as per dimension proposed by the Tenderer, the Capacity of the Reservoir is found to be more than 64 million litre, no extra payment on account of increased capacity will be made.

There may be variations in details and sizes of pump bases, cable trenches, different working rooms, sump depth, levels etc. depending on the specification of the suppliers of Pump, Motor etc. which shall be accommodated by the successful Tenderer during construction without any extra cost to ADC. The final working drawings will be vetted by the pump & motor suppliers to satisfy their requirements and also be approved by EIC.

3.2 A tentative Lay-out Drawing showing the location and levels of the Intake Well-cum-Raw Water Pumping Station, Water Treatment Plant, Clear Water Reservoir-cum-Pumping Station, alignment of raw water and clear water trunk mains and WDCs is enclosed in the NIT. The Tenderer has to quote his Rate for Construction of Entire Water Supply system as specified considering all structures except certain minor structures like valve chambers, thrust blocks, small building (upto G+1) in deep cast-in-situ R.C.C. Bored Piles Foundation. The Tenderer has to quote his rate on the basis of his own design as per Tender Stipulations, which is not to be submitted with the Tender.

However, a tentative design and lay-out drawing if different from the tender drawing, showing the scope of civil work including size, shape, inlet and outlet arrangements, overflow arrangements etc. as proposed by him, shall have to be submitted with the tender. The work will however, be executed on the basis of the detailed designs and drawings submitted by the successful Tenderer which will be prepared on the basis of the Technical Parameters and the terms and conditions of the NIT duly approved by the Authority.

The RCC pile foundation has to be in such a manner that the same can withstand all dead loads, live loads, effect of wind, earthquake and service loads. The pile foundation must satisfy the settlement criteria.

4. FLOOR SPACE REQUIREMENT

Requirement of Floor Spaces and tentative Room Sizes at various water-work sites are given below:

S. No	Description	Min. Area of Room (Sq.m)
At Intake Well		
1	Electric Indoor Substation / SCADA Control Room	607.50
2	Office cum-Guest House (G+2)	300 in each floor
3	Staff Quarter (G+4) – 2 Nos	100 in each quarter in each floor
4	Security Cabin	10
At WTP		
5	Administrative Building (G+2)	600
6	Electric Indoor Sub-Station / SCADA Control Room	649.25
7	Chief Engineer's Bungalow (G+1)	150 in each floor
8	Chief Engineer's Bungalow (G+1)	120 in each floor
9	Staff Quarters (G+4) - 1 No - A & B Category Employees-8 no's	120 in each quarter 240 in each floor
10	Staff Quarters (G+4) - 1 No - C Category Employees-8 no's	100 in each quarter 200 in each floor
11	Command Control Centre	180
12	Security Cabin	10

At SUGRs

Location of SUGR-cum-Pump house along with minimum area required is given below.

Location		Area Available (Sq.m)
WDC No.	Nearby Village Name	
18	Dondapadu	5055.50
23	Ananthavaram	5234.72
24	Thulluru	5134.31
42	Nekkallu	3825.99

43	Ananthavaram	6670.42
44	Ananthavaram	5930.88
45	Nekkallu	5948.35
46	Nekkallu	6217.54

Note: Need to confirm with APCRDA

5. MANDATORY LEVELS

Mandatory Levels for various water-work units are given below:

- Avg. Existing Ground Level at WTP : +19.0 M
- Seed Access Road Level (finished) : +21.5 M
- HFL of Krishna River at Prakasam Barrage : +21.5 M
- HFL of Kondaveeti Vagu : +15.0 M
- Finished Ground Level of WTP campus : +22.0 M
- MWL of CWR : +22.5 M
- Free Board in CWR : 0.50 M
- Minimum depth of water in CWR : 5.00 M
- Repair Bay floor level of CWPS : + 22.50 M
- Top level of Crane Rail in CWPS : + 29.00 M
- Clear height of Substation Room / H. T. Room: 4 M
- Office room : 4M
- Clear height of Control Room/L. T. Panel Room: 5.0 M
- Clear Opening for Roller Shutter for unloading Bay: 3.60 M wide x 4.50 M Height
- Plinth Level of Building : 0.5 M above FGL

6. DESIGN CRITERIA

6.1 The basic layout of the Intake-cum-Raw Water Pumping Station, Water Treatment Plant, Clear Water Reservoir and Pumping Station shall be as per Indicative Drawings provided in the Tender Document necessary modification will be allowed if found suitable by the Authority. The Elevation of the Intake-cum-Raw Water Pumping Station, Administrative building, Chemical and Filter house in the Water Treatment Plant and other superstructures shall be of suitable Architectural design. The Tenderer shall submit with his Tender, the Architectural Elevation of these buildings. However, the architectural Elevation may have to be modified at the time of approval by the Authority for which no extra charge will be paid.

Design and construction of all RCC Structures, brick masonry walls and Foundation shall conform to the latest edition of the following IS Codes:

a) Loading Standards	IS: 875
b) Earthquake Resistant Design	IS: 1893 & IS: 4326
c) Reinforced and Plain Concrete	IS: 456
d) Foundations	IS: 1080, IS: 2950
	IS: 2911 & IS: 2974
e) Liquid Retaining Structures	IS: 3370
f) Structural Steel	IS: 800
g) Reinforcement	
Mild Steel	IS: 456 & IS: 432
Ribbed Tor Steel	IS: 1786 & IS: 1139
h) Masonry and Brickwork	IS: 1905 & ISS: 2212
i) National Building Code of India	
j) Design & Construction of Pile Foundation	IS: 2911

6.2 All the structures of the Water Supply system except minor structures shall be including the Clear Water Reservoir, the Pump House Building the Pump Suction Sump and maintenance/repairing Bay shall be designed with deep Cast-in-situ RCC bored Pile Direct Mud Circulation Foundation. It is to be noted that no foundation other than Pile Foundation will be accepted. Minor structures like valve chambers, Weigh Bridge etc. may be constructed on the virgin soil if its bearing capacity is found to be sufficient to take the entire load from the structures. The Agency has to satisfy the Authority about the justification of the ordinary foundation for the minor structure. It may be noted that only the Engineer-in-Charge has the right to designate a structure as minor structure.

Such piles shall be bored Cast-in-situ R.C.C. Piles. The design, construction and workmanship for these piles shall fully conform to and satisfy the codal requirements of IS 2911 (Latest Edition). Concrete to be used in Piles shall be of M-25 Grade having a Cement content not less than 400 kg/m3. Reinforcement in piles shall be in conformity with the requirements contained in IS:2911 (Latest Edition). The minimum area of Longitudinal

Reinforcements shall be as per Codal requirements and such requirements shall be provided for the full length of piles. For piles subject to Upward Tension, reinforcement shall be provided throughout the full length and such reinforcement shall be designed on the basis of upward load they are supposed to carry.

The safe working loads of the R. C. C. Cast-in-situ bored piles shall be that as computed as per IS:2911 on the basis of Sub-soil Parameters of the Site with a minimum Factor of Safety 2.5 (Compression) and 3.00 (Tension) applied there on. The safe working load or the design capacity of the piles shall be least of the design capacity calculated according to the Agency soil exploration data and the data provided in the Tender Document. The Diameter, Length, Cut Off level, Termination Depth of piles under the different structures shall be according to the layout and levels of the structures following the Department's guidelines. It is mandatory to the Agency to approve his proposal of general arrangements, layouts and levels of the different structures including foundation details by the Authority prior to the execution.

In case of any change in Cut off levels, necessary adjustment in the safe working load will be made. Pile Termination levels shall be chosen carefully. The safe working load of the piles shall be substantiated by Routine Load Test. Sub-soil investigation after award of contract by the Tenderer shall be witnessed by the Engineer-in-Charge or his authorized Representative. The Pile Termination Level shall not be reduced from that stated herein the Soil Investigation Report attached with the Tender Document unless otherwise permitted by the Engineer-in-Charge.

The Agency shall maintain the cutoff level of the piles under Underground Reservoir and Clear Water Pump House at a required depth below existing ground/road level. If not possible, the pile cutoff level of the other structures shall be in such a level that it shall be well below the respective ground level, whatever undulation there will be at the respective site. This Piles shall be designed for Seismic Condition also. The Important factor for Seismic Analysis of Structure shall be 1.50. The Tenderer shall include in his Lump Sum price the cost for Load Test of at least one working pile (Routine Test) per 100 piles or part thereof. The testing shall be as per codal Stipulations. The Tenderer shall also include in his price the cost of installation of one R. C. C. cast-is-Situ, Bored Non-working pile having same Structural Details as of Working Pile and Pull out Test of the same as per Codal Stipulations.

6.4 If during initial pile load testing at site, the safe load bearing capacity is found to be more than what has been tabulated in the Agency Soil Investigation Report, the least safe load of the two as furnished by the department or as per Agency Soil Investigation Report shall be followed for which no extra claim will be entertained. In case, the safe load bearing capacity during load testing of piles of site is found to be less that what has been provided in the table furnished by the department, the lesser value shall be followed, in this case also, no extra claim be entertained.

6.5 While designing the Foundation of different structures, the Tenderer may use the Soil Investigation results provided in the Tender. The successful Tenderer shall have to undertake fresh investigation of soil by an approved agency at locations decided by the Engineer-in-Charge after the entire layout of the plant have been decided upon and approved at his own cost for submitting the final design of the foundation and for detailing the piles in conformity with the Soil Test Report.

In the event of variation in Soil Data provided in the NIT and those obtained by the Agency during execution, the more Conservative Values between the two sets of Reports shall be adopted for design. While adopting the conservative values, if the number, diameter and the length of the piles to be provided for safe design increases, the cost of such additional piles shall be paid in accordance to the Schedule of Rates of Public works (Roads) Department for Roadworks, Bridge, Culvert Works & Carriage etc. as was in vogue on the date of submission of the tender. The decision of such payment rests with the Authority.

7. DESIGN PARAMETERS

The parameters and methodologies of hydraulic designs and process designs shall strictly comply with the requirements of the latest edition of “Manual on Water Supply and Treatment” and “Manual on Sewerage and Sewage Treatment” by Central Public Health and Environmental Engineering Organization. Wherever limit has been mentioned for design parameter in CPHEEO manual, minimum average of upper limit and lower limit shall be considered. Wherever the parameters and methodologies are not available, the same can be adopted from the IS Codes or Standard Textbooks. No design parameters and methodologies shall be allowed to use unless those are supported by the basic law of physics and chemistry.

All structural analysis and design procedures must comply with the norms as stipulated in relevant latest IS Codes. It is mandatory to the Agency to abide by all the norms or instructions of the relevant latest IS Codes. No other software will be accepted for structural design except STAAD.

The Authority will accept no hydraulic, process or structural analysis and/or design procedures or methodologies, which are not stated and defined in CPHEEO Manual, IS Codes or in Standard Textbooks. The Agency shall not declare any such book as Standard Textbook, which will not be accepted by the IITs regarding the procedures and/or methodologies under question.

The design ambient temperature and water temperature shall be 15ºC.

For all liquid retaining structure and other RCC structures except piles, micro silica admixture of approved quality and make at the rate of 5% by weight of cement used in concrete as per IS Code of practice shall be applied for protection from leakage and corrosion.

8. LOADINGS

Loading shall be as per relevant IS code. However, following Live Load are specified in the respective areas for this project:

i.	Operating platform and walkways	300 kg/m^2
ii.	Pipe gallery	750 kg/m^2
iii.	Control panel switch room, chlorination room, laboratory, wash pump room, blower room, store room etc.	500 kg/m^2
iv.	Passage, corridors, entrance lobby, toilet etc.	300 kg/m^2
v.	Accessible flat roof	150 kg/m^2
vi.	Shell roof and other inaccessible roof	75 kg/m^2
vii.	Space in front of alum/coagulant dosing tank	750 kg/m^2
viii.	Walkway over clear water channel of filter house	500 kg/m^2
ix.	Live load on pump house Floor	500 kg/m^2
x.	Live load on Control Room Floor	300 kg/m^2

8.1 Clear Water Reservoir

A park is proposed to be located on the roof of the Clear Water Reservoir. The roof is to be designed for a live load of 400 kg/M^2 and the superimposed Load of saturated compacted earth of 500 mm. depth. No relief shall be allowed due to this Superimposed Load of saturated earth while computing the Uplift on the reservoir.

8.2 Clear Water Pumping Station

Besides the above, the Tenderer shall assess the loading arising from various machines, control panels, pumps & motors including base frame, cable and pipe trenches etc. and the supporting units are to be designed to withstand all types of dead and live combinations. The effect of impact loading and vibration effect due to rotating machinery as per relevant IS Codes are to be analyzed and properly assessed by the Tenderer during design and execution. Other live loads not specified above shall generally conform to IS:875 latest edition.

N.B. Loading details given herein above are tentative and subject to verification during final execution. No extra cost will be paid to the Agency on account of variation within $\pm$ 30 % limit.

Vertical load data for pumps and motors are inclusive of impart factor subject to confirmation of the Pump Manufacturer during final design. The cost in this regard shall by included in the lump sum offer by the Tenderer and no additional claim will be entertained in future due to variation in load data, if any.

The floor slab is to be designed for the worst loading conditions that the floor will be subjected due to the equipment to be housed and may be put anywhere on this floor. The floor slab shall be so designed as to withstand such loads.

The floor supporting M. S. suspenders / Cable trays are to be designed for a concentrated static load of 200 Kg. at any point. The Cable Trenches wherever provided shall be absolutely free from any obstruction so as to allow the Cables to be lowered in the trenches from top only during laying.

Live load in Battery Room, operator Room and Store	500 Kg/Sq.m
Load of M. S. Chequered Plates	500 Kg/Sq.m
For trench covers over opening in Floor	500 Kg/Sq.m
Loading from all Electrically & Manually operated Crane	As per Crane Manufacturer's Specifications

The Unloading Bay of Clear Water Pumping Station is to be designed for 18 MT full truck load. All cover slabs placed on the drains, cable ducts etc. subjected to thoroughfare of vehicles are to be designed for 18 MT full truck load.

While designing the side walls of the water retaining structures, clear water reservoir, pump house, and all other relevant structures, a surcharge of 500 Kg/Sq.m on the soil is to be taken into consideration.

The tenderer has to design in such a way that the permissible limit of vibrations of Rotodynamic Equipment shall be within the limit as specified in IS:11724 (latest edition).

The R.P.M. of pump Motor set may be 740 to 990 RPM subject to confirmation of the manufacturers and duly approved by EIC.

N. B. For calculating earth pressure on the walls of water retaining structures including underground reservoir and pump house, the worth value among co-efficient of active earth pressure (Ka) and that of Earth pressure at rest (Ko) is to be considered. Standard backfill materials with conservative soil data are to be considered. No extra claims are to be entertained in this regard. Where passive earth pressure will be considered in the design, the Agency shall have to refill the excavated ground with properly compacted silver sand only, and not with fly ash or other material.

8.3 Level and Other Salient Information

A list of figures highlighting the following are given herein below:

- Levels in Meters
- Difference in Height / Clearance
- Minimum Length, Slopes etc.

Out of the above list, the figures marked with "Astericks" are mandatory requirements whereas the others are suggestive only.

A. Levels in Meters (Mandatary)

S No	Description	Level in mts
1	Existing E3 road level	+ 21.50
2	Finished ground level	+ 22.00
3	Sub-Station floor level	+ 22.50
4	Top of Crane Rail over Crane Girder	+ 29.00
5	Minimum clearance between Crane Top and Bottom of Roof beam	+ 1.0
6	Unloading Platform Level	+ 22.50

B. Difference in Height, SWD and Head Room in Building and Structure

S No	Description	Level in mts
1	Side Water Depth (SWD) in Semi Underground Clear Water Reservoir	Not less than 5.00 M
2	Free Board in Clear Water Reservoir	0.50 M from TWL to below the soffit of Slab/Beam/Drop Panel

C. Minimum Length, Slope, Clearance etc.

S No	Description	Remarks
1	Minimum Length along direction of Flow near pump sump (slope portion)	3.75 M
2	Maximum slope from clear water Reservoir to Sump	45º
3	Minimum length of the flat Sump Along the direction of flow	2.85 M

9. Special Notes on Horizontal Centrifugal in Horizontal Execution Pump Foundation Design

9.1 Foundation system for support of Rotary machines such as Horizontal Pumps shall strictly comply with the requirements of Code IS:2974 (Part-IV)-1979. The Rotary Machine support system require careful study of the foundation system with due consideration of vibration characteristics. For satisfactory design and construction, the following precautions need be taken with careful dynamic analysis of machine foundation and its supporting structures:

- The natural frequency of the Foundation System shall be analyzed and the mass of the Foundation System shall be considerably larger than the mass of the whole machine.
- Dynamic Analysis due to insufficient clearance between impeller and causing of Pumps shall be checked and frequency out of this type of vibration need to be made as per relevant IS Code.
- Dynamic Response check of the block foundation may be carried out as per relevant IS Code.
- Permissible amplitude of Vibration of displacement as per IS Code 2974 (Part-IV), Clause 5.4 Page No. is to be calculated and the design will be checked accordingly.
- Permissible stresses in Soil / Concrete be suitably as per IS Code.
- Natural frequency of Foundation System shall be such as will avoid resonance with the Operating Speed of the Machine. The natural frequency of the foundation system shall not be within ±20% of the operating of the machine.

- The foundation system shall be so dimensioned that the resultant force due to mass of the machine and mass of the Foundation passes through the Centre of gravity of the base area of the Foundation.

9.2 The Tenderer is required to submit a "Technical Write-up" with relevant details of Foundation System along with the Part-I of this Tender. This would help the Authority to fix up the accepted Parametric Norms of the foundation System that would finally be adopted in the design and construction of the Building and Structures after award of the contract.

9.3 The Agency shall be aware of the fact that various cables, ducts, small machinery, lighting arrangements, electrical appliances etc. of considerable weight, will have to be supported from the concrete or brick walls or from the roof slab. MS plates or hangers of requisite sizes with suitable weight carrying capacity shall have to be inserted on wall or roof slab. It is the responsibility of the Agency to insert the MS plates or hangers during the casting of concrete slab/wall in time to avoid dismantling of the wall/slab.

10. ARRANGMENT OF ROOF TREATMENT: EARTH FILL VENTILATING SYSTEM

10.1 It is proposed that the Clear Water Reservoir top shall have minimum 500 mm thick earth fill.

10.2 The provision for saturated earth load on the roof slab shall be considered in the design of roof slab of the Clear Water reservoir by the Tenderer. The actual earth fill work is also included in the Scope of this Tender. The load from the earth fill shall not be considered while calculating the buoyant force of the reservoir as well as to calculate the pile capacity in tension under the reservoir.

10.3 The R. C. C. Roof Slab of the Clear Water Reservoir shall be protected with water proofing treatment as per specification given in the other relevant section of this tender book.

11. SUBMISSION OF DESIGNS, DRAWINGS & OTHER INFORMATION

11.1 Within Thirty days of getting the Work Order, the Agency shall conduct topographical survey and geotechnical investigation at all the sites and shall prepare a report to submit the same to the Authority for approval.

The Agency shall submit, within fifteen days of getting Work Order, the Time-Activity Bar Chart showing all the major activities and sub-activities and its individual commencing and completion times. Each Bar in the Bar Chart will represent the time duration of each activity or sub-activity, which may be proportional within its each sector of time duration. A tentative work programme in Network Diagram using CPM technique is also required to be submitted by the successful tenderer within a fortnight from the date of issue of the letter of acceptance.

Within the thirty days' of getting Work Order, the Agency shall submit the concrete mix design along with sufficient numbers of test results and get it approved by the Authority. Requisite number of concrete cubes shall be casted according to the mix design and tested by an Agency approved by the Authority. It is obligatory that the cube crushing strength will be more than the mix design strength submitted by the Agency. It is advisable to install a Weigh-Batcher at the site for maintaining the exact proportion of concrete ingredients. If not possible, it is the Agency responsibility to make sufficient numbers of buckets of suitable sizes to carry fine aggregates and coarse aggregates within one month after getting the Work Order. The size of the bucket shall be in accordance with its carrying capacity in weight to make requisite design grade of concrete. The size and shape of the buckets must be approved by the Authority prior to use it at site. Agency has to declare in written whether he would consider any mound of aggregates above the carrying bucket top surface in calculating the size of bucket and he has to practice that accordingly at site while carrying the aggregates with the bucket. While calculating the bucket size considering the mound of aggregates, the Agency has to consider the mound angle as follows,

Type of aggregates	**Geometry**	**Mound angle (degree)**	**Dynamic angle (degree)**
Fine aggregates	Angular	378	36.58
Coarse aggregates	Angular	37.58	348

On the award of the Contract, Agency shall submit to the EIC layout drawing, process design, hydraulic flow diagram and the general arrangement drawings and designs of different structures within twenty-one (21) days from the date of issue of Letter of Acceptance and thereafter the balance detailed design and drawings and design calculations

will have to be submitted phase wise keeping pace with the work programme. The different levels of the units shall be designed in such a way that the R.L. of the top water level of the underground reservoir is at a higher level than the R.L. of the invert level of the filter water channel.

The Agency shall submit six copies of design and drawing along with editable soft copy to the EIC for approval. On approval of design and drawing for any RCC members, the Agency shall submit six copies of the Bar Bending Schedule for those members without delay. Cutting, fitting, fixing of the reinforcement will be in accordance with the Bar Bending Schedule at site.

If called upon the Agency shall also submit within reasonable time relevant books and other reference which have been referred to or used in the design. Such books and other relevance will be returned to the Agency when done with Secrecy in regard to details of design materials and equipment etc. shall not be pleaded by the Agency in the name of "Trade Secret" for not furnishing the requirement details asked for by the EIC. The design and drawings shall be subject to modifications at no extra cost, if found necessary and such modifications shall not vitiate the contract. Similarly, any additional new drawings as found shall be submitted by the Agency and the drawings shall form part of the Contract Drawings.

Notwithstanding what has been stated above the Agency shall be responsible for the correctness and soundness of the design and if any provisions are found inadequate or faulty necessary modification will have to be carried out at any stage upto the expiry of the Guarantee period.

The Agency will not be permitted to commence the Actual Work at site unless detailed design and working drawings are approved by the EIC. Four copies of the approved design and six copies of the approved drawings are to be furnished by the Agency free of cost for use by the Authority during execution of the work. Any additional copies of same drawings, if required, shall also be submitted by the Agency free of cost at the request of the Authority.

The drawings from foundation onward will have to be submitted by the successful tenderer successively as per the work programme to be approved by the EIC. Adequate resources are to be mobilized during execution of the work, for which no extra payment shall be made.

Agency shall provide the necessary tools and apparatus like standard sieves, balance etc., to test the quality of coarse and fine aggregates according to IS:2386 and IS:383. It is mandatory to carry out tests for the quality of coarse and fine aggregates as per relevant IS Codes at site and as instructed by EIC. The EIC retains the right to instruct the Agency to test one or more representative samples from any stack of aggregates supplied by the Agency at site, and if the result of testing is not satisfactory, the Agency has to remove the entire stack of aggregates from the working site without delay at his own cost.

Agency shall provide the necessary tools and apparatus to test the quality of brick according to IS:3495 and IS:1077. It is mandatory to carry out tests for the quality of bricks as per relevant IS Codes and as instructed by EIC. The EIC retains the right to instruct the Agency to test one or more representative samples from any stack of bricks supplied by the Agency at site, and if the result of testing is not satisfactory, the Agency has to remove the entire stack of bricks from the working site without delay at his own cost.

The Agency shall provide required tools and instruments to carry out tests for compressive strength of concrete regularly at site as per IS:456 and IS:516. Also, apparatus required for slumps test of concrete shall be available at site and the Agency has to carry out the slump tests as per instructions of relevant IS Codes and the EIC.

11.2 Completion of Drawings and Other Documents to be Submitted the Agency

The Agency shall submit, within one month after the completion of all construction works, the followings drawings and document, free of cost.

a. Six copies of all approved Completion drawings. These drawings shall be on black and white prints of thick paper and there shall be one RTF transparency of each drawing. These drawings are to be submitted in a presentable form as directed by the EIC.
b. Four copies of final designs in properly bound from as directed by the EIC.
c. Four copies of detailed specification and schedules of the completed installations etc.

d. Two copies of Manufacture's Manual of all pumps, motors and all other mechanical, electrical, electronic instruments, SCADA and laboratory equipment.
e. All license copy related to WTP operation shall be renewed up to end of O & M period without any additional cost.
f. Public liability insurance, explosive license etc. The Agency shall renew insurance and explosive license as per requirement to the end of O&M period without any additional cost.

SECTION - II

GENERAL SPECIFICATIONS OF WORKMANSHIP & MATERIALS FOR CIVIL WORKS

1. GENERAL

1.1 Materials

1.1.1 All materials used in the permanent works shall be of the best quality of the kind and upon approval of the Engineer-in-Charge. Any material not covered by these Specifications, shall comply with the relevant latest Indian Standard Specifications (Referred to as IS as revised or modified up to date one month prior to Tender date). British or American Standard Specifications shall be referred to in case any specification is not available in any of the aforesaid Specifications.

1.1.2 Samples of materials to be supplied and used by the Agency in the works shall be to the prior approval of the Engineer-in-Charge. For this purpose, the Agency shall furnish in advance representative samples in quantities and in the manner as directed by the Engineer-in-Charge for his approval. Materials brought to the Site, which in the option of the Engineer-in-Charge do not conform to the approved sample, shall, if so directed by him, be removed by the Agency from the Site and replaced by the materials of approved quality.

1.1.3 In spite of approval of the Engineer-in-Charge of any materials brought to the site, he may subsequently reject the same if in his opinion the materials have since deteriorated due to long or defective storage or for any reason whatsoever and is thereby considered unfit for use in the permanent works. Any material thus rejected shall be immediately removed from the Site at Agency cost and expense.

1.1.4 All materials brought to the Site shall be properly stored and guarded in the manner as directed by the Engineer-in-Charge and to his satisfaction.

1.1.5 The Engineer-in-Charge may carry out test of materials as he may decide. The Agency shall, at his cost and expenses, for this purpose supply requisite materials and render such assistance to the Engineer-in-Charge as he may require.

1.2 Workmanship

All works are to be carried out in proper workmanship like manner. Items of works not covered by these Specifications or by other tender documents, shall be carried out as per

best practice according to the direction of the Engineer-in-Charge and to his satisfaction. The relevant IS Specifications, and in case of necessity, British or American Standard Specifications shall be taken as guide for the purpose.

1.3 Works Included

The rates for all items, unless specifically stated otherwise in the Contract, must cover the cost of all materials, labour, tools, machinery, plant, pumps, explosives, scaffolding, staging strong props, bamboos, ropes, templates and all appliances and operations whatsoever necessary for efficient execution of work.

1.4 Ground Conditions

The Agency shall visit the site and ascertain local conditions, traffic restrictions, obstructions in the area without asking for extra expenses likely to be incurred due to any limitations whatsoever.

1.5 Setting Out and Leveling

The Agency shall set and level the works, and shall be responsible for the accuracy for the same. He shall provide all instruments and proper qualified staffs required for checking the Agency works.

1.6 Safety

The Agency shall take adequate precaution to provide complete safety for prevention of accidents on the site.

1.7 Keeping Works Free from Water

The Agency shall provide and maintain at his own cost, electrically or other power-driven pumps and other plants and equipment to keep the sites, excavated foundation pits and trenches free from surface as well as subsoil / leakage water from the Primary Grid of any other source thereof and shall continue to do so during construction and afterwards to the complete satisfaction of the Engineer-in-Charge till the site is handed over. Method of dewatering shall need approval of the Engineer-in-Charge but no payment whatsoever shall be allowed on this count. The pumped water shall be drained out in such a manner so that it doesn't create any inconvenience to others.

1.8 Rubbish

1.8.1 The Agency shall clear all rubbish, vegetation, roots, soda etc., and dump then in the area indicated to the satisfaction of the Engineer-in-Charge. No separate rate shall be allowed for the above work.

1.8.2 After the work is completed, the Agency shall clear the area surrounding the built-up structures and buildings, of all hutments and excess stores and remnants of building materials such brick, metal, sand, timber, steel, etc.

1.9 Bench Marks and Ground Water Gauges

The Agency shall protect surveyor's bench marks and ground water gauges, zero-line marks and base line marks from damage of movement during the works in progress and thereafter.

1.10 Inspection

The Agency shall inspect the Site of works and ascertain site condition and the nature of soil to be excavated.

1.11 Agency Staff

The Agency must provide always efficient staff of trustworthy, skillful and experienced assistance capable of carrying out the work in accordance with the drawings and specification and to correct levels. The cost towards this establishment shall be included in his quotes.

1.12 Method of Measurement

Unless otherwise specified, the method of measurement for building works shall be as per IS:1200.

1.13 Specifications Referred to

1.13.1 The specification contained herein are not exhaustive and for such items of works which may arise and which are not covered by this specification, the provisions in the relevant Indian Standard (Latest Edition) shall apply.

1.13.2 A list of some Indian Standards is given herein.

1.13.3 Wherever reference to the Indian Standard mentioned below or otherwise appears in the specification, it shall be taken as reference to the latest version of the Standard.

	IS Code No.	Description
General	IS:1200	Method of measurement of building And Civil Engineering works.
Cement	IS:269	Ordinary, Repair Hardening and Low Heat Portland Cement.
Sand	IS:1242	Sand for plaster.
Aggregates	IS:383	Aggregates-Coarse and fine, from Natural source for Concrete.
	IS:515	Aggregates for use-in Mass Concrete, Natural and manufactured.
Concrete-Plain And Reinforced	IS:456	Code of Practice for Plain and Reinforced Concrete for General Building Construction.
	IS:3370	Code of Practice for Concrete Structures for the Storage of Liquids.
Brick Work	IS:1077	Common Burnt Clay Building Bricks.
Paving and Floor Finish	IS:1235	Flooring Tiles, Cement Concrete.
	IS:1443	Cement Concrete, Flooring Tiles Laying and finishing.
Plaster and Pointing	IS:1661	Cement and Cement Lime Plaster finishes on walls and Ceilings.
Steel and Iron Work	IS:226	Structural Steel (Revised)
	IS:800	Code of Practice for use of Structural Steel in General Building Construction.

2. EARTH WORK IN EXCAVATION & FILLINGS

2.1 General

Applicable provisions of Conditions of Concrete shall govern work under this section.

2.2 Excavation for Foundation, Trenches, Pit etc.

The excavation work shall be carried out in all kinds of Soil including Sand in workman-ship like manner without endangering the safety of the nearby structures or works and

without causing any hindrance to other activities in the area. The existence of old buildings, boundary walls, hutment, sewer lines, water lines, if any, very close to the area of excavation shall be given careful consideration while designing and carrying out the excavation work. The excavation shall be done in such a manner as would technically be appropriate and befitting the site conditions subject to the approval of the Engineer-in-Charge. All foundation trenches shall be excavated to the full width and depths shown on the approved drawing or to such ordered to the Agency.

The Agency shall not undertake any earth work without having obtained prior approval from the Engineer-in-Charge and the methods EIC proposes to employ in order to execute the work in the most efficient manner. He shall not modify such methods without the approval of the Engineer-in-Charge. This approval, however, shall not in any way make the Engineer-in-Charge responsible for any consequent loss or damage.

2.2.1 Shall any excavation be taken down to the specified levels, the Agency shall fill in such excavation at his own cost with concrete as specified for foundations, well rammed in position until it is brought up to the specified level.

2.2.2 The Agency shall notify when the excavation is completed and no concrete or masonry shall be laid until the soil for each individual footing, rafts etc. is approved.

2.2.3 The Agency shall keep the site clear of water always. To this end, he shall provide arrangements for bailing and pumping or any special arrangements as required within his quoted prices.

2.2.4 All foundation pits shall be refilled to the finished ground level (formation level) with approved materials, which shall be suitably consolidated in layers to the satisfaction of the Engineer-in-Charge.

2.2.5 Nothing extra will be paid for bailing out water collecting in excavation due to rains, ordinary springs, leakage from existing primary grid etc., or any other reason.

2.2.6 For the work of excavation, the Tenderer shall include in his quotation the shoring, sheeting, bracing and sheet pilling (if required). The quotation shall also include the cost of compaction of foundation sub-base, removal and storage of excavated materials and back-filling.

Road crossing by the trench less technology / HDD (Horizontal directional drilling): Work include the laying by hydraulic jacking and smooth controlled pushing method under running traffic condition as per standards including carrying out the survey work at the site for determining underground cable trenches like telephone, cables , water , sanitary drains and resistivity test for finding the soil strata using necessary equipments for completeness of works mobilizing of the machineries and specialized crews at construction site etc complete in all respects including the excavation of the driven pit and exit pit with proper protection at 3 sides with shoring sheets and ISMB (providing and castinf MS cutting edges for front shield and construction thrust bed at designated level as directed by the engineer, necessary dewatering and providing the concrete foundation at the base of the driven pit, crane for holding the pipe and any other machinery, tools , tackle required, construction of the temporary works as per the requirement and approval of the concerned authorities and engineering in charge, as per the scope of work defined.

2.3 **Shoring**

Timber shoring whenever required, shall be closed boarded with minimum 50mm thick good and seasoned timber planks of sufficient length driven side-by-side to the required depth. The gaps between adjacent timber planks shall be such as would not allow any flow of soil particles. If necessary, the sides of the planks shall be placed smooth to ensure this. Sufficient number of bracing struts, walling etc. are to be provided to make the shoring rigid and non-yielding by earth pressure. Where necessary, sheet pilling shall be done to ensure safety to the adjoining structures, if it is found that it is not feasible to protect the structure by timber shoring only. The Tenderer is strongly advised to inspect the site before tendering and apprise himself of the requirement of any Sheet piling in addition to the timber shoring before submitting his Quotation accordingly.

2.4 **Back Filling**

The space around the foundations in trenches or sites shall be cleared of all trash and loose debris and filled with approved excavated earth, all clods being broken upto the finished G.I. Filling shall be done in 200mm layers, each layer to be property moistened and well rammed. Excavated materials which is surplus or which is consolidated unsuitable for back filling is to be disposed of in spoil dumps as directed by the Engineer-in-Charge. No extra payment will be made for this.

3. CONCRETE

3.1 General

3.1.1 Applicable provisions of Conditions of Concrete shall govern work under this section.

3.1.2 All concrete work, plain or reinforced shall be carried out strictly in accordance with this specification and any working drawing or instructions given from time to time to the Agency.

3.1.3 The Agency states shall allow for wastages in all materials as well as for all tests of materials and concrete.

3.1.4 No concrete shall be cast in the absence of the Engineer-in-Charge or any other person duly authorized by him. The Agency Engineer-in-Charge shall personally check that both the form work and reinforcement have been correctly placed and fixed, and shall satisfy himself that all work preparatory to the casting is completely ready, before informing the Engineer-in-Charge for final inspection and approval and for which purpose at least 24 hours' notice shall be given by the Agency.

3.1.5 The Indian Standards wherever referred to herein shall be the latest addition of such standards.

3.2 Cement

Cement shall conform for IS:269. Cement tests shall have to be carried out at Agency expense as and when directed. Cement which has or practically set shall not be used under any circumstances.

3.3 Aggregates

The fine and coarse aggregates shall conform to all provisions and test methods of IS:383 and / or IS:515. Samples of aggregates, proposed to be used in the work shall be submitted free of charge in sufficient quantities to the Engineer-in-Charge with sieve analysis and other physical and chemical analysis data for his approval. Approved samples will be preserved by him for future reference. This approval will not in any way relieve the Agency of his responsibility of producing of specified qualities.

3.3.1 Coarse Aggregates

Coarse aggregates for use all reinforced and other plain cement concrete works shall be crushed black granite trap stone obtained from approved source and shall consist of uncoated, hard, strong dense and durable pieces of crushed stone, and be free from undesirable matters, viz. Disintegrated stones soft, friable, thin, elongated or laminated pieces, dirt, salt, alkali, vegetable matter or other deleterious substances. The aggregates shall be thoroughly washed with water and cleaned before use to the satisfaction of the Engineer-in-Charge at no extra cost of the Authority.

The maximum size of coarse aggregates shall be as follows unless specified otherwise elsewhere.

Reinforced Concrete	:	20 mm
Plain Concrete	:	20 mm.
Thin R. C. C. Members		
With very narrow space	:	12 mm.
Mat/Lean Concrete	:	20/40 mm.

(The actual size to be agreed by the Engineer-in-Charge)

Grading of coarse aggregates for a size shall generally conform to relevant I. S. Codes and shall be such as to produce a dense concrete of the specified proportions and or strength and consistency that will work readily in position without segregation.

3.3.2 Fine Aggregates

Sand shall be clear River sand brought from approved source and consist of siliceous material, having hard, strong, durable uncoated particles, free from undesirable matters viz. dust lumps, soft or flaky particles or other deleterious substances. The amount of undesirable shall not exceed the percentage limits by weights as specified in relevant IS Codes. Washing of aggregates by approved means shall be carried out, if desired by the Engineer-in-Charge, at no extra cost to the Authority.

Coarse and fine sand shall be well graded within the limits by weight as specified in relevant IS Code. Fineness Modulus shall not vary by more than plus or minus 0.20 from that of the approved sample. Fineness Modulus for sand shall not be less than 2.5.

3.4 Reinforcement

3.4.1 The Agency shall prepare and furnish to the Engineer-in-Charge, Bar Bending Schedules in considerations of the approved drawings for all R. C. C. works for review and checking by the Engineer-in-Charge before taking up the work.

3.4.2 The mild steel reinforcement shall conform to IS:432 & the for-steel reinforcement shall conform to IS:1788.

All steel for reinforcement shall be free from loose, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.4.3 The Reinforcement shall be bent to the shapes shown on the approved drawings prior to placing and all bars must be bent cold. The Steel shall be placed in such a way that it is rigidly held in position while concrete is being cast. The correct clearance from the form shall be maintained by either precast mortar blocks or by metal supporting chairs to be supplied by the Agency free of charge.

The intersection of roads crossing one another shall be bound together with soft pliable with No. 16 to 18. S. W. G. at every intersection so that reinforcement will not be displaced in the process of depositing concrete. The loops of binding wire shall be tightened by pliers.

3.4.4 The work of reinforcement shall also be inclusive of stirrups distribution bars, binders, initial straightening and removing of loose rust, if necessary, cutting to requisite length, hooking and bending to correct shape, placing in proper position including supplying and binding with block annealed wire as stated in clause 3.4.3 above.

3.4.5 Welding of reinforcement shall be done according to the IS specifications where binding wire will not be sufficient without any extra payment to the Agency.

3.5 Water

The Water shall be clean and free from acid, alkali, oil or injurious amounts of deleterious materials. As far as possible, the water be of such quality that it is potable. If any chemical analysis of water is necessary and ordered, the same shall be carried out at an approved laboratory at the Agency cost and expenses.

3.6 Concrete Proportioning

3.6.1 The concrete proportions shall be as indicated on the approved drawings and shall conform to IS:456 & IS:3370. The quality and character of concrete shall be governed by IS:383. It shall be sampled and analyzed as per IS:1199. The concrete shall stand the test specified in IS:516.

3.6.2 The minimum cover of main reinforcement shall be 25 mm or the diameter of the bar whichever is greater. Cover to any reinforcement of R. C. C. piles shall be minimum 65 mm. In case in-situ and 50 mm. In case of precast piles. Suitable spacer blocks shall be provided at intervals not exceeding 1.2 m. throughout the length of the pile.

3.6.3 The workability shall be measured by slump. Slump for different grades of concrete shall be as per IS 456 unless specifically permitted by the Engineer-in-Charge.

3.6.4 All concrete works shall be thoroughly compacted and fully worked around the reinforcement, around embedded fixtures and into corners of the form work.

The Concrete shall be thoroughly and shall be efficiently vibrated during laying. The use of mechanical vibrators shall comply with IS:2608, IS:2506 and IS:4656. Whenever vibration has to be applied externally, the design of form work and deposition of vibration shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

3.6.5 **Test for Water Tightness of Structures / Pipes**

All liquid retaining structures including underground reservoir, and different units of water treatment plant like inlet chambers, flocculator, clarifier, filter etc. shall be deemed to be satisfactory water tightness test as per relevant clause of IS:3370. Approved corrective measures, if necessary, shall be undertaken by the Agency at his own expenses. This water tightness test is mandatory for all type of water retaining structure and no security deposit shall be released without satisfactory water tightness test results.

As regards the pipe lines, the tests shall be performed for the Hydrostatic Pressure of 10 Kg/Sq. cm in case of Mild Steel & DI K9 pipes and 2 Kg/Sq. cm. for P.S.C./R.C.C. respectively. The tests shall be carried out as per relevant IS Codes and pipes shall be considered satisfactory if the tests results satisfy the requirements of the relevant clauses of the Codes. The Agency shall give all these Hydraulic Tests by making his own arrangements for water supply and filling and disposing the water after the tests. The Agency shall rectify the defects noticed and carry out the tests again and repeat the testing operation till successful result is obtained and accepted by the Engineer-in-Charge. The rates Quoted for the work shall be considered as inclusive of cost of all Labour, materials and equipment required to give successful tests for Water tightness.

3.7 Workmanship

3.7.1 All Concreting work shall be carried out according to the IS:456 and IS:3370. It shall, however, be noted that for every 15 Cu.m. of concrete placed or for everyone day's volume of concrete whichever is lower, a minimum of 3 (three) Cubes shall be cast for test purpose, and tested at the Agency cost and expenses at a Laboratory as approved by the

Authority. The number of test cubes may, however, be altered at discretion of the Engineer-in-Charge. It is compulsory to test 3 (three) cubes in each case.

3.7.2 Structural Concrete

Design mix Concrete shall be on all concrete works except in case of Mud-mat concrete/lean concrete where nominal mix concrete will be allowed.

Design mix Concrete will be used in Reinforced Concrete Structures shall be in Grade or M20 or richer.

The mix shall be designed to produce the grade of concrete having required workability and a Characteristic Strength not less than appropriate values given in Clause 5.1 or IS:456-1978. For mix design, procedure given in Indian Standard.

Recommendation or any other standard procedure shall be adopted. As long as the quality of materials does not change a mix design done earlier may be considered adequate for later work. Batching mixing, sampling and Strength Test of concrete shall be carried out in compliance with the relevant clause of IS:456-2000 and all other relevant Indian Standards recommended therein.

The mix design by the Agency shall be used for works only after obtaining written approval of the Engineer-in-Charge. Mix design shall be entirely the responsibility of the Agency and any approval by the Engineer-in-Charge shall not relieve him of his responsibility in respect thereof.

The Agency shall prepare all the Calculations. Tabulations, Graphs etc. pertaining to Mix design/Test result and supply copies of such Calculations, tabulations, Graphs etc. required by the Engineer-in-Charge. The minimum Cement content in each grade of Concrete shall be as per relevant IS codes

On proportioning concrete, the quantity of both cement and aggregate shall be determined by weight, where the weight of cement is determined on the basis of weight per bag a reasonable number of bags be weighed periodically to check the net weight or shall be either weighed or measured by volume in calibrated tanks. All measuring equipment shall be maintained in a clean serviceable condition and shall periodically checked for accuracy.

The grading of coarse and fine aggregates shall be checked frequently and frequency of testing shall be determined by the Engineer-in-Charge. Where weight batching is not possible or practicable, the quantities of coarse and fine aggregates may be determined by volume but cement in any case shall be weighed by weight only. If fine aggregate and volume batching is adopted, allowance shall be made for bulking. The bulking shall be determined in accordance with IS:2386 (Part-III).

The Water-Cement Ratio shall be maintained to its correct value. Surface moisture content of aggregate shall be determined as per IS:2386 (Part-III) and the amount of water to be added shall be adjusted accordingly to maintain the correct Water-cement Ration.

During the progress of work in order to ensure correct strength of concrete proper control shall be exercised by the Agency as specified in Specifications mentioned in the Clause 3.7.1 above. Test strength of every sample shall be determined in accordance with the recommendations of IS:456-1978. If one out of ten consecutive test cubes show a deficiency in strength up to a maximum limit of 10%, the concrete will be deemed satisfactory. If two of the test cubes out of ten show a deficiency in strength up to a limit of 10%, the concrete shall be deemed to be less satisfactory and a reduction of 1% will be made on the cost of such concrete. If three out of ten test cubes show deficiency in strength up to a limit of 10%, a reduction of 5% will be made on the cost of such concrete. If more than three rest cubes show a deficiency in strength up to a limit of 10% a reduction of 10% will be made on the cost of such concrete. If more than five show a deficiency in strength up to a limit of 10%, the concrete shall be rejected. Such rejected concrete work shall have to be dismantled and replaced to the satisfaction of the Engineer-in-Charge by the Agency free of cost to the Authority. No payment for the dismantled concrete, the relevant from work and reinforcement, embedded fixtures etc. wasted in the dismantled portion, shall be made. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall also be made good free of charge by the Agency to the satisfaction of the Engineer-in-Charge.

If the deficiency in strength of one test cubes exceeds the 10% limit, a reduction of 5% will be made on the cost of such concrete. if the deficiency in strength to two out of ten test cubes exceeds the 10% limit, a reduction of 10% will be made on the cost of such concrete. If the deficiency in strength of two out of ten test cubes exceeds the 10% limit,

a reduction of 10% will be made on the cost of such concrete. If the deficiency in strength of three out of ten test cubes exceeds the 10% limit, a deduction of 20% on the cost of such concrete will be made.

With permission of the Engineer-in-Charge for any above-mentioned grades of concrete, if the quantity of water has to be increased in special cases, cement shall also be increased proportionally to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment for additional cement will be made.

3.8 Precast Concrete

Precast Concrete items shall conform to relevant IS Specifications. Precast items shall be suitably marked with the date of casting identification marks and shall show the right way up as may be required. The arrangements to be made by the Agency for Site manufacture and handling of precast items shall be done to the approval of the Engineer-in-Charge. Each precast unit shall be cast in one operation and no construction joints shall be permitted. No damaged or defective units shall be built into the works and units shall be so stored that they are not over stressed.

Precast units shall be provided in places as shown in the approved drawings. The precast units shall be cast at site strictly following the Specifications of Precast Concrete work. Proper care shall be taken to ensure that the units are obtained from the moulds without any damage. Before erecting in position, the position units shall be cured adequately by keeping units immersed in water.

3.9 Form Work

3.9.1 The Form Work shall conform to IS:456. Whenever necessary, shuttering must be provided. The work shall also include providing all necessary staging, centering, form work and moulds for placing concrete. Shuttering may be for approved dressed timber true to line, not less than 37 mm. thick. Surface to be in contact with concrete are to be planed smooth. Alternatively, sufficiently rigid plywood shuttering or steel shuttering may be used. In every case, joints of the shuttering are to be such as to prevent the loss of liquid from the concrete. In timber shuttering the joints shall, therefore, be either lounged and grooved or the joints must be perfectly close and lined with draft paper polythene films or other types of approved materials. In case of plywood or Steel shuttering also the joints

are to be similarly lined. All shuttering and framing must be adequately stayed and braced to the satisfaction of the Engineer-in-Charge for properly supporting the concrete, during concreting and the period of hardening. It shall be so constructed that it may be removed without shock or vibration to the concrete. No through bolts are allowed for holding the shuttering in water retaining structure.

3.9.2 Cleaning, Treatment and Removal of Forms

All forms shall be thoroughly cleaned of old concrete, wood shavings, saw dust, dirt and dust striking to them before they are fixed in position. All rubbish loose concrete chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Form work shall not be used/reused, if declared unit or unserviceable by the Engineer-in-Charge.

If directed by the Engineer-in-Charge, compressed air jet/or water jet shall be kept handy along with wire brushes, brooms etc. for the purpose of cleaning.

Before shuttering is placed in position, the form surface in contact with the concrete shall be treated with approved non-staining oil or composition. Care shall be taken that the oil or composition. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

Forms shall be truck in accordance with the relevant clause of IS:456 or as directed by the Engineer-in-Charge. The Agency shall record on the drawings or in other approved manner, the date in which the concrete is placed in each part of the work and the date on which the form work is removed therefrom and have this recorded checked and countersigned by the Engineer-in-Charge.

The Agency shall be responsible for the safe removal of the form work, but the Engineer-in-Charge may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of form work or loading shall be entirely reconstructed without any extra cost to the Authority.

3.10 Protection and Curing of Concrete

Newly placed concrete shall be protected by approved means; from rain, sun and wind and extreme temperature. Concrete placed below the ground level shall be protected from

failing earth during and after placing. Concrete placed in ground containing deleterious substance shall be kept free from contact with such ground or, with water draining from such ground during placing of concrete and for a period of at least 3 (three) days or as otherwise directed by the Engineer-in-Charge. the ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage at the cost of the Agency. Adequate steps shall be taken to prevent flotation or flooding. Steps, as approved by the Engineer-in-Charge, shall be taken to project immature concrete from damage by debris, excessive loading, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently for the surfaced to be marked it shall be covered with hessian, canvas, or similar materials and kept continuously wet for at least 7 (seven) days after final setting. This period may be extended at the direction of the Engineer-in-Charge, up to 14 (fourteen) days. Concrete slabs and floors shall be cured by flooding with water of minimum 25 mm. depth for the period mentioned above.

Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compound shall be applied to all exposed surface of the concrete as soon as possible after the concrete has set. No extra payment is allowed on such count.

3.11 Concrete Finish

The Concrete surface on removal of form work shall be such that no finish in necessary, If, however, the surfaces is not satisfactory the Agency shall, if so instructed, remove unwanted, projecting parts by chipping and smoothening the surface with cement rendering at his own expenses. The shutter marks shall invariably be removed by rubbing with carborandum stone. The Agency shall therefore take all precaution for avoiding the shutter marks.

3.12 Construction Joints

These shall be in according with IS:337 or as directed.

3.13 Expansion Joints

Expansion joints shall be provided at position as directed and the spacing shall not exceed the limits specified in IS:456. These shall comply strictly with the details shown on approved construction drawings. Reinforcement shall not extend across any expansion joint and the break between the two sections must be complete.

3.14 Details of typical expansion joints and construction joints shall comply with the suggestive arrangements shown in IS:3370 (Part-I), Clause 8.1 (a)(2), Figure 2 (for expansion joints) and Clause 8.1(a) Figure 1, Clause 8.1 (b) Figure 4 (for construction joints).

3.15 P.V.C. Water Stops

The materials shall be durable and tough and as per approval of the Engineer-in-Charge. The minimum thickness of PVC sealing strips shall be 6 mm. and the minimum width 225 mm. actual shape and size shall be as per drawings. The materials shall be of good quality polyvinyl chloride highly resistant to leading abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties will generally be as follows:

Specific Gravity	1.3 to 1.35
Shore Hardness	60 A to 80 A
Tensile Strength	100 to 150 Kg/Cm2
Minimum Safe Continuous Temperature	75^0C
Ultimate Elongation	Not less than 275%
Water Absorption	Not more than 5% by weight in a 7-day test.

3.16 Rubber Water Stops

The materials must be very durable and tough and as per approval of the Engineer-in-Charge. The ribs shall be sufficient to ensure proper bonding with concrete. The width shall be minimum 225 mm. and thickness minimum 6 mm. The rubber water stop must be used in long lengths to avoid splicing as far as practicable. Ends shall have at least 200 mm. overlaps and volcanized. The materials shall be natural rubber and be resistant to corrosion tear and to attacks from acid, alkalis and chemicals normally encountered in service. The physical properties will generally be as follows:

Specific Gravity	1.1 to 1.15

Shore hardness	65 A to 75 A
Tensile Strength	250 to 300 Kg/Cm^2
Maximum safe continuous temperature	75^{0}C
Ultimate elongation	Not less than 350%
Water Absorption	Not more than 350% by weight in a 7-day test.

3.17 Agency Supervision

The Agency shall provide constant and strict supervision of all the items of construction during progress of work, including the proportioning and mixing of the concrete and bending and placing of reinforcement. Before any important operation such as concreting or stripping of form work adequate notice shall be given.

3.18 Laying Cement Concrete Foundations and Under Floors

Before laying the concrete, the bottom and sides of the trench up to the proposed height of the concrete shall be moistened.

The concrete shall be laid and not thrown, in layers not exceeding 150 mm. in depth and shall be tamped / vibrated immediately after laying.

3.19 Chases, Holes, Recesses and Inserts

All chases, holes and recess for foundation or other bolts, various services and other requirements must be formed as shown on the approved drawings or as directed during the execution of the work, without any extra charge. The Agency shall fix all necessary inserts or fixtures in the concrete for support of hangers etc., for pipes and cables, ceiling clamps for lights and fans or for duct etc. If any of the inserts are to be supplied by other agencies, no extra payment will be made to the Agency for placing the inserts in position. The approximate nos. of MS inserts required for fixing of cable tray/hangers in 400. The load carrying capacity of inserts per sq. m. may be taken as 100 kg.

3.20 Load Testing of Structure

Load tests shall be carried out in accordance with IS:456, if required.

4. BRICK WORK

4.1 Applicable provisions of Conditions of Concrete shall govern work under this Section.

4.2 The Agency shall build the whole of brick work, shown on the approved drawings with first class bricks conforming to IS:1077 and IS:2212 in cement mortar as described. All brickwork, unless otherwise specifically mentioned, shall be of 1st Class brick of approved quality.

4.3 Unless otherwise specified, the proportions of cement-sand mortar for various classes of brick work shall be as given below:

S No	Type of Work	Cement	Sand
1	Ordinary brick work with Thickness 250 mm. above for building superstructure	1	6
2	Brickwork in pillars and foundation	1	4
3	Half brick or brick-on-edge portion wall with H.B. netting in every alternative 3rd layer	1	4

The cement and sand shall be thoroughly mixed dry in specified proportions. Water shall then be added just sufficient to make a stiff and workable paste. The mortar shall be used within half an hour of mixing.

4.4 The Agency shall build all brickwork uniformly, no one portion being raised more than 1 meter above another at a time. The joints shall not exceed 12 mm. in thickness and shall extend the full thickness of the brickwork. All joints shall be properly raked and the surface washed down.

4.5 All the bricks shall be kept fully immersed in water at least for a minimum period of six hours till they are completely soaked and only thoroughly soaked bricks shall be used in the work.

4.6 The Agency shall keep wet all brickwork for at least 10 (ten) days after laying. The surface of unfinished work shall be cleaned and thoroughly wetted before joining new work to it.

4.7 Before supplying the bricks, quality and grade of the bricks must be approved by the Engineer-in-Charge on the representative sample.

5. PLASTERING, PAINTING AND SURFACE TREATMENT

All outside and inside walls, ceiling etc., of the building shall be finished with cement plaster, 1.5mm thick cement based putty over plaster. Visible External surface of water retaining structures shall be finished with cement plastering. The external surface shall be plastered up to 0.1 m below FGL. The Agency shall provide neat Cement finish over plaster up to 0.1 m below FGL and 0.3 m above FGL on all external surface as directed by the EIC. The visible external surface of all the structures shall be painted with two coats of acrylic exterior emulsion paint over a coat of primer. Internal wall and ceiling of all structures except water retaining structures shall be finished with cement plaster, 1.5mm thick cement based putty over plaster and painted with two coats of superior grade emulsion paint (plastic paint) over a coat of cement based primer. The shade of the paint shall be approved by EIC. The thickness of plaster is mentioned here under.

5.1 Cement Plaster

5.1.1 The plastering work shall be governed by IS:1661. Unless otherwise specified cement plaster shall be composed of 1 part of cement and 6 parts of sand. For ceiling plaster, the composition shall be 1 part of cement and 4 parts of sand. The thickness of sealing plaster shall be 6 mm. The thickness of plaster to the fair faces of brickwork shall be 15 mm, uneven faces of brickwork shall be 20mm and ceiling plaster shall be of 12mm. The thickness mentioned shall be minimum thickness. The Agency shall allow in his rate for any rubbing out due to inequalities of brickwork. Except underground reservoir and unless otherwise specified by the Engineer-in-Charge, cement plaster shall be applied on all inner and outer surfaces except floors of all structures.

5.1.2 The rate shall also include for forming of any moulding drip course etc., and for extra thickness due to corbelling of brick work in parapet or at any other place. If required, all internal angles shall be rounded off as per drawing or as directed by the Engineer-in-Charge without any extra charges.

5.1.3 Cement and sand shall be measured and mixed dry thoroughly to a uniform color on a platform specially constructed for the purpose. Care shall be taken to see that no foreign matters get mixed with the mixture. Only enough water shall be mixed to make the mixture workable. The mix shall then be turned over and again to a uniform color and texture. No. more cement mortar shall be mixed at a time than cannot be used within thirty (30) minutes of mixing.

5.1.4 Surface to be plastered are to be brushed clean, wetted for 24 hours before the plaster is put in and the joints of the brick work raked out 12 mm. deep minimum. The concrete faces to be plastered shall be chipped, roughened and soaked with water for achieving required bond with the plaster without any extra cost.

5.1.5 The surface of the plaster shall be finished absolutely in one plane. All unevenness shall be rubbed down by the Agency with corboandum stones at his cost and expenses. Care shall be taken to see that no mark remains at the junction of plastering done at different times. If necessary, the junctions shall be rubbed with corborandum stones to eliminate such undesirable marks. The Agency may be required to use normal sprinkling of thin cement slurry on the surface for satisfactory finishing of the plastering work for which no extra payment shall be made.

5.1.6 Plaster shall be protected and cured by keeping it thoroughly wet with sprinkling of water for 10 (ten) days continuously.

5.1.7 The cost of plastering work shall also include the cost of necessary scaffolding, staging etc. as would be required for the work.

6. SURFACE FINISHING

6.1 General

The cost of all the items of work under this section shall include the cost of necessary scaffolding, staging, preparing sub base, removing stains from the floor, skirting, wood work, glass etc. caused through execution of the work.

6.2 Acrylic exterior emulsion paint

6.2.1 Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified. For the external surfaces of the Pump House, Chemical House, Annexe Building, the quality and colour scheme shall be as per direction of the EIC.

6.2.2 **Plastic (Acrylic) Emulsion Paint:** All internal surfaces including ceiling of the Buildings constructed under this tender shall be finished with plastic (acrylic) emulsion paint. On the plastered surfaces, a cement priming coat is required before application of plastic emulsion. Plastic emulsion paint of approved brand and manufacturer and of the required shade shall be used. The paint will be applied in the usual manner with brush and roller.

The paint dries by evaporation of the water content and as soon as the water has evaporated the films gets hard and the next coat be applied. The time for drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces. The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the undercoat which is applied on the absorbent surface. The quantity of thinner to be added shall be as per manufacturer's instruction. The surface on finishing shall present a flat, velvety, smooth finish. If necessary more coats shall be applied till the surface present a uniform appearance.

6.3 Painting to Steel Works

6.3.1 Any shop coat of paint shall not be considered as a coat of paint for the purpose of specification.

6.3.2 Ready mixed synthetic enamel paint of 'Jenson & Nicholoson' 'British Paints', 'Shalimar Paints' or similar other approved make and approved color and shade shall only be used. The primer shall be red oxide zine chromate primer (IS:2074) or any other anticorrosive primer as approved and directed by the Engineer-in-Charge. The Agency shall furnish the details of paints to the Engineer-in-Charge for approval of paints before commencement of painting work.

6.3.3 The surface to be painted shall be properly cleaned, de-rusted, all loose scales removed and smoothened with emery papers. Then a coat of anticorrosive priming shall be evenly applied. After this has dried up, two successive coats of best quality ready mixed synthetic enamel paint shall be given to the entire satisfaction of the Engineer-in-Charge. Brushes of approved size and make shall only be used for application of paint and use of cloth is definitely prohibited.

6.4 Painting to Internal Walls

Whether or not specified, entire internal surfaces of all buildings (except Alum godown) shall be given two coats of acrylic interior emulsion (plastic) paint of approved make, color and shade on a coat of approved primer. The surfaces are to be prepared and both primer and paint are to be applied as per manufacturer's specification. Painting works shall be carried out only by trained hands with roller in order to achieve a high-grade finish to the entire satisfaction of the Engineer-in-Charge.

6.5 Painting to Doors and Windows

All doors and windows unless otherwise mentioned shall be painted with high quality (Grade-I) synthetic enamel paint of approved shade over a coat of primer. The wooden doors and windows of guest house, SCADA room, superintendent bungalow, Chief Engineer bungalow, etc., shall be provided with high quality polish finish.

7. DAMP PROORING WORK

7.1 Unless otherwise specified, damp proof course shall be 25 mm. thick cement concrete (1:2:4) with stone chips graded 10 mm to 3 mm with 3% Cico or similar approved water proofing compound conforming to IS:2645 by weight of cement. The proportioning, laying etc., shall be done is conformity with specification for cement concrete work. The damp proof course shall be used for all brick walls of the building. Wherever brick wall is there, above or below the plinth level, the Agency shall provide plinth protection as per the direction of EIC.

8. ROOF WATER PROOFING TREATMENT

8.1 Unless otherwise mentioned, both flat and curved roofs, whether accessible or inaccessible, shall be provided with polyurethane based water proofing paint over 35 mm thick skid concrete with proper slope.

Specification for Roof Water Proof Treatment with Polyurethane based Water Proof Paint:

8.2 Preparation of Surface

The top surface of the roof shall be chipped off where necessary and all loose particles, dust impurities, are to be removed by rubbing the entire roof surface with wire brush and by application of High Pressure Compressed Heated Air to have a complete dust free and moisture free surface.

The roof surface, receiving polyurethane based Water Proofing paint, shall be provided with cement punning having smooth finish over 35mm thick skid concrete (1:2:4) with 12mm down stone chips. A cross slope of 1 in 300 shall be provided in the roof of Building to allow proper drainage of rain water.

8.3 Specification of Materials

The polyurethane based paint is essentially an elastic and water proof film having a good adhesion to concrete; water and abrasion resistant properties and shall have long term

weather proof characteristics. The paint/film material shall be of two components which is to be mixed and processed as per manufacturer's specification. The mixture shall be homogeneous before applications, as it has tendency to settle.

The polyurethane based water proofing system shall be manufactured by reputed manufacturers of proven record and shall be approved by the Central Building Research Institute (CBRI) / National Chemical Laboratory (NCL) / Council of Scientific and Industrial Research (CSRI) / National Test House or similar such Government/Public Sector Undertakings.

The materials are to be inspected/approved by the Engineer-in-Charge as per procedure to be mutually agreed upon by the agency and Engineer-in-Charge of the work.

8.4 Since the product has a very short self-life, the materials are to be used in the work shall not be older than four (4) months from the date of manufacture (i.e. the date of bottling). Necessary Test Certificate of CBRI/NCL/CSIR/National House etc. are to be furnished by the Agency to the Authority, for the materials procured for the water proofing work.

8.5 Application

The two components of polyurethane based water proofing system shall be mixed as per manufacturer's specification before application. The tack coat shall be applied by brushing or roller to the entire surface in normal temperature and 4 to 6 hours setting time or as specified by the manufacturer shall be allowed before application of the second coat. The record and final coat of polyurethane based mixed water proofing sealing over the priming coat to be applied at normal temperature and curing time between 36 to 48 hours or as specified by the manufacturer shall be allowed.

The application to be made by technically trained and approved applicators duly certified by the manufacturers.

8.6 Guarantee Period

The entire water proofing job shall be covered with a written guarantee of leak proof performance for a minimum period of 10 (ten) years.

8.7 Defects Liability Period

The percent (10%) of the cost of water proofing work shall be retained by the Authority for two (2) years from the date of completion of work. Any defect observed during the Defect Liability Period shall be rectified by the Agency without any extra cost to the Authority.

9. FLOORING

Unless otherwise mentioned, requirement of flooring of different buildings is given below:

S. No	Description of Building	Type of Flooring	Minimum Thickness	Remarks
1	Intake Well Pump house	Epoxy flooring over ironite flooring	Min. 5 mm thick epoxy flooring over 50mm thick ironite flooring	Skirting shall be minimum 150mm height. Flooring pattern shall be submitted for EIC approval.
2	Office and Guest house	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
3	Staff Quarter	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
4	MCC Room	Nonskid Vitrified tiles	8 - 10mm	Skirting shall be minimum 150mm height
5	Filter House Annexe Building	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
6	Operator Room	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
7	Security Cabin	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
8	Toilets & Bathroom	Nonskid Vitrified tiles	8 - 10mm	Toilet wall shall also be provided vitrified tiles upto 1.8 m height
9	Filter House	Polished Granite	25 mm	Skirting shall be minimum 150mm height
10	Platform of Intake well	Polished Kota Stone	25 mm	Skirting shall be minimum 150mm height
11	Filter house Ground Floor lobby	Granite slab of area not less than 1.5 sq.m each	25 mm	Skirting shall be minimum 150mm height.

12	Kitchen platform	Granite slab of area not less than 1.5 sq.m each	25 mm	Skirting shall be minimum 750mm height over the platform.
13	Kitchen floor	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
14	Laboratory	Chemical resistant vitrified tiles	8 - 10mm	Skirting shall be upto window sill level
15	Chemical Storage Area	Bituminous Mastic Asphalt	25 mm	Skirting shall be upto 0.3 m above chemical storage height
16	Chemical house	Kota Stone	25 mm	Skirting shall be minimum 150mm height
17	CWPS Pump floor	Epoxy flooring over ironite flooring	Min. 5 mm thick epoxy flooring over 50mm thick ironite flooring	Skirting shall be minimum 150mm height. Flooring pattern shall be submitted for EIC approval.
18	Walkway of Pump house	Polished Kota Stone	25 mm	Skirting shall be minimum 150mm height
19	Walkway of Treatment Plant (Open to Sky)	Chequered tiles	25 mm	
20	Chief Engineer Bungalow	Italian Marble Slab of size not less than 2 Sqm	8 - 10mm	Skirting shall be minimum 150mm height
21	Superintendent Bungalow	Vitrified tiles (800mm x 800mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
22	Administrative building	Vitrified tiles (600mm x 600mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
23	Command Control Center and SCADA room	Granite slab of area not less than 1.5 sq.m each	8 - 10mm	Skirting shall be minimum 150mm height
24	Car parking area	Anti-skid Ceramic tiles (450 mm x 450 mm) flooring	8 - 10mm	Skirting shall be minimum 150mm height
25	Stair case (except pump	Marble (single stone) for rise and tread.	12 mm	Skirting shall be minimum 150mm height

	house & SUGRs)			

9.1 'Ferrosite' or 'Ironite' Flooring shall be 50mm. Thick to be laid in two layers. First a layer of 25mm. thick patent stone flooring shall be laid in M15 grade concrete and allowed to dry. Then the second layer of 25mm.thick flooring of M15 grade concrete with 10mm.to 6mm. stone chips using at least 1Kg/Sq.m. of floor hardening compound of approved quality and make shall be laid and cured. The flooring shall be laid in rectangular panel with diagonal length not exceeding 3.0 Meters. All floors with pump and motors, chlorinator and chlorine drums, pipeline higher than 300 mm diameter, electrical panel board, blowers, alum/coagulant storage room, unloading bay, stack yards for pump and motors shall be of this type of flooring.

10. IRON MONGERY

10.1 The rain water pipe of the materials and of size as specified shall be of approved manufacture end jointed as follow:

10.1.1 For heavy cast iron pipes with gasket and lead properly caulked.

10.1.2 Where required these are to be run in chase left out in walls, columns, slabs and to be encased in cement concrete 1:2:4 (1 Cement, 2 Sand, 4 washed Stone Chips 19mm. down) with metal lath wrapping or with M.S. loops placed at approximately 325mm. centres or as directed by the Engineer-in-Charge. All pipes encased in walls, columns or under floors must be heavy cast iron with lead caulked joints. For exposed lengths of pipes, these are to be neatly secured clear from the finished wall face with nails and bobbing in the case of cast iron pipes, nails or screwed to hard wood tapping pugs embedded in wall.

10.1.3 All cast iron rain water pipes shall be painted two coats inside with approved anticorrosive paint. The exposed cast iron pipes shall be painted outside with two coats of ready mixed Synthetic Enamel Paints of approved make, shade and color over a coat pf priming of approved make.

10.1.4 The mouth of rain water pipes shall be fixed with C.I grating and the pipe jammed in position in 1:2:4 cement concrete with stone chips and neat finish on the surface.

10.1.5 The work shall include all supply, fitting and fixture of materials cutting, making chases, encasing, painting, jointing, etc.- complete in all respect. The work shall include supplying, fitting, fixing, and jointing of all the specials required for the completed work.

10.1.6 Rain water Spouts shall be of C.I pipes cut to exact length as per approved drawing or direction of the Engineer-in-Charge and laid in position in 1:2:4 cement concrete with stone chips, adjoining roof being finished in neat cement. The interior faces shall be painted two coats with anticorrosive paint and the faces shall be painted with two coats of ready mixed Synthetic Enamel paint of approved make, shade and color over a coat of priming of approved make.

10.2 Metal Casement

10.2.1 Unless specified otherwise, all doors, windows and ventilation in general shall be of mild steel casement with sections as per I:1038. They shall be of approved make. The Agency will submit the name and address of the manufacturers whose mental casements he intends to use for approved of the Engineer-in-Charge. The workmanship shall be of high quality and shall be upto the entire satisfaction of the Engineer-in-Charge.

10.2.2 All the steel doors and windows sashes shall be given a shop coat of Red Oxide Zinc Chromate Primer I.S:2070 after these are thoroughly cleaned off dust, dirt, scales etc., and passed after inspection by the Engineer-in-Charge.

10.2.3 Windows are to be prepared for puffy glazing from the outside and for opening outwards unless otherwise mentioned. All steel sashes shall have holes drilled at suitable places for inserting glazing clips which shall also be supplied by the Agency. All glazing shall be fixed to the shutters or frames in addition to glazing clips with quality putty of Shalimar or equivalent make. Glass must not be placed directly against the metal. A thin layer of putty must be evenly spread over the glazing rebate and the glass pressed firmly against it.

10.2.4 Ventilators shall be constructed from solid filled universal casement section being double weathered at all points to ensure water tightness and bedded in mastic and screwed to the sashes.

10.2.5 The fitting shall be of heavy pattern bronze oxidized brass and of approved quality, side hung casement will have two-point locking handle and casement fasteners. The hung windows shall have 200mm. long adjustable casement stay, arrange to lock the windows from inside horizontally at the center, hung windows shall have spring catch designed for

hand cord or pole operation as approved by the Engineer-in-Charge. The fitting to be fitted either by screwing to the window sections or to steel bracket welded to the window section as approved by the Engineer-in-Charge.

10.2.6 Galvanized weather bars shall be provided to sills of all windows.

10.2.7 Mental casement are on no account to build in at the time the walls are constructed. Holes to accommodate the fixing lugs are to be left or cut and the casement fixed after all rough masonry plaster works have been finished. The lugs of the casement shall be jammed in 1:2:4 cement concrete with stone chips after holding the casement in proper position, line or level.

10.2.8 **Glazing** for windows and ventilators shall weight not less than 8.0 Kg/Sq.m. For doors, 6mm. thick wire net reinforced glazing shall be used as approved by the Engineer-in-Charge. The glasses shall be cut to size accurately to suit all openings to glazed with slight margin of about 1.50mm. on all sides or as directed. These shall be securely fixed in position in the manner described earlier. On completion of the building, the Agency shall clean all the glass and leave the same perfectly in a tidy condition.

10.2.9 The cost of marginal doors, windows and ventilations shall include supplying fixing, fitting, glazing cleaning, necessary scaffolding, staging etc. and shall be for the complete work in all respects to the satisfaction of the Engineer-in-Charge.

10.2.10 The Agency shall without any extra charge, submit three sets of shop drawings from the manufacture showing full details of each type of doors, windows and ventilators including section, position of all fittings and fixtures for the approval of the Engineer-in-Charge before manufacture and finally six sets of approved final drawings with notes on the method of fixing.

10.2.11 Where specified, mosquito fly proof brass wire screen of approved gauge and mesh shall be used in combination with windows. The screen shall be fixed to the inside of the frames and the windows to be opened outside and be fitted with 'Folio operator' for opening to any position and closing. Additional intermediate members be fixed to the frames to receive the fly screen so that the clear span of the screen does not exceed 300 m. or as approved by the Engineer-in-Charge.

10.2.12 All windows shall be provided with grills of approved design made of 12 mm x 12 mm M.S. square with clear openings not exceeding 100 mm.

10.2.13 The work for grill shall also include the cost of painting with 2 coats of ready mixed synthetic enamel paint of approved make, quality color and shade over a coat of approved anticorrosive primer.

10.3 Collapsible Gate

The M.S. collapsible gates will be obtained from manufacturer as approved by the Engineer-in-Charge. These shall be of mild bar type, out of 20 mm. channels and shall be top ung with roller bearing and shall have locking arrangement. Collapsible gates under 2.700 m. height shall be with 4 sets of lattices. Guide tracks shall be to the entire satisfaction of the Engineer-in-Charge. The gates shall be fixed in position, de-rusted, descaled and painted with 2 coats of approved ready mixed paint over a coat of approved anticorrosive primer.

10.4 Rolling Shutter

10.4.1 The M.S. roller shutter shall be obtained from manufacturer as approved by the Engineer-in-Charge. The roller shutter shall be of 18 G x 75 mm. galvanized mild steel laths of convex corrugation complete with one-piece construction. These shall be fitted with pressed side guides and pressed bottom rail, brackets, door suspension shafts, top rolling springs (of strong English Continental Spring Steel Wire) with a four-lever concealed lock as also separate locking arrangement for padlocks, pulling hooks, handles and top cover. The roller shutters shall be fixed in position with all accessories and the design and the workmanship shall be to the entire satisfaction of the Engineer-in-Charge. This shall be finished with two coats of approved ready mixed paint over a coat of approved anti corrosive primer.

11. STRUCTURAL STEEL WORK

11.1 All Structural Steel to be used for gantry beam etc. shall be of tested quality conforming to IS:226 and IS:2062 latest addition.

Finished steel shall be free from cracks, lamination and other visible defects. Section shall be adequately protected from rusting and scaling. Rivets and bolts, nuts and washers shall be of mild steel and comply with requirements of relevant IS Codes. Steel used for rails shall have tensile strength of about 50-60 Kg/Sq. mm. and yield point at 26 Kg/Sq. mm. The electrodes for welding shall conform to IS:814. All steel work shall be fabricated and

erected as per IS:800 and IS:806. Welding shall be carried out as per IS:814, IS:815, IS:816 and IS:823, all of the latest editions.

11.2 All steel work, after preparation of surface, shall be given a coat of red oxide zinc chromate primer (IS:2074) and finished with two coats of Synthetic enamel paint. Surface to be painted shall be thoroughly cleaned of mill scale, oil grease, rust etc. over coating and finishing paints shall be of well-known make (viz Jenson & Nicholson / British Paints (Berger Paints) / Shalimar Paints). The Agency shall furnish details of Paints to the Engineer-in-Charge for approval of paints before commencement of painting work.

11.3 Steel work shall be hoisted and erected in position in a safe and proper manner. No. riveting or permanent bolting shall be down until proper alignment has been made. For grouting, cement and clean fine sand shall be used in a proportion of 1:2 and properly mixed with water. All trapped pockets shall be fully vented for full penetration of grout. All grouting shall be cured for a minimum period of seven days.

12. CABLE TRENCHES

12.1 The Agency shall design the size of cable trenches and shall provide insert plates made of M.S. of dimension 100 mm x 750 mm x 12 mm (W x D x Th) are to be provided at an interval of 600 mm all along. The cable trench shall be of RCC M30 grade.

12.2 The Cable Trenches shall be covered with precast concrete slabs of required dimension and adequate thickness to withstand a load of 500 Kg/m^2 are to be provided as covers of trench all along. For easy access of cable from room to room, the design of the tie beam and level of the rooms may be adjusted to avoid bend in the cable.

12.3 The cable trenches shall be free from any obstructions as to allow the cables to be lowered in the trenches from top only during laying. The space inside the trenches throughout the entire lengths shall in no case be encroached by any beam or columns.

13. POCKETS & HOLDING DOWN BOLTS

Provision have also to be kept for pockets and holding down bolts as per requirement of the electrical and mechanical equipment at no extra cost. The extract details of such pockets and holding down bolts will be supplied to the Agency as per specifications of the suppliers of the equipment after award of the contract. It is contemplated that M.S. hangers shall be provided from the underside of slab/beam of the operating floor, and is to be

executed in a separate contract. However, for the above arrangement suitable pockets and holding down bolts are to be left.

14. CHEQUERED PLATES ETC.

These shall be manufactured from structural steel conforming to IS:226. They shall be of the specified size, thickness and pattern as per relevant drawings or as directed by the Engineer-in-Charge. Cover plates will generally be of chequered plates with or without stiffeners as detailed in the drawings. For convenience, the Agency shall prepare detailed floor plans of the layout of cover plates for floors and platforms to include all openings, cuts etc. and so as to match the patterns of adjacent cover plates/gratings. Where necessary, the floor will have to be made leak proof by properly welding cover plates. If necessary, packing shall be welded to the bottom of cover plates to raise the cover plates on sides, so as to provide necessary slopes as shown in the drawings or as directed by the Engineer-in-Charge in the floors and platforms to drain away any liquid failing on the floors and platform. Necessary gutters at the ends of platforms shall be provided for sloping floors and platforms as shown in the approved drawings or as directed by the Engineer-in-Charge. Kerbs of flats shall be provided where necessary, around openings and cuts in order to prevent liquids falling to lower floors or platforms.

15. HAND RAILING

Double rows of 30 mm. dia. S.S. tubular hand railing fixed in S.S. stanchions shall be provided on the edge of walkways and platforms as specified. The stanchions shall be fixed with mild steel rag bolts with chromium plated cap nuts. The stanchions shall not be less than 1000 mm. high and placed at a distance not exceeding 2500 mm. The hand railing shall be fixed true to exact line and level. S.S stanchions and hand railing layout shall be of architectural design with pleasing appearance.

16. SANITARY INSTALLATIONS

16.1 The Urinals shall be of flat back, front lipped having a size of 46.5 cm. x 36.5 x 26.5 cm. or nearest available size. The Indian type W.C. shall be of minimum 58 cm. Complete with foot rest in one piece.

16.2 All Sanitary works shall be of "Parry, "Neycer", "Hindusthan Sanitaryware" or any other equivalent make. They shall be of approved quality conforming to relevant IS Codes and

shall bear ISI Certification marks. All G.I. pipes shall be of ITC or equivalent make heavy quality conforming to relevant IS Code. Wheel valves and stop cocks shall be of gun metal and of "leader" or "Annapurna" or equivalent make as approved by the Engineer-in-Charge and shall conform to relevant IS Codes.

16.3 Minimum two urinals, one bathroom, one European W.C. (Commode), one change room with cupboards shall be provided in each toilet block.

17. MANHOLE COVERS

Heavy duty plastic fiber reinforced concrete manhole covers shall be of heavy duty type conforming to IS:1726.

17.1 Overflow Arrangement

Overflow line shall be provided with openable SS net at Outlet fixed with a flange arrangement.

18. DOORS

Timber doors

The timber door shall be of 1st. Class CP Teak Wood for both frame (100 mm x 100 mm) and shutters (49 mm thick). All such doors shall be fully paneled. All timber shall be of best quality, well-seasoned and/or well treated for prevention and protection against decay etc. It shall be uniform in substance, straight in fibers, free from large or dead knots, sap, flaws, sub cracks, shakes, or blemishes of any kind. Any insect damage or splits across the grain shall not be permissible. The color of the timber shall be uniform throughout, firm and shining with a silky lustre when placed and shall not emit dull sound when struck. The doors shall be made as per approved drawings and as directed by the Engineer-in-Charge and the timber shall be sawn in direction of the grains and shall be straight and square. The door fittings shall be highly polished as per direction of the Engineer-in-Charge.

Aluminium Doors

Main entrance of all main buildings shall be of glazed anodized aluminium door of approved shade with hydraulic door closer.

WINDOWS

All windows shall be of glazed anodized aluminium door of approved shade. Sliding window with Double glazing glass shall be provided at Control room and SCADA room at WTP.

19. Painting of PIPELINES

All above-ground pipelines shall be painted with epoxy coating.

19.1 R.C.C N.P-3 CLASS PIPELINE

The Agency shall design detail Engineering of storm water drainage as per the specification given in other section of the bid document.

20. ELECTRICALLY OPERATED OVERHEAD CRANE

Provisions shall be made at Intake well-cum-pump house for a 15.0 M.T. capacity and at clear water pump house for a 10.0 M.T. capacity Electrically Operated Traveling Crane (E.O.T.) suitable for inching operation with a lift to operating above Ground Level for handing pump, motor and other accessories. The horizontal travel of the EOT crane shall cover the maximum possible length along longitudinal and transverse direction of the pump-motor room including operation/maintenance platform and unloading bay. They shall be of reputed make as per vendor list and as approved by Engineer-in-Charge. Suitable type of crane rails, girders and all other accessories as necessary for installation and operation of the crane are to be designed and provided by the Agency within the Lump Sum pipe quoted. The two travels and two hoists i.e. long, cross & main Auxiliary etc. must be electrically operated with provision for mechanical operation. The buffers must be spring loaded operation. The speed and other criteria are as follows:

Speed for Hoisting	4-5 (normal) MPM
Speed for Cross Travel	1-12 (normal) MPM
Speed for Long Travel	15-20 (normal) MPM

Type of Brake - AC (Electromagnetic) shoe type for hoist and disc type for C.T.

Motor - Ship disc type.

Suitable vertical clearance is to be provided over the rail level to the bottom of the roof beam.

There shall be another additional 3.0 MT capacity EOT crane at CWPS covering same horizontal and vertical limit as of 10 MT capacity EOT crane. Provisions shall be made at Backwash Pump room, Chlorine drum storage room, chlorine rom at chemical house for a 5.0 M.T. capacity Electrically Operated Monorail Trolley with Auxiliary hook of 1.0 MT capacity suitable for inching operation with a lift up to operating above-Ground Level

for handling pump, motor and other accessories. At Alum/coagulant mixing tank room (2 nos. of 2.0 MT capacity) having above specification shall be provided.

Provisions shall be made at clear water pump house at WDC with SUGRs for a 3.0 M.T. capacity Electrically Operated Monorail Trolley with Auxiliary hook of 1.0 MT capacity suitable for inching operation with a lift up to operating above-Ground Level for handling pump, motor and other accessories.

21. SLUICE GATE/PEN STOCK GATE

Electrically actuator operated SCADA compatible Cast iron single faced Thimble Mounted Sluice Gate/Penstock Gate shall be designed as per IS:13349-1992.

22. D.I. SLUICE VALVE

Electrically actuator operated SCADA compatible D.I. Sluice Valve conforming to IS:2906-1869 suitable for water works purposes and as per requirements of the Clear Water Reservoir/Clear Water Pump Sump. The detailed specification has been given in the "Specification for Valves" in this bid document.

23. S.S COWL VENTILATOR

150 mm. diameter Specially designed heavy-duty S.S. 316 Cowl Ventilator with mos-quito-proof SS Net shall be provided in the outer peripheral walls below the reservoir roof. The Agency shall design the number of SS Cowl Ventilator to be required and shall submit the same to the EIC for approval.

24. ARRANGEMENTS OR PLASTIC FIBRE REINFORCED CONCRETE MAN-HOLE COVER M.S. LADDER ETC.

24.1 Manhole Cover

Heavy duty plastic fiber reinforced concrete manhole covers with frame shall conform to relevant IS Code. The clear opening for access to the M.S. Ladder for going inside the reservoir shall be 600 mm. and the overall dimension of the Heavy-Duty Manhole Cover shall be specified by the Tenderer conforming to relevant IS Code. The manhole cover with frame shall be of 'Double Seal Type'. The Agency shall design the number of man-hole to be required and submitted to the EIC for approval. The specification for manhole in sewer line and drainage line has been given elsewhere in this bid document.

24.2 RCC Stair case

The Agency shall provide RCC (M30) staircase with handrail for going inside of the reservoir. The width of the stair shall be of minimum 1.0 M. The riser and tread shall be of 150mm and 250mm respectively.

24.3 Rung Ladder

Where over specified, shall be formed out of 20 mm. dia M.S. Rods. The rods forming Rung Ladder shall be properly bonded inside the R.C.C. walls. The spacing of Rung Ladder shall not exceed 300 mm. and the size of the rung formed shall be 300 mm. wide x 150 mm. deep. The rods are to be painted with anti-corrosive paint with suitable primer as per manufacturer's specification to be approved by the Authority.

25. MOTOR FLOOR AND CONTROL ROOM

There must not be any column in the motor floor for easy movement of the E.O.T. Crane. Similarly, in the Control room, office room and Scada room, these must not be any column in the room. The motor floor shall have suitable openings at appropriate location as per requirement of the pump manufacturer for lowering and taking up of pumps, motors, valves, entry for cable etc. The motor floor shall be suitably designed to take care of the vibration generated from the motor pump assembly while in operation.

26. ARCHITECTURAL VIEW

Pleasant architectural view shall be provided for Guest house at Intake, Clear water pump house (WTP site & WDC site), Electric Substation building, Office building, Façade of Pump house and buildings.

27. TRIAL RUN AND COMMISSIONING

When in the opinion of the Engineer-in-Charge the initial performance tests as specified in Other Section are satisfactory the Agency shall arrange for trial run of the plant at its rated capacity and their performance tests in presence of OEM representative after his certification. Before proceeding for the trial run of the plant, individual electromechanical equipment to be trial run with no load condition in presence of the OEM representative after his certification. Also, all electromechanical equipment, performance parameter of the individual equipment like head, discharge, power consumption, Vibration, dB level, pressure, ampere, voltage, earthing etc., shall be performed in the presence of EIC/representative of EIC and OEM representative as per the approved QAP and Data sheet. The performance reading is tabulated and submitted for EIC approval. The performance test of the pump shall be as per IS 11346 (latest edition). During such tests and trial run of

WTP, the Agency shall arrange to collect samples of water from the different units as specified in Schedule-B. These samples shall be sent by the Engineer-in-Charge or his authorized representative to the plant laboratory or any other laboratory nominated by the Engineer-in-Charge, for analysis and determination of the quality of the water samples. All costs of the sample collection, delivery to the laboratory and test shall be borne by the Agency.

Before proceeding for the trial run, mock tests of Instrumentation and control system and SCADA shall be completed and certified by the EIC so that all the trial run performance shall be recorded through SCADA.

After completion of successful performance test of the system, the entire system shall be put to trial run and commissioning for 3 months duration.

The proposed water supply system shall be deemed to be ready to be put into normal use when trial run of the system and the quality of the clarified water and filtered water are certified satisfactory by the EIC/representative of EIC. The period of maintenance shall be reckoned from the date of the Engineer-in-Charge's certificate.

28. OPERATION AND MAINTENANCE

After the proposed water supply system is deemed to be ready to be put into normal use, the Agency shall operate and maintain the same for a period of 10 years including the 2-year DLP by his own men under the overall supervision of the Agency. chemicals and other consumable and stores required for the operation of the water supply system shall be supplied by the Agency at its cost. The Authority shall bear the cost of electrical energy as mentioned in KPI. During the aforesaid period of operation of the water supply system, the Agency supervisory staff shall train and instruct technicians and other staff deputed by the Authority about the correct method of operation and maintenance of the proposed water supply system as a whole and its various mechanical and electrical components. The Training shall be such as would enable the Authority's staff to take over the proposed water supply system from the Agency for its operation and maintenance independently. The Agency training personnel shall give special attention to this.

During the period of operation and maintenance, the Agency shall arrange to take regular samples of the clarified and filtered water as directed by the EIC and shall have such samples tested at his cost in the plant laboratory or any other laboratory nominated by the

EIC, to determine the quality of the samples and the performance of the water treatment plant. Such tests shall be continued up to the penultimate week prior to the end of the maintenance period and the plant shall be taken over by the Authority subject to the final performance tests being certified as satisfactory by the Engineer-in-Charge.

The tenderers shall submit with their offer a list of technical and non-technical staffs they propose to engage for operation and maintenance of the proposed water supply system for the entire duration of 8+2=10-year O&M period.

29. GUARANTEE PERIOD

The Agency shall stand guarantee for the successful operation of all the civil, mechanical, electrical, electronic components and structures including all types of pipelines and road-works for 10 (ten) years period from the date of the certified commissioning. as stated in relevant clause within which any defects and shortcoming due to faulty design of the water supply system, defective mechanical and electrical equipment or defective con-struction shall have to be made good without any extra cost to the Authority. During the guarantee period, the Agency shall ensure thorough checking of the proposed water sup-ply system at least once every month and shall arrange for immediate rectification of any defects detected during this special checking by his experts.

30. GUARANTEES

The Agency shall give the following guarantees:

30.1 Civil and Structural Works

The Agency shall guarantee the proposed water supply system against any structural fail-ure due to faulty design, bad workmanship, substandard materials, etc. for a period of 10 years. Any defect found during the guarantee period shall be rectified by the Agency to the satisfaction of the Engineer-in-Charge without any extra cost.

30.2 Plant and Equipment

Even when a plant or equipment has been manufactured and / or marketed by a vendor, it shall be deemed to have been supplied and installed under the Agency supervision. The Agency shall provide back to back guarantee along with the vendor but shall solely be responsible for its repair/replacement. He shall not cite the vendor and claim absolvement of responsibilities. In addition, all equipment shall be free from any defects due to faulty designs, materials and / or workmanship. The equipment shall operate satisfactorily and

performances and efficiencies shall not be less than the values guaranteed by the manufacturer and endorsed by the Agency.

Formal acceptance of the work or equipment covered under the Contract by the Engineer-in-Charge shall not be made until all the works done by the Agency has satisfactorily passed all tests required by the specifications.

If, during testing of work and / or equipment prior to formal acceptance, any equipment or materials shall fail in any respect to meet the guarantees, the Agency shall replace such equipment in a condition which will meet the guaranteed performance. Any such work shall be carried out by the Agency at his own cost and expenses in necessity thereof, shall in the opinion of the Engineer-in-Charge be due to the use of materials or workmanship not in accordance with the Contract or to neglect or failure on the part of the Agency to comply with any obligation expressed or implied on the Agency part under the Contract. If in the opinion of the Engineer-in-Charge, such necessity shall be due to any other cause, the value of such work shall be ascertained and paid for as if it were additional work.

If the Agency shall fail to do any such work as aforesaid, required by the Engineer-in-Charge, the Authority shall be entitled to carry out such work by its own workman or by others of such works supposed to be carried out by Agency, the cost thereof shall be deducted that may become due to the Agency.

30.3 Treated Water Quality.

The Agency shall guarantee the quality of the clarified, filtered and disinfected water and these guaranteed results shall conform to the following;

i. Clarified water - The turbidity of the clarified water effluent from each clarifier/plate settler shall be less than 5 NTU when the plant is operated under normal design flow conditions and less than 10 NTU when under overload condition due to one of the clarifiers/plate settlers taken out of operation for maintenance, repair, etc. even when handling raw water at its worst condition i.e. at its highest turbidity level.

ii. Filtered and disinfected water - The turbidity of filtered and disinfected water shall be less than 1.0 NTU even with the maximum turbidity of raw water. The finished water must not be acidic in nature under any circumstances and shall not at any time contain less than 10 ppm of total alkalinity (as $CaCO_3$). In no case, pH value shall

be less than 6.5 or exceed 8.5. Iron content shall not exceed 0.3 mg/l. There shall not be any nitrate (as NO_3).

30.4 Wash Water Consumption

The Agency shall guarantee that the wash water required for backwashing shall not exceed 3% of the total water filtered, based on the average working of the units over a period of the year.

30.5 Zero Liquid Discharge

The Agency shall implement ZLD concept as envisaged in Central Pollution Control Board (CPCB) most recent guidelines and shall implement the same in the WTP design and construction fully.

31. IMPORTANT GUIDELINES & SPECIFICATIONS

31.1 Unless otherwise specified elsewhere, the work shall be carried out as per the following specifications. Wherever any work is not covered in this entire document, the decision of the Engineer-in-Charge regarding the specification of the same shall be deemed final and binding on the Agency.

31.1.1 Pleasant architectural plan & view shall be provided for Guest house at Intake, Clear water pump house (WTP site & WDC site), Electric Substation building, Office building, Façade of Pump house, filter house annex, staff quarter building, bungalows and office cum guest house.

31.1.2 All civil works shall be carried out as per specifications contained in other sections of the tender specifications.

31.1.3 All electrical works including supply of all electrical equipment shall be carried out as per specifications contained in other sections of the tender specification.

31.1.4 All mechanical works including supply of equipment shall be carried out as per specifications contained in other section of the tender specifications.

31.1.5 The erection and commissioning works shall be carried out as per specifications contained in other section of the tender specifications,

31.2 A minimum free board of 500 mm shall be provided for all water containing structures viz, collecting well, flash mixer, filter beds, channels, etc. except underground reservoir and unless otherwise specified elsewhere.

31.3 For the convenience and ready accessibility to the operating level, each unit of the treatment plant shall be so interconnected by walkways/gangways as will permit reaching one end of the treatment plant to the other by means of walkways/gangways without having any necessity to get down to the ground level.

31.4 Walkways and operating platforms shall be provided with SS hand railings as specified in other sections.

Open to sky Walkways and operating platforms shall be provided with Chequered tiles floor finish

31.5 All Roofs shall be provided with water proof polyurethane paint,

31.6 All the exterior doors and windows shall be provided with R.C.C. chajja of approved design.

31.7 All windows and ventilators/skylights shall be provided with mild steel square bar grills of approved design.

31.8 Construction of permanent roads within the proposed water-works sites are within the scope of this contract up to the porches of all the buildings like filter house, annexe building, etc. Tenderer shall also include the cost of construction of temporary access roads required for their construction of different units of the treatment plant and reservoir units for easy maneuver of their construction equipment. This would necessitate cutting of trees, clearing of bushes, filling of a pond, leveling and dressing of site, the cost of all of which shall be taken into account by the Agency while arriving at their quoted cost. Wherever cutting of trees becomes inevitable, the Agency shall maintain an inventory of trees cut by the Agency and handover the inventory as well as the trees removed to the EIC.

32. GENERAL TECHNICAL SPECIFICATION FOR R.C.C. PILE FOUNDATION

32.1 General

32.1.1 The design of the tenderer shall be based on cast-in situ Bored reinforced concrete piles.

For this, Sub-soil investigation shall be carried out by the Agency for arriving at the appropriate foundation design.

32.1.2 The specialist firm engaged by the Agency may quote any proprietary system of piling subject to approval of the Engineer-in-Charge consistent with the load, moment and forces to be encountered by each pile.

The Tenderers shall submit with his tender drawings, calculations explaining his scheme, draw up specification and submit the schedules of prices following the format of the schedules of prices accompanying this tender document.

32.3 **Design and Concrete Quality**

32.3.1 The grade of concrete of all types of R. C. C. pile shall be minimum M-20/M-25 unless otherwise specified elsewhere. The cement content in concrete to piling work shall be minimum 400 kg/M3 with ordinary Portland Cement. Water cement ratio and slump shall be as per I. S. Specification for relevant piling work. Maximum size of coarse aggregate shall not exceed 20 mm.

Grading and other requirement of coarse and fine aggregates, water and concrete shall be as specified for reinforced cement concrete work under this Contract.

32.3.2 The average basis length of the piles is to be assumed from cut off level to the tip of the pile (however for piles with muff the basic length shall be from tip of the pile up to underside of muff). The final length shall be decided by the Agency with approval of the Engineer-in-Charge on the basis of driving/boring resistance actually observed at site. It will be the responsibility of the Agency to prove by subsequent load test/pullout tests that the adopted length of pile shall carry the specified safe load, tension and the resulting deflections being within the permissible limits. In no case, extra claim over the originally quoted price will be entertained for any increase in number/length/cross-sectional area/reinforcement of piles and in the site of other foundation structures if required at the time of execution after the load tests of piles. Similarly, no deduction in payment will be made from the lump sum price quoted for decrease in number/length/cross-section of area/reinforcement and in the size of other foundation structures at the time of execution or after the load tests of piles, provided that the complete safety of the Structures is fully assured.

32.3.3 For Intake Wells, pile foundation shall have permanent steel casing/approved alternative methodology. Scour depth below bed level will be a major guiding factor. All relevant provision of I.S. code for R.C.C. Structure on river bed (under water) will have to be strictly followed. However, Tenderers may suggest other methodology without deviating from major objectives & provisions well within I.S. standards. In any case, the Agency shall ensure the stability of the structure.

32.3.4 Tenderers/Agency will be given full liberty to opt for design mix as per satisfaction of E.I.C. with minimum cement content as mentioned.

32.4 **Specification for Bored Cast-in-Situ piles**

32.4.1 Unless specified otherwise in the following paragraphs, stipulations of relevant section of current I. S. 2911 shall be followed.

32.4.2 The tenderer shall submit within his tender the layout and number of piles based on allowable load carrying capacity, tension on the pile section design by him.

32.4.3 Boring equipment and accessories shall generally conform to IS: 2911 relevant section. Boring may be done by either rotary or percussion equipment or grassing equipment using reverse or direct non-circulation method. In case of unstable soils, the boring tools used shall be such that, suction effects are minimized. Stabilization of the sides of bore hole shall be done by the use of bentonite slurry or casing. The size of cutting tool shall not be less than the diameter of the pile by more than 75 mm.

32.4.4 In case of boring with casing, the casting shall be used from the ground level. The casing shall be kept ahead of boring in cases where there is danger of carrying in due to subsoil entering into the borehole or where soil is loose. While boring below sub-soil water, precaution shall be taken so that no boiling of the bottom of the hole occurs due to difference in hydrostatic head.

32.4.5 Concreting of bore holes shall start soon as possible after its completion. Shall a borehole be left without concreting for more than two hours, it shall be cleaned thoroughly as directed by the Engineer-in-Charge before placing concrete. Concrete under water shall be placed by means of a tremie pipe. It shall, however, be ensured that concrete entering the tremie pipe does not get mixed up with the slurry and ¼ kg of granulated vermiculite

shall be poured in the tremie pipe before pouring concrete as directed by the Engineer-in-Charge.

32.4.6 The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out of the bottom. The concrete levels in the tremie shall be checked every meter in order to judge the difference, if any, between the theoretical quantity that shall have been placed and the actual quantity that has gone in. This is to locate the position of cut off during boring.

In addition to the normal precautions to be taken in tremie concreting as per relevant Section of current IS: 2911, the following specifications shall be particularly applicable for the use of tremie concrete in pipes.

i) The concrete shall be coherent, such in cement (not less than 400 kg/m3) and of slump not less than 100 mm.
ii) The hopper and tremie shall be closed system.
iii) The tremie shall be large enough with due regard to the size of the aggregate. For 20 mm aggregate the tremie pipe shall be of diameter not less than 200 mm.
iv) The first charge of concrete shall be placed with a sliding plug pushed down the tube of it or with a steel plate of adequate charge to prevent mixing of concrete and water. However, the plug shall not be left in the concrete as a lump.
v) The tremie pipe shall always penetrate the concrete with an adequate margin of safety against withdraw of the pipe surged to discharge the concrete.
vi) The pile shall be concreted wholly by tremie and the method of deposition shall not be charged way up the pile to prevent into laittance from being trapped within the pile.
vii) All tremie tubes shall be scrupulously cleaned after use.

Normally concreting of the piles shall be carried out without any interruption. In the exceptional case of interruption in concreting, but which can be resumed within 1 hour, the tremie shall not be taken out of the concrete. Instead, it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting shall be resumed by introducing a little richer (5% additional amount) concrete with a higher slump for easy displacement of the partly set concrete.

If the concreting cannot be resumed before final set of concrete already placed, the pile so cast may be rejected or accepted with modifications at the sole discretion of the Engineer-in-Charge.

In case of withdrawing of tremie out of the concrete, either accidentally or to remove a blockage in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laittance or sewer laying on top of the concrete already deposited in the bore.

The tremie shall be gently lowered on the old concrete with very little penetration initially. A vermiculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm. And 175 mm. Shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing laitance/sewer. The tremie will be pushed further in steps, watering fresh concrete sweeping away laittance/scum in its way. When tremie is buried by about 60 to 100 cm. concreting may be resumed.

32.4.7 The top of concrete in a pile shall be brought above the cut off level to permit removal of all laitance and weak concrete before capping to ensure good concrete at the cut off level for proper embedment into the pile cap. Where cut off level is less than 1.5 M. below the working level concrete shall be cast to a minimum of 500 mm. Above cut-off level. For each additional 0.3 m. increase in cut-off level below the working level additional coverage of 50 mm. Minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile as directed by the Engineer-in-Charge. When concrete is placed by using tremie material, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one meter above cut-off level. In the circumstances where cut off level is below ground water level the need to maintain pressure on the freshly laid concrete equal to or greater than water pressure shall be formed out and accordingly the length of extra concrete above cut-off level shall be determined and provided in works.

32.4.8 During piling, the sequence of construction and installation of piles shall as per direction of the Engineer-in-Charge.

32.4.9 In case defective piles are formed during construction, they shall be removed or left in place whichever is found convenient without adversely affecting the performance of the adjacent piles or the pile cap. Additional piles shall be provided at Agency cost to replace

them as per direction of the Engineer-in-Charge and in this respect the Engineer-in-Charge's decision shall be final and binding upon the Agency. Any deviation from the designed location, alignment or local capacity of any pile shall be noted and adequate measures shall be taken well before concreting of the pile cap, etc. if the deviations are beyond the permissible limit. All such alternations shall be done at Agency own cost and expenses and to the entire satisfaction of the Engineer-in-Charge.

32.4.10 Piles shall be installed accurately as per approved design and drawings. For vertical piles, a deviation of 1.5 percent from vertical line shall not be exceeded. Piles shall not deviate more than 75 mm. or one tenth of diameter whichever is more (in case of piles having diameter more than 600 mm) from their designed positions at working level of the piling rig.

In case of piles deviating beyond the above-mentioned limits and such an extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap & pile trees, the piles shall be replaced or supplemented by one or more additional piles by the Agency at his own cost and expenses along with any additional cost for pile cap, etc. being borne by him.

32.4.11 While manual chipping may be permitted after casting of pile, pneumatic chipping, if permitted by the Engineer-in-Charge, shall not be started before 7 days under any circumstances.

32.4.12 Main longitudinal reinforcement in the length of the piles and links or spirals shall be provided as per the approved drawing. Longitudinal bars where possible shall preferably be in one length. Every care shall be taken in handling of the reinforcing cage so that its shape is not damaged.

32.4.13 When working adjacent to existing structure every care shall be taken to avoid any damage to such structures, in the case of bored piles care shall be taken to avoid effect due to loss of ground. In the case of deep excavations adjacent to piles proper protection shall be provided to safeguard against the lateral movement of soil stratum or releasing the confirming soil stress.

32.4.14 During piling work the following data shall be recorded along with any other data as may be directed by the Engineer-in-Charge. These data shall be submitted to the Engineer-in-Charge in triplicate copies on completion of installation of each pile.

i. Sequence of installation of piles in a group.
ii. Dimensions of the pile including reinforcement details and mark of the pile.
iii. Depth bored and founding level along with a bore log depicting the nature of strata encountered during boring.
iv. Time taken for penetration of every 15 cm during last 2 m depth before founding level.
v. Method of cleaning bottom of hole at founding level before concreting.
vi. Time taken for concreting.
vii. Cement consumption and slump of concrete.
viii. Cut off level/working level/R. L. of top concrete Any other relevant/important observation.

32.4.15. During execution at any stage if any variation is required to be made to suit the site condition, E.I.C shall be technically satisfied and his decision will be regarded as final. All/ any of data /information given if not found reasonable (this will also include data of Design Parameters) shall be given during detailed engineering. Tenderers/Agency therefore are advised to consult with manufacturer/ experts at his own cost, if so felt, to reach more correct figure for Tendering purpose. The same is also advised for any other data supplied/missing. But in no case, it shall be treated as a Fault of the Tendering Authorities. If any data is found in variance in same chapter/ section or anywhere of the tender document, the same shall be brought to the notice of the Tendering Authority & his interpretation/ decision shall be considered as final.

32.5 Load Test on Piles

32.5.1 The load tests shall be carried out as per IS: 2911 unless specified otherwise in the following paragraphs. The tests shall be carried out on test pile and a selected representative pile as approved by the Engineer-in-Charge. Sufficient time shall be allowed before tests to permit adjustment on the soil conditions following disturbance from the method of installation. The period between installation of the test pile or any other pile in the vicinity and the test loading of the pile shall be least 28 days.

32.5.2 The test load shall be applied by jacking against Kent ledge or any other structure approved by the Engineer-in-Charge. No working pile shall be permitted to be used for any loading for load test on pile. The design of the Kent ledge shall be such as to

prevent instability, particularly in the event of a sudden change in the load reaction from the pile. The reaction from Kent ledge to be made available for the test shall be at least 25 percent more than the final test load to be applied. The test shall be carried out at cut off level or at maximum 1.5 m below G. L. as directed by the Engineer-in-Charge. Anchors, if provided, for load test shall be at specified distance away from test pile as per relevant I. S. Code of Practice and there shall be minimum two anchors at two ends of the pile.

Details regarding the testing arrangement shall be submitted well in advance to the Engineer-in-Charge for his approval. Load tests shall only be undertaken after obtaining the approval.

32.5.3 The jack is to be hydraulically operated. The load applied to the pile shall be recorded either by a gauge in the hydraulic system or a proving ring duly calibrated from an approved laboratory before load tests. The sensitivity of the full load and in any event, the accuracy and sensitivity of the system is to be checked against an approved instrument.

A test certificate and fresh calibration chart as obtained from an approved laboratory for jack as well as pump supplying hydraulic power shall be produced before the Engineer-in-Charge well in advance before use for any load testing pile.

32.5.4 The settlement of the pile shall be recorded by three dial gauges recording to 0.02 mm and placed at equal distance around the test pile. The dial gauges shall be fixed on datum bars whose ends rest upon non-movable supports. The supports for datum bars with reference to which the settlement of the pile would be measured shall be at least 5d (d being the diameter of the circular pile of the side of the square pile) away and clear from the test piles, subject to a minimum of 1.5 m.

32.5.5 The testing equipment employed shall be capable of loading a pile to failure or to three times the design loading.

32.5.6 Before testing the top of the pile shall be clipped off carefully till sound concrete is encountered. The projecting reinforcement shall be cut or bent suitably and the top finished smooth and level with Plaster of Paris, when required or as directed by the Engineer-in-Charge. A series 25 mm thick bearing plates shall be placed on the head of the pile for jack to rest as directed by the Engineer-in-Charge.

32.5.7 The Agency shall have to perform rotating load test on working piles on load as decided and selected by the Engineer-in-Charge and the results must satisfy the requirements of the test. At least one working pile of each diameter shall be tested. The test shall be carried out at cut-off level or at such level as per direction of the Engineer-in-Charge. The Agency shall also have to carry out initial test on a non-working test pile as described below:

A. Initial Test on a Non-working pile:

i. At least one non-working pile test shall be performed before execution of working pile.

ii. The test load shall be applied in equal increments of amount one-fifth of the estimated safe load as directed by the Engineer-in-Charge. Each state of loading or unloading shall be maintained till the rate of movement of the pile top is not more than 0.02 cm per hour in the case of clayey soils and 0.1 mm per hour in 2 hours whichever is greater.

iii. The estimated safe load shall be maintained for 24 hours and settlements shall be observed and recorded every hour during the period.

iv. Time-settlement observation shall be made at the commencement and completion of each increment. The rebound observation shall be made with suitable unloading as per direction of the Engineer-in-Charge.

v. The loading shall be continued till the settlement of the pile top equals one tenth of the diameter of the pile stem (one tenth of the side in case of square piles) or the load is two times the estimated safe load on the pile, whichever is earlier.

vi. The safe load on pile shall be the minimum of the following:

a) Two thirds of the final load at which the total settlement attains value of 12 mm unless it is specified that a total settlement different from 12 mm is permissible or required in given case on the basis of nature and type of structure in which case the safe load shall correspond to actual total settlement permissible or required.

b) Fifty (50) percent of the final load at which the total settlement equal one tenth of the pile diameter of the size of the pile.

B. Routine Test on Working pile:

- Routine Load test in working pile shall be as per current IS 2911.Pile integrity test shall be at least 1 in 100 or part thereof.

Load on the pile in routine test shall be applied up to and a half times the estimated safe load carrying capacity of the pile. The loading procedure and settlement observations shall be the same in initial test described hereinabove. The safe load on the pile shall be the minimum of the following:

a. Two third of the final load at which the total settlement attains a value of 12 mm unless it is specified that a total settlement different from 12 mm is permissible in a given case on the basis of nature and type of structure.

b. Fifty percent of the final load at which the total settlement equals one tenth of the pile diameter of size of the pile.

C. Lateral Load on Working pile:

i) The Agency shall have to carry out lateral load test on one vertical working pile. Reaction may be obtained from suitable set up as approved by the Engineer-in-Charge and hydraulic jack shall be inserted in between the loading set up and pile in order to apply the lateral load. Thrust pieces need be inserted on either end of the jack to fill up the gap. Lateral deflections shall be measured at cut-off level or at maximum 1.5 M below G. L. as directed by the Engineer-in-Charge by means of dial gauges fixed to immovable supports.

ii) Loading shall be applied in increments of about 20% of the estimated safe load till the rate of deflection reduces to 0.02 mm per hour in the case of clayey soil and 0.05 mm per hour in the case of sandy soils or 2 hours whichever is earlier.

iii) Displacements shall be measured by issuing at least two dial gauges spaced at 30 cm and kept horizontally one above the other on test pile. Where it may not be possible to place one of the dial gauges on the line of jack axis, then the two dial gauges shall be kept at a distance of 30 cm at a suitable height and the displacement

interpolated at load point from similar triangles. To fix dial gauges on the pile surface, uneven surfaces shall be chipped of and 25 to 30 mm square glass piece shall be fixed to provide a smooth surface. The dial gauge tips shall rest on the central portion of the glass plate.

iv) The safe lateral load shall be the least of the following:

a. Fifty (50) percent of the final load at which the total displacement increases to 12 mm.

b. Final load at which total displacement corresponds to 5 mm.

c. Load corresponding to any other specified displacement due to performance requirements.

32.5.8 All pile test data i.e., load, displacement and time shall be recorded in a suitable chart along with other information about the pile in a manner as directed by the Engineer-in-Charge.

From the data, curves shall be drawn showing load displacements and displacement time and safe load shall be indicated on the graphs.

All data and curves shall be submitted to the Engineer-in-Charge in triplicate copies along with the originals.

32.5.9 If on load testing, it is found that the capacity of the pile is more than the designed capacity nothing shall be paid extra for such extra capacities.

SECTION - III

DETAILED TECHNICAL SPECIFICATIONS FOR CIVIL WORKS

1. SPECIAL NOTES

1.1 The layout of the Intake well-cum-pumping station, water treatment plant and semi underground reservoir (SUGR) at WDCs, as shown in the drawing attached, is not binding on the tenderer but is only indicative. However, the floor areas and other requirements specified hereinafter shall not be curtailed and shall be binding.

1.2 The tenderer shall not quote for works differing from the specifications of the tender unless specifically permitted elsewhere in the tender document.

1.3 The suitability of the proposed water supply system shall not be decided only by the low capital cost but the economy in the operational costs shall also be considered. For this purpose, all relevant details shall be furnished by the Agency.

1.4 There shall not be any ambiguity in the offer. Tender containing any ambiguity may be interpreted in a manner advantageous to the Authority.

1.5 If not mentioned elsewhere in the tender document, the Agency shall provide the following arrangements:

a. Water supply to different treatment processes namely chemical dosing including lime dosing; disinfection shall not be made solely dependent on the operation of clear water pumps. Separate pumping arrangement for supplying water to alum solution tank and chlorine dosing equipment are to be provided. Maximum pressure available in the proposed supply main may be considered as 3.0 kg/cm^2.

b. Disposal of drainage of the treatment units shall be made by gravity system as far as practicable. If ultimate disposal has to be pumped, emergency gravity overflow must be provided.

c. Care shall be taken for satisfactory disposal of sludge from the clarifier.

d. All electrical components, appliances, switches, flow measuring devices etc., installed outside, shall be well protected from rain and other weathering effects by providing sheds, enclosures, canopies, etc.

e. All sluice valves, gates and their passages shall be placed under proper sheds as per instruction of the EIC.

f. The levels of the Intake well-cum-pumping station, water treatment plant units and the SUGR at WTP shall be fixed in such a way that all the units of WTP can be isolated and kept dry (free from water) for maintenance even at 100% filled up condition of the SUGR.

1.6 All valves, sluice gates, etc. shall be of reputed make and shall conform to available I.S. specifications and the manufacturer shall have IS accreditation where name of manufacturers does not appear in the List of Venders. In case of non-availability of relevant I.S. specifications, it shall conform to British Standard Specification or American Standard Specification.

1.7 The water works being a process plant, it is imperative that the layout of the plant inclusive of all Civil, Mechanical and Electrical Components shall meet the requirements of Indian Factory Act. Indian Explosives Act. and all other relevant statutes of the State and Central Government. The Agency has also to procure Explosive License for use of chlorine during Trial Run. All Structures, Vats, implements etc. forming part of on-site emergency plan shall be provided by the Agency.

1.8 The water treatment plant shall be designed to provide a net output of 3000 m3/hr. Filtration, the inflow, flash mixers, alum dosing, flocculators and plate settler clarifiers shall be designed for a flow of 3000m^3/hr with required overloading. The subsequent units may be designed for 3000 m^3/hr. with over loading capacity as prescribed in this document or by the Engineer-in-Charge.

1.9 Proper bypass arrangements shall be provided so that the water could be flown avoiding the flocculation, clarification and filtration units. If the situation needs, the raw water could be flown from the flash mixer to directly the filter water channel.

2. MAJOR WORKS

The requirements and the design criteria for the following major works of the proposed water supply system as given herein below are mandatory.

a) Raw water Intake well cum pumping station

b) Raw water trunk main

c) Water Treatment Plant

d) Sub-Underground Clear Water Reservoir

e) Clear water Pumping Station
f) Clear water pumping main
g) Distribution Pipelines up to WDCs
h) Site development
i) Work-site Boundary walls
j) Work-site Internal road network
k) Work-site Internal drainage
l) Work-site Landscaping

3. RAW WATER INTAKE WELL CUM PUMPING STATION:

3.1. Description & Scope of Work:

The Intake well-cum-pumping station will be located on the bank of River Krishna, 2 km. upstream of the Prakasam barrage to draw raw water throughout the year. The exact location of the structure shall be finalized based on the bathymetric survey and geotechnical investigation to be conducted by the Agency and as per approval of the Engineer-in-Charge.

The work involves, as per Tender contained in Schedule-B of the Tender Document:

(i) Planning, designing and construction on EPC basis of two No of R.C.C. Jack wells including raw water pump house for housing 3 No. of 8265 m3/hr capacity vertical turbine pumps and motors in the present tender and 3 No. of 8265 m3/hr capacity vertical turbine pumps and motors as future provision along with required diameter suction main, delivery main fabricated from 14.2 mm thick SW Mild Steel pipe in each well connection for supplying of raw water to the proposed 380 MLD Water Treatment Plant at Undavalli for Amaravati water supply project.

(ii) Design, drawing and construction of the intake well-cum pumping station shall be based on R.C.C. well sinking method of designed diameter. The pump house floor shall be of reinforced concrete along with all the structural works

(iii) Providing an elevated approach road and RCC bridge of approximate lengths 218 Rmt and 290 Rmt from the Seed Access Road to the Intake well-cum-pumping station with necessary structural support / pile foundation including fixing R.C.C. hand railing with R.C.C. post of adequate size to serve as precaution on both sides of elevated approach road.

(iv) Providing suitable screens at the sluice gates in the jack wells for arresting large floating matters.

The work is on EPC basis and the offer of the tenderers shall be inclusive of all works necessary for completing the Intake well-cum-pumping station complete in all aspects.

The HFL of Krishna River at Intake location is +21.5 m. Level of the Flood Bund is +25.0m. Pump floor level shall be kept at +25.15 m.

3.2 Design Consideration

The Intake well-cum-pumping station structure and its sub-units shall be reinforced cement concrete and shall be designed for suction safely with the effect of the combination of various loads, forces and stress that can possibly coexist. All calculations shall distinctly tabulate the various combinations of the loads and stresses covered by the design. The loads, forces and stresses to be considered in designing the structure shall include the following:

i. **Dead Load** – Dead weight of all structural elements, weight of intake pipes including its supporting arrangements and probable silt deposits on the upper surface.
ii. **Live Load -** Live load shall be considered as per relevant IS codes.
iii. **Effect of bore and water current –** The Maximum flood and ebb velocity when high flood occurs is 3.07m/s. The Intake well are to be designed to withstand the maximum of surge of bore current.
iv. **Berthing forces from Vessels -** For this, maximum capacity of Barge in National Waterways with a velocity of 1.5 m/s shall be considered. The approach angle shall be taken as 20 degrees.
v. Mooring forces.
vi. Forces due to wind.
vii. Temperature stress due to variation in temperature of 30^0 C.
viii. Seismic forces.
ix. Erection stresses.
x. Water hammer in Suction Mains.
xi. Any other forces that the Tenderers may consider.

xii. Maximum anticipated scour depth at the Intake well-cum-pumping station shall be designed by the Agency. The design shall be such that the entire structure is totally safe with this scour depth.

xiii. Other than Intake well cum pump house, all major structures shall be supported on direct mud circulation bored pile foundation.

xiv. Unless specified otherwise elsewhere, a factor of safety of 2.5 shall be applied to the ultimate load to arrive at the safe load of the piles.

xv. Spacing of piles (centre-to-centre) in a pile group or between any two piles of adjacent group shall not be less than 2.5-time diameter of the pile or the diameter of the circumscribing circle in the structural area in case of non-circular sections.

xvi. Vertical load bearing capacity of pile under any combination of loads shall not be allowed to exceed normal load bearing capacity under static condition.

xvii. In the case of R.C.C. bored piles, the main reinforced shall not in any case be less than 0.80% of the gross sectional area and shall extended for the full length in all piles made into cages and well wired lines/stirrups (8 mm dia at 150 mm c/c or equivalent) and spot welded to make them stiff enough to withstand handling without damage.

3.3 Screening around Bell-mouth of Suction Main & in front of Sluice Gate

Suitably designed screens shall be provided around the bell mouth of the Vertical Suction main. The screens shall be suspended from a suitable level of the Intake well-cum-pump house platform and aligned accurately. The screen shall be made of SS 304 of suitable size to prevent entry of large floating matters and shall be provided with all arrangements and facilities for proper cleaning. The Agency shall also provide screen arrangement at sluice gates of Intake well. The screen shall be made of SS 304 flat and shall have provision for lifting and cleaning whenever necessary.

The Tenderers shall submit detailed drawing and design of the screening arrangement for approval of the Engineer-in-Charge.

3.4 Specification for Work

The work shall be carried out, in general, according to the IS specifications applicable for the respective items of the work. During execution, at any stage, if any variation is

required to be made to suit the site condition; E.I.C shall be technically satisfied about it and his decision will be regarded as final.

ALL load data are tentative. and if not found reasonable (this shall also be applicable for data of Design Parameters), shall be given during Detailed Engineering submission. Tenderers therefore are advised to consult with manufacturer/experts at his own cost, if so felt, to reach more Correct figure for Tendering purpose. The same is also advised for any other data supplied/missing. But in no case, it shall be treated as a Fault of the Tendering Authorities. If any data is found in Variance in same chapter/ section or anywhere of the tender document, such matter shall be brought to the notice of the Tendering Authority whose interpretation/decision shall be considered as final.

The depth of water table varies but while designing, the tenderer shall take into account the probability of floatation and local flooding due to rains. The tenderers may assume higher values since he would be responsible for establishing and ensuring safety against possible floatation. The tenderers are to take adequate precautionary measure for the safety of the adjacent existing structures (which, though dilapidated, is functionally important) during the entire period of execution, and as such vibration in any form are to be kept to the minimum level. Therefore, driving of driving sheet piles, Z piles etc., are ruled out.

The tenderers shall make all provisions for the safety of the structures. The Raw Water Pump House will be functional mainly at floor level at (+) 23.0 M (operating platform level). The pumps are Vertical Turbine Type (V.T) in vertical execution & thus motors will be installed at an elevated level on the motor stool which shall be mounted on the operating floor. Suitable walkways have to be provided as per requirement of site/ detail design so as to reach every valve/ actuator on the pump delivery side. This will also help for inspection and maintenance of the valve/ actuator and its accessories. The specific levels will be finalized at per site requirement at Detailed Engineering stage. The bases for the same, intermediate walkways and vertical support for suction main, valves, other accessories, all other pipes are within the scope of the contract including hanging support. Pedestal foundations/ cut outs for all pumps / motors & relevant items are within the scope of contract.

Cable trays/ Cable trenches insert plates, dowels chequred plates, M.S. gratings, pre-cast slabs for cable trenches as required for the electrical/ mechanical equipment at both Raw Water Pump House & Electrical Substations are within the purview of this contract.

The motor floor will also accommodate cable trench, cut out at different locations for the pump motor sets. Capacitor and reactor, control and instrumentation panels and H.T. switchgears whose weight need be considered within the live load as per relevant IRC Code. The same is applicable for the elevated platform also.

On entry, the vehicle will negotiable a mild upward slope in the form of a range in the passage. Trucks transporting materials and equipment shall reach the unloading bay of the pump house through the approach road and shall be able to load and unload with the help of an overhead E.O.T. crane. Unloading bay shall be constructed at the middle of two Intake well cum pump house where truck will enter.

A 15 tonne EOT crane along with auxiliary crane hook of 3 tonne capacity shall be provided in the pump house. The Agency shall also provide suitable crane arrangement at the unloading bay in between two Intake well cum pump house.

The Indoor substation cum Scada control room at Intake well cum pump house shall have the following facilities:

a. HT Room (Switch Gear Room)
b. L.T. Room (Switch Gear Room)
c. Scada room
d. Store room
e. Service room
f. Three number of Transformers

The following dimensions (approx.) may be considered for tendering process.

i) Intake well cum Pump House of minimum internal diameter of 13.0 M with a cantilever walkway of width 1.5m wherever required.
ii) Indoor Substation cum SCADA Control Room including Electrical Panels, SCADA room, Service room, Store room with an area of 32.50 m x 15.0m, Transformers (3 Nos), HT metering room with area of 8m x 15m,
iii) Security cabin 10 Sqm

a) Each well of Intake well cum pump house shall accommodate three V.T. Pump Motor sets, Valves, Specials, expansion joints, necessary valves with SCADA compatible electrical actuators, one Flow Meter, one Dismantling Joint (D.J) on the common delivery manifold, four delivery lines with its bends, PDVs, Valves etc. Loading and Unloading Bay.

b) Sub-station Zone on the elevated platform to accommodate Control room, H.T. room, Battery room., Store Room, Corridor, (U/B) Unloading bay and Platform., Stair etc. **The tentative number & dimensions of the rooms under substation zone is shown in the tender drawing. But the actual dimension and number of rooms may vary during detailed Engineering stage as per the satisfaction of the Directorate of Electricity (Govt. of A.P.) and the EIC keeping the total area constant. No extra payment shall be made to the Agency for such addition/ alteration.**

c) RCC Approach road for the Intake well cum pump house & the Sub-station on the elevated platform.

The water supply of entire pump house compound will be covered by a RCC tank of capacity 10 m^3 placed over administrative building.

The Agency shall use micro silica in RCC in all water retaining structure as specified elsewhere in bid document. The Agency shall not take any advantage of using micro silica in design of the water retaining structure. The Authority will not entertain any extra claim at a later date of such provisions. The design must indicate that provisions are being made in this regard.

The contract shall be on lump-sum basis including complete design together with construction of all civil works as per specification and directions of the Engineer-in-Charge. Before proceeding with any detailing and designing of various components of work under this contract, the Agency shall first prepare a layout plan to a sufficiently large scale and elevations of the pumping station and parts thereof. The entire work has to have a suitable architectural treatment in conformity with the surroundings. For this purpose, the services of a reputed architect shall be enlisted by the Agency at his cost. Economy in construction, without sacrificing architectural and aesthetic get up of the work can only be considered.

For guidance of the tenderers we have enclosed Schematic drawings demarcating the tentative. Tenderers shall strictly comply with the internal dimensions of the pumping station.

i. The work shall be carried out in general according to IS specifications applicable for the respective items of the work.

ii. The RCC design shall be based on IS:456 for plane and reinforced concrete for general building construction and current IS:3370 for cement concrete structures for storage of liquids for the underground part keeping water unit.

iii. All RCC works coming in contact with subsoil water shall be designed as per current IS 3370, with concrete grade not less than M-30 and cement content not less as stipulated in respective manual/I.S. Code. In case the tender adopts a richer concrete mix, then in such case they must specify the cement content per M^3 of concrete. **Tenderers/Agency will be given full liberty to opt for design mix as per satisfaction of E.I.C. with minimum cement content as stipulated in I.S. code.** It is the responsibility of the Agency to make good or reconstruct the part or whole of a structure if gets damaged or demolished/ crushed/ settled down due to water hammer or similar external reasons or for faulty design at his own cost. Faulty Design submitted by the contactor even if accepted by the department will not relieve the Agency from above responsibility. Agency will be considered total responsible for any accident caused due to negligence on his part/ poor workmanship/ faulty design. **Agency has liberty to go for design mix for achieving Rich concrete having minimum cement content as stipulated in I.S. code or go for variation if so required at site subject to the satisfaction & permission of E.I.C.**

First class brick work in cement mortar of 1:6 shall be used for 250 mm thick super-structure panel walls. Super structure panel walls of the building shall have 20 mm thick cement plaster (1:6) inside and 15 cement plaster (1:6) faced outside. Internal and external finishing of all the building shall be as per specification given elsewhere in this bid document. Adequate number of 150 mm dia UPVC rainwater down pipes shall be provided of heavy duty type with fittings, as necessary.

Double chequered damp proof course of 25 mm thickness of 1:2:4 with stone chips will have to be provided at plinth level of all brick walls. A 1.2 M wide plinth protection shall be provided surrounding all building. The plinth protection shall be of 100 mm thick

1:2:4 PCC over single layer brick flat soling. The plinth protection shall be finished with 35 mm thick IPS.

The roof slab of the Intake well-cum-pump house along with inter connecting platform (unloading bay) shall be of architectural appearance.

The roof shall be of RCC construction of mix not leaner than Grade M-30 with minimum cement content as specified in relevant I.S. Code.

The super structure of the pump house buildings shall be of RCC frame with brick panel walls. The brick walls shall be of minimum 250mm thickness. All the buildings in the Intake well cum pump house compound shall be RCC framed with brick panel wall.

The finishing of all buildings has been mentioned in general specification.

The building shall be of architectural design as per approval of **EIC**. Adequate skylights and windows shall be and as approved provided to admit sufficient natural light. The total shutter area of doors, windows & ventilators shall be not less than 20% of the total carpet area of the buildings. All doors, windows and ventilators shall be of steel except otherwise indicated in our drawings and their pattern shall be up-to-date and fitted with floss of not less than 13 Kg/M^2. The external doors shall have a width of 1200 mm except that of the unloading bay. All internal doors shall be not less than 1050 mm wide where the application is only a pathway for persons and not less than 2500 mm where Panels, Transformers etc. are to be installed. All exterior doors and windows shall have RCC Chajja in a box type or any other approved architectural pattern so as to be useful and effective in giving an architectural effect to the building in general. The main door shall be 1500 mm. wide.

All fastenings and fixtures of doors, windows and ventilators shall be of heavy duty type as per direction of EIC. The position of windows shall be such that these will open out-side and close easily when necessary. One rolling shutters with a provision of ramp shall be provided. The windows shall be provided with M.S grills of approved Design.

The Pump house would have one emergency exit.

ALL/many load data are tentative. & will be given during Detailed Engineering. Many data/ design information being tentative may be verified with stipulated standards/site information's etc. Tenderers/Agency therefore are advised to consult with manufacturer/ experts at his own cost, if so felt, to reach more Correct figure for Tendering purpose. The same is also advised for any other data supplied/missing. But in no case, It will be

Treated as a Fault of Tendering Authorities. If any data is found in Variance in same chapter/ section or anywhere of tender document, is to be brought to the notice of the tendering Authority & his interpretation/ decision will be considered as final.

Agency shall supply necessary office furniture for SCADA room, pump house, substation, security room etc. as per direction of the EIC.

3.5 Guest House/Administrative Building

Agency shall design and construct office building cum guest house at raw water pump house campus. The building shall be of RCC framed structure resting on pile foundation with 250 mm thick external wall and 125 mm thick internal wall. This building shall be of 300 sq.m built up area in each floor. Ground floor of the building shall be car parking and one servant room with toilet and kitchen. First floor shall be office for administration staff which contains two cabins with air conditioned, ten cubical with necessary furniture. Second floor shall be 4 bedrooms with attached bathroom, separate hall, common kitchen, common toilet and dining space in 250 sq.m area & 50 sq.m open terrace with an ornamental parapet wall including all furniture. The first-floor level i.e. office floor level shall be same as pump floor level. There shall be access from platform level to the first-floor level/office floor level through gangway. The internal and external surface of the building shall be plastered with cement mortar. The external and internal surface shall be finished with 1.5 mm thick cement putty. The external surface will be finished with two coats of premium quality Acrylic weather coat emulsion paint over a coat of primer. Internal surface shall be finished with two coats premium quality Acrylic emulsion paint (plastic paint) over a coat of cement primer. The finishing and flooring in the guest house and office building has been given in general specification. The ground floor i.e. car parking area shall be of anti-skid ceramic tiles flooring as approved by EIC. The open terrace shall be provided with The Agency shall provide premium quality furniture for office, guest house as per the requirement and direction of EIC. All the rooms and drawing & dining room shall be provided with air conditioning system.

4. Raw Water Trunk Main:

Technical specification for SWMS pipe has been given elsewhere in bid document

5. Water Treatment Plant

The scope of work for the Water Treatment Plant (WTP), to be located at Undavalli, includes erection, testing, commissioning, trial run for 3 months, 2 years of DLP, 8 years of operation & maintenance and training of departmental Engineers and operators and handing over the plant in full operational conditions after the O&M period.

5.1 Major Components

The WTP consists of following major components/units

1. Raw water Inlet pipe
2. Stilling chamber and Parshall flume with ultrasonic flow measuring device
3. Pre-chlorination with Alum/PAC
4. Chemical dozing with thorough mixing of raw water
5. Flash mixers
6. Flocculator
7. Sedimentation with plate settler technology
8. Rapid sand gravity filters with modern under drainage system.
9. Backwash arrangement with backwash sump cum pump house
10. Sludge drainage, sludge pump house
11. Sludge thickener with ZLD concept
12. Centrifuge
13. All pumps, motors, compressors, air blowers & other electro-mechanical equipment related to water treatment process
14. Storage of disinfectant
15. Collecting & conveying channels of raw and filter water along with bypass channel
16. Weigh bridge of capacity 30 MT.
17. Chlorination
18. Chemical house
19. Recirculation sump cum pump house
20. Filter house annex building
21. Well-equipped laboratory
22. Semi underground reservoir
23. Clear water pump house
24. Substation building

25. Transformer yard
26. MCC room
27. Administrative building (G+4) with G+5 foundation.
28. 2 No of Staff quarter building (G+4)
29. Chief Engineer-in-Charge bungalow (G+1)
30. Plant superintendent bungalow (G+1)
31. Instrumentation & control with SCADA & integration with main SCADA

5.2 Process Design Parameters

The plant shall be designed, constructed and installed considering site ambient conditions, local conditions and location. For these, the Agency shall make due allowances in his design for the increased temperatures which may be experienced by Plate Settler clarifiers and filter plant exposed to direct sunlight.

The WTP shall be hydraulically designed to produce 190 MLD (23 hours operation) of treated water to specified quality standards. The loss of water in terms of sludge bleed from the clarifiers and filter backwash shall be kept to the minimum and not exceeding 3% of the raw water input.

5.2.1 Raw Water Quality

Available raw water quality of River Krishna (water source for the WTP) and required treated water quality are given in Table 1 & 4. The treatment plant shall be designed to treat water having the raw water quality as discussed subsequently.

However, the raw water quality given in Table - 1 & 2 are indicative, it is the Agency responsibility to check the required details of raw water on their own and accordingly design the treatment plant. The Agency shall, in addition, carry out the treatability tests he considers necessary to deliver the guaranteed water quantity & quality. The Agency, while designing the WTP. shall provide for treating raw water having maximum turbidity up to 1000 - 1500 NTU.

Table 1: Quality of Raw Water in Krishna River - Pre-monsoon

S. No	Parameter	Units	Sample-1	Sample-2
1	pH at 25 ^{O}C	-	8.39	8.12
2	Color	Hazen units	12	15
3	Conductivity at 25 ^{O}C	·S/cm	698	654
4	Turbidity	NTU	6.8	7.5
5	Dissolved Oxygen	mg/L	5.3	5.6
6	BOD (3 days at 27^{o}C)	mg/L	07	05
7	Chemical Oxygen Demand	mg/L	38	22
8	Total Dissolved Solids	mg/L	446	418
9	Total Hardness as $CaCo_3$	mg/L	150	150
10	Chloride as Cl	mg/L	90.0	85.0
11	Fluorides as F^-	mg/L	0.6	0.6
12	Sulphate as SO_4^{--}	mg/L	70.3	66.5
13	Alkalinity as $CaCo_3$	mg/L	140	130
14	Nitrates as NO_3	mg/L	5.0	4.4
15	Calcium as Ca	mg/L	32.0	32.0
16	Magnesium as Mg	mg/L	16.8	16.8
17	Sodium as Na	mg/L	87.4	77.2
18	Potassium as K	mg/L	2.3	2.3
19	Residual Sodium Carbonate	mg/L	<0.1	<0.1
20	Iron as Fe	mg/L	0.15	0.09
21	Zinc as Zn	mg/L	0.069	0.072
22	Oil and grease	mg/L	<0.1	<0.1
23	Silica as SiO2	mg/L	4.1	4.0
24	Total Chromium as Cr	mg/L	<0.001	<0.001
25	Lead as Pb	mg/L	<0.001	<0.001
26	Temperature	^{o}C	26.9	26.6
27	Total Suspended Solids	mg/L	9.3	8.6
28	Phosphate as po4	mg/L	<0.02	<0.02
29	Phenolic Compounds	mg/L	<0.001	<0.001
30	Mercury as Hg	mg/L	<0.0001	<0.0001
31	Total Arsenic as As	mg/L	<0.001	<0.001
32	Cadmium as Cd	mg/L	<0.001	<0.001
33	Hexavalent Chromium as cr-6	mg/L	<0.05	<0.05
34	Copper as Cu	mg/L	0.035	0.028
35	Total Plate Count	MPN/250ml	750	680
36	Coli form Organisms	cfu/ 100ml	18	12

Table 2: Quality of Raw Water in Krishna River - Observed at Vijayawada Municipal Corporation Intake Headworks at Prakasam Barrage

	Turbidity (NTU)	pH
Max	320.0	7.90
Min	2.20	6.85

5.2.2 Process Guarantees

Apart from the quality of the treated water and the indicated water levels at the output and input of the plant the Agency shall guarantee the following process performances:

Table 3: Quality of Treated Water Process guarantees

Turbidity of the effluent of the Clarifiers	not more than 5 NTU
Suspended solids in the effluent of the Clarifiers	not more than 8 mg/l
Total aluminum in the effluent of the clarifiers	not more than 0.5 mg/l
Minimum free available chlorine residual content in the treated water, after 10 minutes contact.	> 0.5 mg/l
Minimum filter run period at any time of the year between successive backwashing	48 hours
Maximum water losses (filter backwash, desludging etc.) in the treatment plant during a period of any 7 consecutive days.	Less than 3 % of the raw water input

Table 4: Treated Water Quality Parameters

Parameters with Units	Output Standard
Turbidity (N.T.U.)	Less than 1.0 NTU
Color (Units on Platinum Cobalt Scale) TCU	Less than 5.00
Taste and Odor	Unobjectionable
pH	6.5-8.5
Faecal coliforms number/100ml Coliform organisms number/100ml	Not detectable in any 100-ml sample for required output and permissible standards of faecal coliforms number/100 ml and Coliform organisms number/100ml
Residual Aluminum mg/l, Al	<0.1
Residual Chlorine	0.8 to 1.0 ppm

If, at any time during trial run period, any of the quality and process parameters cannot be achieved, the Agency shall at his expenses carry out all necessary modifications to the civil, mechanical, hydraulic, electrical and other components of the plant, or modify the operation procedures and alter the chemicals / chemical dosing parameters to achieve the required performance of the plant.

5.3 Preparatory Work

i. The details of the morphology shall be checked by the Agency before the final layout of the units of the plant. He shall use the land earmarked to accommodate for the siting of all the units of the final capacity treatment plant, semi-under-ground clear water reservoir (SUGR), clear water pumping station and ancillary civil structures along with existing structures (if any).

ii. The Agency shall provide RCC retaining wall wherever the filling is more than 1.0 m. The Agency may consider the retaining wall as a foundation of boundary wall. Surplus earth, if any, shall be disposed of as per the direction of the Engi-neer-in-Charge.

iii. The Agency shall construct approach roads connecting to all treatment units, clear water pumping station and ancillary civil structures to be constructed within the treatment plant campus as shown in the WTP layout plan. Approach Road to WTP site is indicated in this plan. The Agency shall have to use the same for transport-ing the materials to the site.

iv. The Agency shall establish a topographic benchmark at a suitable location within the WTP campus by transferring level from the GTS benchmark as approved by the Engineer-in-Charge. All levels shall be deemed to refer to that benchmark. The Agency may establish other secondary benchmarks on the site. During all stages of preparatory works, design and construction, the Agency shall cooperate with other Agencies working in or near the same site. This is particularly im-portant in the case of linkages such as incoming and outgoing pipes, cables, com-munication lines, access roads, drainage pipes and channels.

5.4 Detailed Design

The Agency shall design Water Treatment Plant i.e. Plate Settler Clarifiers for Clarification and Rapid Gravity Sand Filters for filtration as mentioned in the scope of work. These two processes are fixed and final and cannot be changed. The various design parameters indicated in the following paras and elsewhere cover only the main parameters. All the detailed parameters laid down in the CPHEEO Manual of Water Supply and Water Treatment or the relevant IS Codes however shall be applicable. The only deviations permitted from those contained in the Manual or IS Standards are those contained in the specifications detailed herein. Based on the Agency process design, approved by the Authority, the Agency shall prepare the final detailed design, according to the latest Indian Standards (published up to date of submission of the Bid), the Manual on Water Supply and Treatment, the tender documents and the instructions of the Engineer-in-Charge.

The detailed design of the entire treatment plant including architectural, hydraulic and structural designs shall be prepared in close coordination with the Engineer-in-Charge. The WTP layout and hydraulic flow diagram along with elevation view and all levels shall be submitted for approval of the Engineer-in-Charge. Placement of order, manufacturing or construction shall start only after the approval of all the related designs and drawings. The procedures for the approval shall have to be followed as prescribed in the Special Conditions of Contract. The Agency shall design all water retaining structures considering M30 grade concrete and Fe 500 grade steel based on IS: 3370 (latest edition). The minimum free board shall be of 0.5 m for all components and conveying channels.

5.5 Treatment Works - Plant Specifications

The intention is to automate all the treatment plant operations such as flow control, distribution of flows to various units of the treatment plant, filter back wash operations, chemical and chlorine dosing etc. The Agency shall propose the equipment of standard and reputed manufacturers having the ISI or other relevant standards Mark/conformance certificate for approval of the Engineer-in-Charge. The Engineer-in-Charge shall examine the proposal based on the submitted documents and shall approve it or refuse it if it does not correspond to the highest quality standards and to the specifications.

The specifications deal herein with all treatment plant related works and equipment. Detailed specifications for pipes and appurtenances, mechanical equipment, electrical equipment, instrumentation and control systems and civil works are presented in different sections of this volume which shall be read in conjunction with this Section. The treatment plant and its unit components shall be designed for an input turbidity up to 1000 - 1500 NTU.

5.5.1 Raw water Inlet arrangement

The raw water will be delivered into a collecting well through a 1500 mm diameter SWMS pumping main. Flow Control Valve of diameter not less than 1500 mm with valve chamber shall be provided by the Agency to control the flow of raw water into the collecting well. The valves (including bypass) shall be electrically operated butterfly type. There shall be a provision for remote operation of the valves from the central control room as well as provision to control from its vicinity.

5.5.2 Stilling Chamber

The Stilling Chamber shall be a reinforced cement concrete structure of grade M30 concrete designed as per IS: 3370. The pipe from the raw water pumping main shall be connected at a flange of a pipe which shall be cast in the wall at the lower part of the chamber (puddle collar). The providing and fixing puddle collar is part of WTP. The top of the chamber shall be accessible by the general walkway along the measuring channel. The stilling chamber shall be connected to the drainage system by means of a wall duct and a gate valve of minimum DN 300. A mild steel ladder shall be provided in the chamber to access the bottom. The capacity of the settling chamber shall be in accordance to the plant capacity of 8265 m3/hr (190 MLD with 23 hours operation) output capacity and the required overloading.

The alum/primary coagulant and lime solutions (if & when required) shall be injected into this chamber with feeder pipes. The outlets of feeder pipes shall be placed near the raw water inlet pipe to ensure a thorough mixing. The chlorine solution (for pre-chlorination) shall be injected by bottom mounted diffuser disks or pipes. The diffuser system and baffle walls installed in the chamber shall be designed to guide the incoming water and to ensure a complete diffusion of the chlorine solution before it leaves the chamber. The chlorine solution feeding unit must be detachable for easy maintenance

without interrupting the flow of the raw water into the measuring channel. There shall be no smell of chlorine around 10 m radius from the chamber.

All inner surfaces of the inlet chamber shall be coated with food grade epoxy paint of approved shade, resistive to the aggressive water to avoid corrosion in the acidic environment.

Parameters:

Design Flow: Normal Corresponding to 190 MLD treated water + 20% overloading

Top Level - To be arrived at by the Agency

Free Board - 50 cm.

5.5.3 Raw Water Measuring Channel and Flume

The raw water shall be measured in an open channel by means of a Parshall Flume. Two Ultra-Sonic Flow Meters with flow integrator and electronic display unit shall be provided at the flume. Two Nos of ultrasonic flow meters shall be connected with instrumentation and control panel of WTP. The Agency shall provide a table/ chart with the calibrated values of the flume discharge. The measured discharge shall be indicated in the main control room. The flume shall be designed according to the IS 6063. The top of the channel shall be made accessible by a lateral walkway along the channel. The freeboard shall be at least 50 cm.

5.5.4 Flash Mixer

The raw water from the venture-flume shall enter into the flash mixing units for thorough dispersion of the coagulant chemicals added to the raw water. The flash mixing unit will comprise of eight independent parallel flash mixing chambers, each designed for a flow of 1380 m^3/hr and to give a mixing time of not less than 60 seconds. Six of the flash mixers shall be designed to work at full load and the other two remain as standby. Each flash mixing chamber will be fitted with electricity driven turbine type motor and with inlet and outlet penstock gates for isolation. Individual flash mixers shall be provided with stainless steel impeller fitted at the bottom of stainless steel shaft underslung from driving gears mounted on the roof of each mixing chamber. The impeller, its R.P.M. and the horse power of the electric motor be designed to give a value of G

(Velocity Gradient) greater than 300 Sec^{-1} to ensure adequate turbulence for thorough mixing. The electric motor shall be of weather proof type. Two sets of push button starters shall be provided for each motor, one near the drive unit and the other in the central control room. The flash mixing unit shall be provided with R.C.C. slab fitted with SS hand railings partly covering the chamber for locating the driving unit of the mixer and for approach to the same. Adequate arrangement for cleaning and desludging the flash mixing chamber and finally disposing the same into the plant waste water disposal system and towards the sludge pump house shall be made. The drain pipes shall be of 250 mm diameter D.I. pipes fitted with 250 mm diameter D.I. sluice valve (actuator controlled and SCADA compatible). The valve shall be placed in RCC valve chamber.

After flash mixing, the total flow will be fed into the flocculator units. The raw water flow can be fed into the flocculator units from the top or from the bottom. If the raw water shall be fed into the flocculator from bottom, the stand wells shall be used for delivery of raw water streams, feeding to each flocculator unit. These stand wells may form an integral part of the flash mixing unit or may be constructed very close to the flash mixing unit.

The raw water flow from flash mixer shall be divided into more than one division to fed into stand wells (if more than one in number). Equal division of the flow shall be effected by means of rectangular weirs built in to the wall of the tank. In this case, the tank shall be designed to ensure a low velocity of approach, which will be achieved by providing three chambers within the flash mixing unit. The rectangular weirs shall be provided with arrangements for closing the openings to put the respective flocculation unit out of action. Alternatively, equal division of flow can be achieved by means of C.I. Sluice gates (actuator operated & SCADA compatible Penstocks) in two or more individual channels leading from the flash mixing chambers to the two stand wells feeding the flocculators. For operation of the sluice gates for exact distribution, each individual channel will be provided with a venture-flume with necessary throat width. Local flow indicators of a simple type to show the upper head in the flume will be provided for manipulation of the control sluice gates. The sluice gates shall be single faced as per I.S: 3042 and shall have square openings. The gates shall be fitted with geared operating

head-stocks which shall be placed on top of the channels and shall be accessible from the control room and the filter house.

Agency shall provide suitable bypass arrangements for diverting the raw water directly into the filters to bypass any clarifier. The bypass arrangements shall be operated through sluice gates or sluice valves.

The distribution channel and Flash Mixers (mixing chambers) shall be of reinforced concrete. The inlet and the outlets to the flash mixer and channel shall be designed in such a way so that any flash mixer can receive water from the stilling chamber and can give output to any flocculator. The outlets to the Flash Mixers shall be provided with electrically operated wall gates. Mixing chambers shall be adjacent to the distribution chamber. The outlets to the pipes leading to the flocculators shall be provided with electrically operated wall gates. The free board shall be at least 50 cm. A provision for inlet from the supernatant of the recycling tank (used for storing filter backwash water) shall also be in the raw water Distribution Channel but after the measuring flume. All the sluice gates and valves shall be of electrical actuator controlled SCADA compatible gates and shall be integrated with WTP SCADA.

Each chamber shall be equipped with an impeller type high-speed mixer. The driving motor of suitable capacity and other accessories shall be totally enclosed but easily accessible for maintenance. The shaft with the impeller shall be freely suspended from the driving gear mounted on a platform on top of the reservoir. No thrust or guide bearing shall be located below the liquid level. The shaft of the mixer and the impeller shall be of stainless steel-316.

The outlets of the chambers shall lead to common outlet channel from where it will flow to the Flocculators. The pipes shall be flanged DI pipes. The top of the flash mixing unit is to be made accessible by the general walkway along the measuring channel. Each chamber shall be connected to the drainage system by means of a wall duct and a gate valve of minimum DN 400.

5.5.5 Flocculation and Sedimentation/Clarification

Agency shall quote in its offer for two separate complete arrangement of flocculation and clarification consisting of at least eighteen (18) flocculator units and at least eighteen (18) inclined plate settler units to facilitate purification. Each flocculator unit shall

be designed suitable to the flow requirement with an overload of 22.22% of the average flow so that fourteen (14) units shall be running and four (4) units shall be standby. The flocculators shall be mechanical type with power driven stainless steel shaft and paddles. The flow through the flocculator units shall be either upward or downward according to process design. The flow through the flocculator units shall be parallel. The sludge from the flocculator units shall be delivered to the sludge pump house. While calculating the surface loading or volume of the flocculator units, any area or volume as may be made available by provision of a ledge or a diaphragm beneath the central flocculating zone shall merely be omitted and treated as an advantage for dealing with overloads. The process design and hydraulic design shall strictly be guided by the latest CPHEEO norms. The inlet and the outlets to the flocculator shall be designed in such a way so that it can receive water from any flash mixer and can give output to any inclined plate settler.

Each plate settler unit shall be designed suitable to the flow requirement with an overload of 22.22% of the average flow so that fourteen (14) units shall be running and four (4) units shall be standby. The flow through the plate settler units shall be upward. Design shall be strictly guided by the CPHEEO norms. There shall be sufficient slope (55 degree) at the bottom of the flocculator so that sludge (if any) can be deposited at a sump provided at bottom from where it can be discharged out through 250 mm diameter DI pipe. The sludge pipe shall be provided with DI sluice valve. All the sluice gates and valves shall be of electrical actuator controlled & SCADA compatible gates and shall be integrated with the WTP - SCADA.

5.5.6 Inclined Plate Settlers

Depth of water below and above the Plate zone plays a crucial part in achieving overall clarifier efficiency. Buffer Zone, i.e. zone immediately below the plate modules and above sludge removal zone, may be anywhere between 1.0m to 2.50 m. The size of the plates shall be as per design requirement. The angle of inclination of plates shall be 55^0in between. The plates shall be of rigid SS 316. Suitable no. of hose points to be provided to facilitate cleaning of plates. The plates shall be at least 1 mm thick to withstand the thrust of water jet during cleaning. The size of the plates shall be such that it

may be easily available at local market. At least 10% of the plates required for the plant shall have to be supplied extra as spare. The depth of this zone (modules) shall be 0.5 m to 0.6 m to facilitate proper solid and liquid separation. The zone extended from top of the plate modules up to settled water collection troughs/pipes is considered as collection zone and settled water collectors shall be placed 0.6 to 1.0 m above the top of the plate modules. The collector pipes or troughs shall be provided with collection orifices or notches on both sides to ensure uniform surface loading over the plate modules. The sludge collection zone below the buffer zone shall have an effective hydrostatic head of at least 3.0 m to facilitate effective desludging operation. Electrically operated mechanical scrapers shall be used for proper removal of sludge. The surface loading rate may be considered as per CPHEEO manual. The detention time in the plate settling zone shall be at least 10 minutes or more and the weir loading shall be less than stipulation in CPHEEO manual. These parameters are simple guidelines and the Agency may consider otherwise as per latest CPHEEO manual to suit the requirement of the treatment plant.

Agency shall ensure that plate settling clarifiers offered by them shall be capable of giving a turbidity of less than 5 NTU for average flow and less than 10 NTU when running under overload conditions with raw water at its worst situations.

Arrangements shall be provided for rodding of the sludge main under the floor of the tanks and for applying pressure water for loosening sludge that may consolidate in the pipeline causing a choke. A sluice valve not less than 200 mm diameter shall be provided in the vertical pipe to the trumpet weir for isolating it when applying pressure water. Arrangements for the pressure water shall be provided by the Agency through a minimum 75 mm diameter G.I. pipeline from the proposed pressure main in the vicinity (within 150 m) of the filter house/chemical house. There shall be a terminal point near each sludge well for connecting the pressure line to the sludge pipe. The Sludge pits shall be designed to permit the discharge of sludge from the blow down valve and the trumpet weir to flow to the sump chamber of the sludge pump house. when necessary. Agency shall provide necessary arrangements for diverting the clarified water into the clear water reservoir to bypass the filters. The clarified water shall, however, be post-

chlorinated with a higher dose before diverting into the clear water reservoir. The specification for mechanical equipment shall strictly conform as given in IS codes (latest) & other sections of this tender document.

The electrical motors and other electrical equipment shall conform strictly to specifications for electrical works given in other Sections of these tender specifications. All the M.S. structural members of the units in contact with water and up to 1.0 m above F.S.L. shall be provided with two coats of epoxy lacquer with combination GY 257, HY 830 & HY 850 of M/s Ciba Giegy Ltd. or its equivalent, after sand blasting the members. M.S. structural member beyond 1.0 m above F.S.L. shall be provided with two coats of Epigard/Epilax or equivalent over a coat of suitable Epigard/Epilax primer.

All inlet of plate settler shall be provided with electrical actuator controlled & SCADA compatible sluice gates and all outlets shall be provided with electrical actuator controlled & SCADA compatible sluice valves and shall be integrated with WTP-SCADA.

5.5.7 Civil Works

The flocculator and plate settler clarifier tanks shall be of R.C.C. construction founded on R.C.C. Piles. The peripheral wall and the base slab shall be designed based on uncracked section. The thickness of the base slab shall not in any case be less than 150 mm thick. The floor of the tanks shall be provided with a slope suitable to remove the accumulated sludge by gravity. It shall be anticipated that a considerable quantity of sludge shall be accumulated also below the flocculator units. The bottom of the flocculator units shall be hopper-shaped with suitable slope so that the accumulated sludge, if any, can be disposed of by gravity. Suitable valves shall be provided for desludging the flocculator units. Suitable arrangement shall be provided to remove the accumulated sludge regularly by gravity from the clarifier units and flocculator units and dispose those into the sludge pump house. Suitable pneumatic operated valves shall be provided at each of the sludge outlets of the flocculator and clarifier units which can be operated from the walkway at the top of the units. There shall be a concrete walkway of at least 1200 mm width with proper handrail on each of the flocculator unit and flocculator motor shall be supported from the walkway slab. The slab shall be suitably widened at the place where the motor shall be installed to facilitate proper maintenance. A 1200

mm wide walkway with handrail shall be provided all around the top of all the individual flocculator and plate settler tank walls and it would give access to all the units and adjacent clarifiers, as well as to the chemical house and filter house. Hand railings shall be provided on the walkways. Interconnecting walkways shall have railings on either side. One M.S. step ladder of 900 mm wide with hand railing on one side shall be provided for each clarifier to give ready access to the top of the clarifier from ground level. Proper facility shall be provided so that the plates can be taken apart from the clarification units for washing or maintenance. There shall a be maintenance platform of at least 30 m^2 which shall be an integral part of plate settler zone. The floor level of the platform shall be same as the clarification zone platform level. The platform shall be enclosed by brick wall/double layer aluminum sheet with proper openings as instructed by the EIC. A hand operated travelling hoist of 1.0 MT capacity shall be hanged from the roof of the platform along with RSJ. Two pumps of suitable capacity along with piping arrangements, two brass nozzles and all necessary equipment shall be installed at a suitable position which shall be used for jet washing of the plates at the maintenance platform or at its own position. If proper flow and head shall be available at this end, the jet wash pumps for filter units can also be used instead of a new set of pumps. The water for jet washing shall be drawn from filter water channel. There shall be proper drainage system at the maintenance platform which shall convey all the wash water into the filter waste channel. The waste water from the clarification units shall be conveyed into the sludge pump house with an alternative arrangement to dispose into the surface drainage channel in emergency. The entire maintenance platform shall be covered with RCC slab. The sides of the maintenance platform shall be covered by brick wall with proper openings as per instruction of the EIC.

Two 4 wheeled rubber tyre hand carts suitable to move on the walkway for transport of the plates up to the maintenance platform shall be provided.

All the basic construction works and finishing works shall be carried out as per instruction of the Engineer-in-Charge, specifications relevant to latest IS codes and specifications contained in other Sections of this tender document.

Parameters

Flocculation Zone:

- Detention Time - 30 min.

- Velocity Gradient - 40 to 60
- Tip Speed less than - 1 m/s
- Paddle Area* - 10 to 25% of vertical section

Plate Settler Clarifier:

- Surface Loading - Max 1.0 cum./sq.m./ hr. or as per manufacturer specification whichever is lower
- Weir Loading < 12.50 cum./m./hr.
- Depth at outer edge (side water depth) - Minimum 4.0 m

5.5.8 Bypass of the plate settler Clarifiers; collecting channel; overflow

The clarifiers shall be bypassed by connecting the distribution chamber directly to the collecting channel leading to the filters. The bypass can be used during periods of good raw water quality with minimum of turbidity and suspended solids for direct loading of the filters. There shall be an electrically operated bypass wall gate.

Overflow

An overflow shall be provided at the collecting channel to avoid uncontrolled flooding of the plant. The weir of the overflow shall be designed for the design flow plus over-load in a manner that the upstream head does not exceed the freeboard of the channels and treatment units. The weir plate shall be adjustable. The starting chamber of the overflow shall be adjacent to the channel and the overflow from the weir shall feed it. It shall be suitably sized. Free board of the collecting channel shall be 30 cm and shall be suitably connected through pipe / channel to the general drainage system of the plant.

5.5.9 Sludge Withdrawal

The underflow from the clarifiers shall be led through a DI pipe to the Sludge sump for carrying out the Zero Liquid Discharge concept. Sludge collected in hoppers of each clarifier shall be evacuated individually or in groups by hydrostatic pressure from the bottom of the hoppers through a discharge pipe into a sludge collection channel common to all the clarifiers located between a pair of clarifiers or external to the clarifiers. A gallery shall be provided to accommodate the sludge channel which shall be of sufficient size to provide walkways along the side of the channel and to give access to all sludge and drain valves and to house controls and associated equipment. Enclosed sludge galleries shall be force-ventilated.

All sludge valves shall be of the eccentric plug or ball type and shall be arranged for pneumatic power operation with manual override. Each power operated valve shall be of the spring-loaded type arranged to close on air supply failure and shall be provided with a manually operated guard valve. The quantity of water discharged as sludge from clarifiers averaged over 24 hours shall not exceed 2.5% of the works input averaged over the same 24 hours.

5.6 Rapid Sand Filters

5.6.1 Filters

The filter beds shall be supplied, clarified or by-passed raw water from secondary channels through a main channel coming from the clarifiers. The filters shall be of the constant flow and rising water level type (split flow). All filters shall be identical in internal dimensions. The top level of the filters is the same as that of the feeding channels to avoid overflow in the filter area. The thickness of filter wall shall not be less than 150 mm. A sound mechanism be adopted for water sealing from expansion joints, if provided.

The filter house shall have not less than thirty-six (36) filter beds with single bed. The filter beds shall be designed to give the normal output of 8265 m^3 /hour with a filtration rate not exceeding 6 m/hour and with a filtered water turbidity less than 0.5 NTU. The beds shall be capable of taking overloads up to 16.67% of the average flow to keep one filter bed as standby, even at the time of worst tidal variations in the river without adversely affecting the quality of the filtrate. The filters shall be arranged in two rows with a space not less than 8 m between them to accommodate pipe galleries and a filtered water channel. The filters shall be designed for a head loss not more than 2 m and for cleansing by air followed by water. The minimum sizes of cast iron pipes, pipe fittings, sluice valves and sluice gates shall be as follows:

Filter inlet pipe and sluice gate	600 mm dia
Filter outlet piping & sluice valve	450 mm dia
Filter waste piping & sluice gate	600 mm dia
Filter wash sluice valve	500 mm dia
Pipes and fittings for ring main for backwash water	500 mm dia

Pipes and fittings for wash main from pumps to ring main	600 mm dia
Pipes and fittings for air scour	200 mm dia
Sluice valve for air scour	200 mm dia

A rectangular sharp-edged weir with gate shall control the flow to the filters. The weirs shall be adjusted in a manner that all filters in operation receive the same flow considering the hydraulic conditions of the common feeder channel and fully opened gates. The tolerance shall not exceed +/- 5 %. The gate shall be used for the isolation of a filter in case of backwash or maintenance. It shall be electrically operated from the filter control consoles. All gates shall be electrically operated.

All sluice gates and sluice valves on each filter shall be opened and closed by pneumatic cylinders which shall be of double acting type with adjustable air cushions. The inside surfaces of the cylinders shall be ground and honed to very fine tolerance for efficient and positive operation. The pneumatic cylinders, pneumatic valves and other pneumatic components shall be of reputed and approved make. All the pneumatic operated sluice valves and gates shall be SCADA compatible and integrated with WTP-SCADA.

The cylinders and the operating air pressure system shall be designed to ensure positive action and to overcome all forces due to friction and unbalanced head against the gates. The cylinders shall either be mounted directly on the sluice valves or placed on the operating platform with extended spindles to connect the pistons of the cylinders to the valve spindles. Cylinders shall be designed for 100% over load after assuming compressors to work at 60% of their rated capacity. Agency shall also include filter and lubricator to be provided to the cylinder more than 8 m away (measured along the pneumatic pipeline) and a separate mounting with a solenoid valve would be necessary, keeping the filter exposed. The power and control cables shall lead from the said mounting to the main console. The cylinders shall be designed for an operating pressure of 5 bar. Speed controllers shall be provided to each cylinder - one for each direction of operation, the time of travel in the downward direction being 10 sec. with 20% tolerance either way.

The pneumatic cylinders shall also be actuated by solenoid valves as stated below which shall be arranged on a console placed in front of each filter unit. Double coil solenoid

operated two position valves shall be provided in the console to be able to open or close the valves fully, except for the inlet sluice gate and back wash valves for both of which the solenoid valve shall be of three position type which shall permit inching to hold the valve or gate at any intermediate position. All air supply pipes to the individual valves and sluice gates and from the filter consoles and electrical wiring for pilot lamps on the consoles shall be neatly arranged on the walls in straight horizontal and vertical lines. An air filter regulator and lubricator of approved design and make, shall be provided at each filter console.

The filter consoles shall be of fiber glass reinforced plastic with a smooth finish and shall be fitted with pilot lamps to indicate shut and open positions of the respective valves or sluice gates actuated by limit switches mounted on the cylinders. The consoles shall be provided with push button starters for each of the wash pump and air blower motors with indicating pilot lamps. The consoles shall also be provided with arrangements to give an audio-visual signal to the central control room and to the wash pump/air blower room in case of emergency. The console board shall also be provided with three analogue meters showing the rate of flow, loss of head and rate of wash water flow.

Agency shall include in their offer two (2) electrically driven air compressors of reputed make approved by the Authority mounted on a pressure storage tank for furnishing air power for actuating the pneumatic cylinders. The displacement of the compressor and the capacity of the storage vessel shall be so designed as will make available always with one unit in operation, sufficient quantity of air under required pressure to actuate the cylinders when the filters are washed one after the other at intervals of 30 minutes. The compressors shall be fitted with a pressure switch to maintain the required pressure in the storage vessel and a drier for dehumidifying to ensure dry air to the cylinders. An audio-visual alarm shall be installed in the central control to indicate failure of the pressure system. One compressor shall work at a time and the other one shall be stand by. The compressors shall have a minimum capacity of 15 bar and provided with a pressure switch each with both cut-in and cut-out facilities.

Each filter bed shall be provided with the complete set of underdrain system of latest improved pattern, the system being designed for efficient application of compressed air and wash water during filter cleaning. Agency shall have the option of providing in

their offers underdrain system to suit their own designs, incorporating nozzles fixed on precast slabs. Where nozzles are used these shall be of high density polyethylene nozzles and shall be spaced suitably on the filter floor to ensure uniform collection of the filtrate and even distribution of the backwash air and water over the entire area of the filter bed. The underdrain system shall be designed to ensure that there shall be no air binding during either filtration or backwashing and shall prevent mud ball formation in the sand bed. There shall be no loss of sand during filtration or backwashing and the sand bed shall settle down uniformly. Agency shall submit with their offer detailed specifications and description of the underdrain system with necessary sketches they have incorporated in their design.

5.6.2 Filter Media

The filter media (sand and gravel) shall conform to IS:8419 (part I) amended up to date. Each filter bed shall be complete with the filter media conforming to the following specifications. The filter media shall consist of a sand bed supported on a bed of gravel. The sand bed shall have a depth of not less than 635 mm while the depth of the gravel bed shall be determined by the Agency to suit the type of filter floor offered by them. The gravel bed shall incorporate layers of gravels of different sizes ranging from 6 mm to 50 mm and the total depth of gravel bed shall be not less than 525 mm. Tenderer shall ensure the stability of fine diameter & gravel of the filter bed.

The filter media shall be quartz sand of effective size of 0.55 mm to 0.70 mm with a uniformity co-efficient not exceeding 1.50. The sand shall be granular, hard, and screened through appropriate meshes and shall be thoroughly washed to the satisfaction of the Engineer-in-Charge prior to loading in the filters. The sand shall be free from clay, dust and other impurities and shall not contain more than 1% of micaceous matter. The sand immersed in 40% hydrochloric acid for 24 hours shall not lose more than 5% by weight. It shall not contain more than 1.5% of calcium and magnesium calculated as $CaCO_3$ and not more than 0.7% weight shall be lost after burning. The gravel supporting the sand bed shall be hard, durable and rounded and shall not disintegrate under the action of water. The gravel shall be thoroughly washed to the satisfaction of the Engineer-in-Charge prior to loading in the filters. The solubility of gravel in 40% hydrochloric acid after 24 hours at room temperatures shall not exceed 10% for 10 mm size

gravel and 5% for smaller than 10 mm size gravel. Filter sand when immersed in 40% hydrochloric acid for 24 hours, the soluble matter shall not be more than 5% by weight. It shall not contain more than 1.5% of calcium and magnesium calculated as CaCO3. Ignition loss shall not exceed 0.7% of the weight. The solubility of supporting gravel in 40% hydrochloric acid after 24 hours shall not exceed 10% for 10 mm or larger size gravel and 5% for smaller than 10-mm size.

All filter media shall be supplied in polythene bags. Suitable care shall be taken to protect the media from spillage or contamination. Storage on site shall only be in an approved area, well drained and free of mud and silt. The filter media shall be carefully placed in the filter beds and shall not be dropped or dumped or machine handled to be detrimental to the media floor, nozzles or sealant. etc.

It shall be deemed that the Agency has investigated all potential sources and verified that sufficient quantities of satisfactory filter sand can be obtained, packed and stored on site.

The water level on the filter bed during filtration shall not be controlled. It shall serve as the indicator for the filter head loss. The maximum water level (admissible filter loss) must be such to allow free fall from the feeding channel / rectangular weir. Filters shall be cleaned when the water has reached that upper level. There shall be proper arrangements to avoid destruction of sand surface by freely falling water in case of a low water level in the filters just after cleaning. The lip of the outlet weir shall be at least 100 mm above the top of the sand bed to prevent media running dry.

- A filter false bottom floor with nozzles shall be provided for under drains conforming to IS:8419 (Part 2) and contain polypropylene nozzles of reputed and approved make.
- The under-drain system shall be designed to provide uniform draw-off of filtered water and uniform distribution of wash water and air over the whole area of the filter. Provisions have to be made for the handling of the high air velocities at the inlet zone of the manifold.
- Before filling the supporting layers and the sand of the filter beds, the whole underdrains system shall be thoroughly cleaned and tested for equal distribution of water. The Agency shall take all necessary measures to ensure that false floor shall contain polypropylene nozzles of reputed make and the water conveying system of pipes or

channels connected to the floor are free from any debris, concrete, sand or other material which could otherwise block or partially block nozzles. Uniform distribution of the nozzles of not less than 55 numbers per square metre shall be employed.

The nozzles shall:

- incorporate separate air and water entrances;
- be set at an exactly uniform level;
- be capable of replacement;
- be designed to avoid ingress of sand
- purge valve

It shall be the responsibility of the Agency to remove any such debris before the commissioning of laying filter floors or laterals and shall continue to remain his responsibility for excluding unwanted materials which could block the filters until the O&M period.

For twin bed filter, each filter shall have central and lateral wash water troughs that shall be connected with adequate slope to the wash water outlet to prevent deposits of silt. They shall allow an equal withdrawal of the wash water during backwashing the filter. The filter backwash water shall ultimately be discharged to Recycling (Buffer) Tanks.

A float switch shall be provided at the maximum admissible level of each filter to indicate the need for back-washing.

The Agency shall provide a filter outlet controller which shall permit the filter to operate at a fixed rate of desired output irrespective of the gradual increase in loss of head in the filter bed. The outlet controller shall be designed to operate in the range of zero to 125% of the normal flow. The rate controller may be closed venturi type or open type with double beat valves of not less than 600 mm diameter in outlet chambers in front of the filters fitted with rectangular weirs made of brass for measurement of flow and for controlling the double beat valves by means of floats in the outlet chamber and the filter tank. The control valves for open type controllers shall be of cast iron with gunmetal/S.S. facings to render them water tight in closed positions. The floats in the filter tanks and outlet chamber shall be made of fiber glass. All levers operating the controllers shall be designed to move in ball bearings to ensure free movement. Where open type controllers are offered the top of outlet chambers receiving the filtrate shall be

provided with removable covers framed of aluminum alloy angles and of design to be approved by the Engineer-in-Charge. The portion of the chamber receiving the filtrate over the weir shall be provided with a minimum 6 mm thick framed transparent perplex sheet. An underwater bulk head lighting fixture shall be fitted in the chamber below the perplex sheet. Suitable arrangements shall be made for disposal of waste water from the float chambers and outlet chamber irrespective of head loss in the filter bed or designed on the principle of declining rate of filtration.

Agency shall submit with their offer the details of their designs and complete specifications for the equipment for the filter outlet arrangements.

The filters shall be provided with an automatic slow starting equipment so that after each back wash the filter unit shall give an output at 10% of its rated capacity for a minimum period of 15 minutes before reaching the rated loading. This slow start equipment shall either form an integral part of the outlet controller or be independent of it. In addition, Agency shall provide a rewash valve of at least 200 mm diameter. at the outlet of each filter to operate the filter at a much-reduced rate immediately after backwash. Each filter shall be provided with Rate of Flow and Loss of Head indicators of a diameter type in order to indicate the rate of flow from each filter and the progressive loss of head in the filtration process. The rate of flow indicator shall be operated by a differential head in the venturi controller and in the case of open type controllers by the depth of flow over a rectangular weir in the outlet chamber. The loss of head indicator shall be operated by means of a differential mercury pot or by water columns in which case arrangements shall be provided in the indicator to compensate for fluctuations of water levels in the filter box. The loss of head indicators shall incorporate an electrical contact point to give a signal when the filter is due for washing. Agency shall also provide remote sensing for reading the rate of flow and loss of head indicators in the central control room in the annexe building. The meters which shall be dial type or digital shall be mounted on an instrumentation panel. All electrical wiring and/or air tubing from the local indicators to the instrumentation panel shall be included in the offer.

5.6.3 Filter operation gallery and pipe gallery

The filters shall be operated and back-washed according to the instructions of the Engineer-in-Charge. Minimum guaranteed filter run shall be at least 23 hours under all

conditions. Each filter shall be provided with necessary electrically driven butterfly valves and push buttons provided on the filter operating console. The valves shall have the possibility for manual operation from the pipe gallery in case of problems with the drive. The following valves/gates shall be provided:

- filtered water outlet (electrical)
- backwash water inlet (electrical)
- air inlet (electrical)
- sludge water outlet (electrical)
- inlet gate (electrical)
- drainage of the filter (electrical)

The valves shall be connected to pipe branches coming out of the filter box. These outlet and inlet pipes and inlets shall be provided with proper wall ducts without any leakage. In line type DP transmitter type flow meter with 2% accuracy with 4-20 mA signal output, flow transmitter with local display and a regulation valve shall be installed in the backwash water pipe coming from the reservoir. There shall be a locking arrangement in regulation valve that can be locked after adjustment of flow. The flow rate (m^3/hr) shall be transmitted to a wall mounted electronic digital meter of suitable size so that it is visible and readable from each filter operating console.

The electrically driven valves and the inlet gates shall be operated from individual control consoles positioned adjacent to each filter in the operation gallery with visibility to the respective filter bed. The control panel for the units shall be installed in the Machine Room. The following control functions (-c) and indicators (-i) shall be provided:

-c operation of the inlet gate and the valves (open/closed/intermediate position)

-i indication of the status of the gate and the valves (open, closed, intermediate, motor failure)

-c operation of the air blowers (on, off, failure)

-i signal lamp with acoustic signal if the water level in filter bed has reached the top level and the backwash cycle shall be started

-i indication of adequate water level in the backwash reservoir (yes, no)

The washing cycle of the filter shall have all provisions for its manual operation, step by step. The duration of the cycle shall be prescribed by the Agency, dependent on the

raw water quality. Before back-washing, the filter water level shall be lowered to its minimum in order to avoid wastage,

The pipe gallery shall have the following piping arrangement:

- backwash water pipe with connection to each filter
- air pipe with connection to each filter

The filtered water pipe of each filter shall be connected to a small chamber with an adjustable rectangular weir to the central filtered water channel. This weir shall control the minimum water level in the filter. The weir crest shall be 10 cm above the top sand level of the filter. The length shall be designed to have less than 10 cm head. The completely covered channel shall lead directly to the chlorination chamber and lead to the CWR.

The sludge water outlet and the evacuation outlet shall be directly draining into an open channel in front of all the filters. This channel shall lead to a chamber that is connected to the drainage system leading to the recycling tanks.

In the pipe gallery, easy access to all valves and drives, cables etc. shall be ensured. If required, walkways and ladders shall be provided.

5.6.4 Filter operation gallery and pipe gallery

The filters shall be back-washed with water and air according to a cycle prescribed by the Engineer-in-Charge. Therefore, the following capacity requirements are only tentative. However, one full filter bed / box (i.e. both the sections) shall be back-washed at the same time (simultaneously) to reduce down time of filters.

The filters shall be designed for back washing with water at the rate of 600 litres per square metre per minute proceeded by air scouring at the rate of 750 litres per square metre per minute. Arrangements shall also be kept for suitable surface wash by water jets to break up the surface of the sand bed prior to the application of back wash water.

The water for back washing of the filters shall be obtained by direct pumping, the Agency shall include four pumps of identical capacity. Two of these pumps shall be in normal use and shall be capable of delivering 300 litres per second each. The other two pumps will remain as standby and of same capacity. The pumps shall be designed to operate against a head which shall be adequate to overcome losses due to all causes including friction in the wash main and the filter underdrain system when applying was

water at a rate of 600 lpm/m^2 and the pressure measured in the underdrains of filter beds shall be equal to 5 M to 7 M head of water. The pumps shall be installed in a pump room in the filter annexe building in such manner that it will provide positive suction head to draw water from the filtered water channel or a sump connected with the filter water channel. Each pump shall be complete with driving motors, necessary cast iron sluice and reflux valves and cast-iron piping for suction, downward suitable bell mouth and delivery including all fittings. The wash water from the pumps shall be delivered at the wash valve of each filter through a cast iron main not less than 600 mm in diameter. from the pump room to the filter house and through a cast iron ring main not less than 500 mm in diameter. within the filter house.

Trenches with chequered plate covering shall be provided on the floor of the pump house for placing all pipes and electrical cables. A 5 tonne capacity electrically operated crane with travelling trolley complete with RSJ runners shall be provided in the back-wash pump room for handling of the pumps, motors etc. and carrying the same at the repairing bay at an elevated height.

Two units of Rotary Air Blowers of reputed make to the approval of the Authority each capable of delivering at least 95 m^3 of free air per minute at 0.35 to 0.50 kg/cm^2 pressure at the underdrains complete with motors etc., or of sufficient capacity as designed by the agency whichever is higher, shall be provided to supply 0.75 m^3 of free air per minute per m^2 of the filter bed. Out of two units one will be in operation and the other will act as a standby. The header from the blower shall be at least 200 mm diameter Double Flange Ductile Iron (DFDI) main and the piping leading the compressed air to each filter unit shall be 200 mm diameter Double Flange Ductile Iron pipes only. Requisite air filters shall be provided to control the air supply to the filter beds. Adequate arrangements shall be made to ensure uniform application of air over the entire filter bed. Measuring instrument for measuring quantity of air shall have to be provided of approved make. The design of the blower and its silencer shall be such that the decibel level in the blower room would be within permissible limit, and shall in no case exceed 80 dB at a point 3 m away.

Agency shall provide a flowmeter of the indicating, integrating and recording type for the measurement of wash water flow rate and consumption. The meter shall be of a reputed make to the approval of the Engineer-in-Charge and shall be operated by a

pressure differential in an orifice plate in the 600-mm diameter. pumping main. The loss of head in this orifice plate shall be taken into account for determining the duty of the wash pumps. The indicating and integrating instruments shall be mounted on an instrumentation panel in the central control room. A 100 or 150 mm diameter dial or digital type wash water flow indicator shall also be provided on each filter console for the guidance of the operator when applying backwash water. These secondary instruments shall be actuated by the main wash water meter.

The filter waste water during backwashing shall be collected in waste troughs which shall be provided sufficiently above the level of the sand bed to allows for expansion of the sand bed. The spacings between the troughs shall be arranged to limit the horizontal travel of the waste water to a maximum of 1 m. The waste trough shall be provided with horizontal inverts and shall be designed to discharge with a free fall into the main waste gutter channel of the filter unit. Some arrangements shall be provided to drain off during the washing process such light particles of impurities floating in the water above the sand head which are unable to reach the lip of the waste toughs. Such device shall ensure that the sand held in suspension during the application of wash water is not drained off with the impurities. Agency shall submit with their offer a detailed description with necessary sketches of the equipment offered by them for this and the manner in which it will function.

Agency shall provide a pressure water system for each filter to break up the surface of the sand bed by a pressure (not less than 3.5 kg/cm^2) jet prior to the application of backwash water. The equipment for this arrangement shall include a cast iron pipeline in front of the two rows of filters and a hydrant at the centre of each filter with sufficient length of flexible hose in reels fitted with a gunmetal/SS nozzle for the jets to reach all corners of the filter bed. The pipeline for this pressure water shall be connected to the pipeline specified earlier from the Authority's pressure main for supplying water in the chemical house and pressure water to the clarifier sludge pipes of adequate capacity. Separate high-pressure pumps (one acting and one standby) shall also be provided for supplying water from the filter water channel for jet washing during non-supply hours with suitable valve arrangement.

Pumps

The following control functions (-c) and indicators (-i) shall be provided:

- Remote start, stop with manual override
- auto stop when sump (at filtered water channel) level low
- stop in case of failure of the motor
- on, off, failure (repeat indications at Main Control Panel)
- voltmeter, ampere meter, operation hours
- low level in the sump
- high, middle, low level in the backwash reservoir
- flow of the backwash water coming from the reservoir

Compressors / Blowers

The Agency shall provide compressors (minimum two numbers with 100 % standby units) along with suitable induction motor coupled suitable for operating on 415V, 50 Hz frequency supply for the air delivery for scour of the filter beds.

Each unit shall be provided with a suction air filter and silencer, pressure relief valve and delivery non-return valve. A non-return valve shall be provided on common air main to each battery of filters.

The air pipe to the filter shall be laid with an apex above the maximum water level of the filters and a vacuum breaker at the point to avoid back-flow and siphoning of water in the compressor.

Pressure gauges with stop cock at the pressure side of the compressors shall also be provided.

The air piping connecting the blowers to the filters shall be laid out on the ring main principle. There shall be a provision for the release of air from the system at the end of the scour before backwash commences.

The following control functions (-c) and indicators (-i) shall be provided:

- Remote start, stop with manual override
- local start, stop
- manual start, stop from each filter control console
- on, off, failure (repeat indications at Main Control Panel)
- voltmeter, ammeter, operation hours

The status of both the backwash pumps and the compressors are also to be indicated at the main control panel of the treatment plant. The status of the compressors/blowers shall be indicated on the filter control consoles also.

Design Parameters for Backwashing Arrangements shall be followed:

Type of Filter Back-washing	Sequential Back wash System	Conjunctive Air and Water Wash System
Configuration	Minimum 1+1	Minimum 1+1
Vol. of free air	36-45 m/hr	45-50 m/hr
Vol. of water applied	24-36 m/hr	12-15 m/hr
Air pressure at under drain	0.35 Kg./sq.cm.	0.35 Kg./sq.cm.
Speed	< 1000 rpm	< 1000 rpm
Air velocity in pipe and valves	< 25 m/sec.	< 25 m/sec.

5.6.5 Re-cycling of Backwashed Water

Waste water from filter backwashing process shall be re-used instead of being drained to waste. For this, Agency shall provide a tank to recover the waste water from where it will be pumped into the raw water channel upstream of the venuri throat and coagulant dosing point for feeding it with the incoming raw water at a rate not exceeding 5%(five percent) of the raw water input. The capacity of this tank shall not be less than 50 m^3 and the recirculation pump shall be capable of pumping continuously at the rate of not less than 100 litres per second. The storage tank has to be provided with an overflow weir to discharge excess quantity of waste water into natural drainage or into the sludge pump house sump through a pipeline. This overflow will come into use in the event of breakdown of the recirculation pumps or at times when it becomes necessary to wash the filters in rapid succession. The tank is to be provided at a convenient place near the recirculation pump room. There shall be provision for suitable agitation system for the deposited silts.

Alternatively, the space below the filter inlet channel around or on the two sides can be used to give the necessary volume of storage of the waste water. In this case the floor of the channel shall be provided with a slope from one end towards the pump sump to give a scouring velocity between 1 to 1.2 m/sec. for a flow of at least 100 1/sec which is the rate of recirculation. Provision shall be made for access to the bottom of the sump by means of stair made of non-corrosive materials. The filter waste water channel would be located outside the filter house, below the inlet channel but not below the pipe gallery.

For delivering the waste water from the channel into the raw water channel, Agency shall install two electrically driven mixed flow centrifugal pumps each with a capacity of at least 100 litres per second in a pump room on the ground floor of the filter annexe building. One pump shall be in normal use while the other shall act as a standby. The pumps shall be designed either for horizontal or vertical execution and shall be arranged to start and stop automatically by means of a float/electrode in the channel at a preset level near its floor. The pumps shall be complete with cast iron sluice valves, reflux valves and piping which shall be arranged to deliver the waste water into the raw water channel for reuse or to discharge into the sludge pumps house sump.

There shall be a provision for measurement of the filtered water output from the plant. The measurement shall be by means of an open channel venturi-flume built in the filtered water channel at the end of the filter house. Agency shall include in their offer an open channel flow meter of reputed make to the approval of the Authority incorporating an indicator, an integrator and a recorder which shall be mounted on an instrumentation panel in the central control room. The instrumentation and control of filter console shall have modern equipment with digital display and shall be SCADA compatible. All instrumentation and control in Filter house shall be SCADA compatible.

Design Parameters of RGF:

1. Design Flow: Normal corresponding to 190 MLD treated water + 20% overloading
2. Filters:

Normal Filtration rate	-	5.0 m3/m2/hr
Water column	-	1.0 - 2.0 m
Free board	-	0.5 m

3. Filter media:

Depth of sand bed	-	0.6 - 0.75 m
Effective size of filter media	-	0.8 - 1.0 mm
Uniformity coefficient of sand	-	1.3 - 1.5
Depth of gravel layer	-	0.5 m

5.6.6 Civil Works: Filter House with Annex Building

The filter house and annex building shall be of R.C.C. framed structure with brick panel walls and shall be provided with pile foundation. The filter units and channels shall be of R.C.C. construction only. The annexure building will also be used as administrative purpose.

Total plinth area of the filter house excluding the areas covered by the inlet and waste water channels shall satisfy the following two norms:

i) The distance between the two rows of filters shall be minimum 8 metres to

ii) accommodate filtered water channel and pipe galleries.

The total area of sand beds in the filter units (not less than sixteen in number) shall be sufficient to give the normal output of 8265 m^3 /hour of filtered water along with over-loading at the filtration rate of 6 m./hr after deducting for backwash loss.

The filter tanks shall have a minimum free board of 500mm and operating platforms walkways shall be provided at the level of the top of the tanks. The operating platforms over the pipe gallery and the walkways connecting the two ends of these platforms shall have a width not less than 2500 mm. The two operating platforms shall be intermediately connected at least at three points by 1200 mm wide walkways. The walkways at the rear of the filters and on the cross walls shall be 1000 mm wide. Concrete platforms of adequate size shall be provided outside the building on part of the filter inlet channel to give access to the inlet sluice gates. Hand railings with as specified or directed by the Engineer-in-Charge shall be provided on all walkway and operating platforms. Agency shall also include for the supply of not less than three stairs (at least 1 m wide) of mild steel construction to give access to the top of the filtered water channel from the operating platforms.

There shall be at least three manholes fitted with cast iron manhole cover and frame for getting into the filtered water channel.

There shall be a 900-mm wide R.C.C. staircase at the rear end (end opposite to the annex building and main entrance) of the filter house to give access to the filter house from ground level to operating platform.

One door at least 1.0 m wide shall be provided at the entry to the operating platform.

The annex building shall be a two-storied building each floor having a minimum carpet area of 250m^2.

The building shall have the following minimum areas:

On Ground Floor

Main entrance hall with staircase	100 m^2
Wash Pump Room and Blower Room	120 m^2
Waste Water Recirculation Pump Room	20 m^2
Toilet	10 m^2

On Frist Floor

Central Control Room & SCADA room for the Plant	130 m^2
Operators Room	50 m^2
Chemist's Room including office	30 m^2
Store Room	30 m^2
Toilet	10 m^2

Adequate common passages shall be provided on each floor to give independent access to individual room. Agency may make minor adjustments to the above-mentioned areas in order to suit their own design, keeping the total area unchanging.

The staircase shall be of aesthetic architectural design and the width of steps shall be 1500 mm minimum with 300 m tread and 150 mm rise. The staircase shall provide an access to the operating platform from the entrance hall. The staircase shall be provided with decorative hand railings with wooden hand rest.

The main entrance to the annex building shall be designed in a consultation with an architect to give an aesthetic appearance for which purpose the Agency shall provide a porch of not less than 6 m with an entrance foyer in which decorative plants can be placed. Agency shall submit preliminary sketches of this with the tender.

It is to be noted here that the chemical house and the annexe building shall be interconnected with a covered gangway as specified elsewhere in the tender documents.

The clear height between the filter operating platforms and underside of the roof beams shall not be less than 5.0 m. Similarly, the clear head room for each floor of the annexe building shall not be less than 4.5 m.

Adequate skylights and windows shall be provided in the filter house and annexe building to admit sufficient natural light. The total shutter area of doors, windows and ventilators shall not be less than 25% of the floor area. The windows and skylights shall be

provided with grills of approved design. The position of windows and ventilators/sky-lights shall be such that these can be opened and closed easily. All the windows and ventilators/skylights except the main entrance door of the annexe building operator's room and toilets shall be of mild steel and their pattern shall be up-to-date and approved by the Engineer-in-Charge. The doors including frames to operator’s room and toilets shall be of teakwood, size their thickness polished or painted as per direction of the Engineer-in-Charge. The main entrance door shall be of aluminum alloy construction photo-electric cell controlled sliding type of decorative design as per recommendation of the Agency architect and approved by the Authority. All other doors shall be of 1st class Teak Wood with Sal wood door frame.

The toilets block shall be provided in annex building and shall be connected with sew-erage line of the vicinity.

The roof of the annexe building which is likely to be flat roof or shell shall be provided with roof water proofing treatment with adequate arrangements for rain water drainage. The roof of filter house shall be RCC shell roof and shall be provided with adequate rain water drainage arrangement. There shall be a 250-mm thick parapet wall of 1000 mm height. A suitable access shall be provided to the roof from either within the filter annexe building or outside it without such access being prominently visible from the front of the building. The roof of the filter house may be a flat or shell roof accessible from annexe building roof or separately and with proper water proofing treatment as directed by the Engineer-in-Charge. While the flat roof shall be provided with a parapet wall as mentioned above with roof water proofing treatment, the shell roof shall also be provided with water proofing treatment. Adequate arrangements shall be made for rain water drainage in either case. There shall be architectural blending of roof of the annexe building and the roof of the filter house in order to provide an integrated and pleasant look.

All external doors and windows shall be provided with R.C. Chajja in box type or any other approved architectural design.

A 1200 mm wide apron of 75 mm thick 1:3:6 cement concrete laid on brick on-edge soling and a surface drain shall be provided around the filter house and annexe building. Adequate arrangements shall be provided to dispose of water from the rewash valves, overflow from filter outlet control chambers, leakage water from glands of pumps and

sluice valves in the filter house and annexe building and from all floor levels below finished ground level to natural drainage through surface drains or into the filter waste water sump, for which purpose sump pump shall be provided if necessary. Sufficient number and capacity of pump shall be provided in all areas where leakage water may be encountered to keep the areas free from water all the time. Each sump pump set consists of two equal capacity pumps, one will be acting and the other will be standby. Adequate number of lighting arresters shall be fixed on the top of the filter house annexe building and chemical house and this arrangement shall conform to IS-2307-1969.

The flooring of pipe gallery shall be epoxy flooring over ironite flooring. All the Buildings and structures shall be provided with proper earthing arrangement as per IS-3043 with step & touch potential arrangements conforming to IE Rules as amended up to date. All the basic construction works and finishing works shall be carried out as per specifications.

5.6.7 Machine Room

The machine room of adequate size shall be provided in the ground floor of the Administration and Control building to house the required number of air blowers and pumps. The number of pumps/ blowers shall not be less than two including 100% standby units shall be provided. The area where the pumps are installed shall be lowered by 1.5 m below the bottom level of the sump to provide positive suction head for the pumps. A drainage sump shall be provided at the deepest point of the lower area. The pit is connected to the drainage system leading to the re-circulation reservoirs.

A repair bay of 3 m shall be provided at the entrance of the room. A railing shall be provided around the lower part of the hall. The partial accessibility to the repair bay for a truck must be ensured by a wide and high gate minimum of 3 x 4 m. The room height must be sufficient to allow loading and unloading of the pumps and the other equipment.

Suitable ramps shall be provided to transfer the blowers / compressors from their respective floor level to repair bay level by a hand driven trolley. An electrically operated suitable capacity hoist of standard make shall also be provided in machine room for handling of pump, motor & blower/compressor etc.

5.7 Treated Water Measuring Channel and Flume

The treated water shall be measured in an open channel by means of a flume. An Ultra Sonic Flow meter with flow integrator and electronic display units shall be provided at the flume, to display the raw water flow in the control room. The measured discharge shall be indicated in the main control room. Rated Flow Capacity shall be corresponding to 190 MLD treated water.

5.8 Chemical House

5.8.1 General

The chemical house shall be planned, designed and constructed for the 190 MLD (23 hours operation) output capacity in one building and shall include space for fifteen (15) days storage of alum and lime. The required number of chlorine tonners shall be stored separately in that building too. The chemical house shall have sufficient space for unloading of the chemicals, wide corridors, office space, toilets etc. The ground floor shall be used for the 15 days storage of alum and lime. The first floor shall house the alum/ Primary coagulant, lime preparation tanks, the dosing equipment for all chemicals required. Suitable staircases, platforms etc. shall be provided to have clear access to different units. The building shall be supplied with process water from the overhead tank. The architectural layout of the chemical house shall be functional, adapted to the regional climate conditions and shall give an aesthetic appearance bearing in mind the local environment and culture in the campus. It shall be in harmony with the other buildings in proximity and the treatment units.

The alum/ Primary coagulant and lime dosing room shall be equipped with desert coolers. The cooler supports shall be integrated in the building and easily accessible. Water points and 5 A sockets shall be provided at these locations.

The chemical house shall be supplied from the common manifold of clear water pump house by minimum pipe size DN 150 to supply the solution tanks for alum and lime solution. Branches of minimum of DN 100 - DN 25 shall be installed for supply the sprinkler system of the chlorine cylinder storage area, the solution tanks for alum and lime solution, the booster pumps for the injector system for the chlorinators and the internal supply system.

The regulation shall be made with the adjustable dosing metering devices/pumps. The control over dosing rates shall be capable of being exercised from the control room consoles. The solutions shall be conveyed through pipes to the injection points.

There shall be a single chemical house for the plant under this tender where provision shall be made for alum, PAC or any other coagulant storage, alum tanks, dosing equipment, etc. The coagulant solution shall be fed to the raw water before the venturi-flume by gravity from the alum solution tanks in the chemical house. Provision shall also be made for over the ground storage & pumping of liquid alum and PAC as per I.S. specification for a minimum capacity of storage of 5 Ton of liquid alum/PAC. There shall be two suitable chemical pumps one in operation & the other standby for lifting liquid alum or PAC of pH value of 1.18 at a rate of 4.0 MT/hr. Delivery pipeline shall be capable to handle liquid of pH value 1.18 and requisite pressure to deliver the liquid to the dosing tanks.

Alum dosing shall be done using pumps and shall be controlled through SCADA. Alum dosing arrangement shall be designed to cater for a continuous dose of 50 mg/1 to an average flow of 8265 m3/hr using a 5% strength solution. The solution shall be prepared and stored in ten (10) tanks of sufficient capacity to store alum solution for 2 days. Out of ten tanks, two tanks shall be reserve for PAC solution. The tank shall be planned in such a way that any tank can be used for either PAC or alum dosing without affecting the regular operation. The floor of the alum solution tanks shall be kept at a level which will permit sufficient positive head to the feed pump. The coagulant solution shall be dozed to the raw water by suitable pumping arrangement with 100% standby. The chemical dosing shall be done through instrumentation and control (SCADA). The agency shall provide one tank of same size of alum tank for lime solution. Similar arrangement shall be made by the agency for lime dosing for adjustment of pH.

Provision shall be made in the alum solution tanks for providing timber slats to form trays over which Stainless Steel cages shall be kept for alum blocks which will be placed for preparation of the solution. Provision shall also be made for a jet spray of water over the alum blocks to achieve rapid dissolution of alum. The alum solution tanks shall be provided with fiber glass reinforced epoxy lining.

Electrically driven mechanical agitators shall be provided for continuous stirring of the solution in the tanks. The agitators shall consist of FRP coated stainless steel paddles

mounted on stainless steel shafts. The shafts shall be mounted on top of the tank and no thrust or guide bearings shall be permitted below the liquid level. The paddles in the tank shall be driven by an electric motor through a speed reduction gear of appropriate ratio to provide gentle agitation of the liquid. The driving motor and the reduction gear shall be totally enclosed and easily accessible for maintenance.

Agency shall also quote for providing water jetting and flushing the alum solution tank when it is empty so that any settled insoluble material is flushed out. The drainage of such flushing shall be conveyed into the intake well. Provision for water for the jetting shall be made both from supply main as well as provision of high pressure pumps. Agency shall include in their offer complete arrangements for chemical dosing through instrumentation and SCADA control. The coagulant solution delivery and waste pipes shall be of PVC inside and outside the chemical house. No bends shall be used in the solution delivery pipeline and wherever a change in direction occurs cross pipes shall be used to facilitate cleaning of chokes of the pipelines. All valves for solution delivery and waste water from the tank shall be rubber lined cast iron diaphragm valves. The entire pipe work including valves shall be easily accessible for maintenance for which a walkway at the appropriate level shall be provided.

Agency shall provide two basket type strainers (one acting and other standby) in the coagulant solution delivery pipeline to the dosing tank. The arrangement of the strainers and the delivery pipeline shall permit isolation of any of the strainers for cleaning. The strainer housing shall be of rubber coated Cast Iron construction and fitted with a stain-less-steel mesh screen basket.

Agency shall also provide suitable level indicators operated either electrically or by float. Gauges shall be provided for each tank placed at a convenient place easily visible by the operators.

Owing to regular fluctuations in the quality of raw water/rate of flow of incoming raw water, Agency shall provide arrangements to administer the coagulant solution strictly in proportion to the incoming supply through instrumentation and SCADA control. Agency shall also submit a detailed description of the proportioning device offered by them. This include suitable device for measuring online turbidity as well as chemical dosing. All dosing equipment and online turbidity meter shall be of 100% standby. The piping for the ball valves shall be so arranged as will permit any one of them to be fed

through either any one of the pump. The dosing tank shall be of R.C.C. construction, lined with FRP or of mild steel lined internally with rubber or fiber glass. The ball valve, orifice and the tapered needle shall be of stainless steel and the float for the valve shall be of fiber glass. The entire coagulant dosing measuring device shall be capable to withstand liquid of pH 1.8.

Water supply for the preparation of coagulant solution shall be obtained from a tapping off the proposed clear water pressure main in the vicinity of the filter house/chemical house. Agency shall include in their offer inter connection with the proposed main with a C.I. sluice valve of required size and all pipes and fittings from this valve to the co-agulant solution tanks. Agency shall also provide pumping arrangements for supplying filtered water from the filtered water channel in the filter house. Agency shall include in their offer the cost of all these arrangements including pipelines, valves, pumps, motors etc. There shall be a provision for 100% standby of pumps & motors for supplying water to coagulant solution tanks. Agency shall include in their offer for the supply and erection, where necessary, of the following ancillary equipment for use in the chemical house.

i. Two electrically operated 2 - tonne capacity travelling hoists of reputed and approved make moving on rolled steel joists fixed on top of the coagulant tanks for lifting alum or other coagulant in trays from ground floor to individual tanks. There shall be sufficient head room for directly placing the SS cages in the dissolving trays of the solution tanks by the hoists. Both vertical and horizontal movement of the hoist shall be controlled by a single hand control switch connected by flexible cable of suitable length to control both vertical and horizontal movements separately. Easy inter changeability shall have to be ensured. One electrically operated 2.0 MT travelling hoist may also be provided instead of two, if the arrangement of the alum/coagulant solution tanks permits.

ii. Necessary stainless-steel S.S. cages of suitable size of a suitable design approved by the Engineer-in-Charge. The cages will be loaded with alum blocks or other coagulants and placed directly on the dissolving trays of the coagulant tanks for preparation of solution. The trays shall be of best quality teak wood and shall be made with mortice and tenon joints and with timber nails. All the edges of the trays shall be strengthened with stainless steel angles or straps. The S.S. cages

shall be made of robust S.S. tube-frames and slotted S.S. sheet of approved design. The top of cages shall be provided with hooks of stainless steel for lifting.

iii. Two 4 wheeled rubber tyred hand carts for transport of the cages containing alum blocks or other coagulants.

One 1000 kg dial type platform weighing machine of reputed and approved make.

5.8.2 Civil Works

The chemical house shall be of R.C.C. framed structure with brick panel walls founded on R.C.C. piles. Overall plinth area shall not be less than 320 m^2. The minimum areas to be provided for different purposes shall be as follows:

On Ground Floor

Coagulant storage, coagulant tanks and dosing arrangements	320 M^2
Operator's room	40 M^2
Two batteries (one in operation plus one in standby mode) of chlorine drums	128 M^2
Toilet block	12 M^2

On First Floor

Chlorination Room	150 M^2
Laboratory	100 M^2
Office room	100 M^2
Lobby	50 M^2
Store room	20 M^2
Toilet block	12 M^2

The Agency shall be free to provide additional areas within their quoted price.

Agency may make minor adjustments to these areas to suit their own design requirements within the allowable minimum overall plinth area.

Adequate common passage and circulation space shall be provided on each floor to give independent access to each individual room.

An independent stair case of 1000 mm wide steps shall be provided from coagulant dosing area in the ground floor to the first-floor lobby. A separate stair case of 1200 mm wide steps shall be provided to access from the ground floor to the first floor for laboratory and chlorination room and the roof. The stairs shall be fitted with grilled hand railings with timber hand-rest.

Any adjacent rooms shall be separated from the alum/coagulant storage space by a 375-mm thick brick wall and shall be provided with a separate entrance.

The chlorine storage room also shall be separated from the coagulant storage space by a 375-mm thick brick wall and shall be provided with independent 2400 mm wide entrance and exit. There shall be two ramps of mild slope of 2700 mm wide in front of the entrance and exit to facilitate easy handling of chlorine drums. The clear head room between the floor level and the bottom of the roof beam shall be 5.5m. Similar clear head room shall be maintained for other appropriate areas of the chemical house except for the mezzanine floor. Additional covered storage space for 6 tonner drums shall be provided outside the chemical house in conformity with the statutory regulation of explosive departments.

The chlorine storage room shall be provided with one electrically operated travelling hoist of 3.0 metric tons capacity complete with R.S.J. runners and two sets of drum lifting tackles. The R.S.J. runner shall be extended suitably in both direction beyond this room to facilitate the lifting of the chlorine tonners from carrier trucks and placing directly on the trunnion base. Chlorine drum storage room shall be provided with adequate chlorine neutralization pits including arrangements for neutralization. All the chlorine tonner drums shall rest on a ball-bearing/roller bearing trunnion system so that only one person is capable of rotating a completely filled chlorine drum in any direction on the trunnion resting system. This shall be done in conformity with the explosive department's acts and regulations.

Both the chlorination room and chlorine storage room shall have adequate ventilation. The total shutter area of doors, windows and ventilators shall not be less than 25% of the floor area. Exhaust fans ensuring four air changes per hour shall be provided just above the floor level. The chlorination room shall be provided with minimum two wooden doors. Easy access to toilets are essential from chlorination room and chlorine

storage room. The chlorination room shall preferably be placed above the chlorine storage room to facilitate easy conveyance of chlorine gas.

For other parts of the chemical house the total shutter area of doors, windows and ventilators shall not be less than 20% of the floor area.

The coagulant storage shall be provided with an entrance, 4500 mm wide fitted with gear operated rolling shutter. Entrance of trucks into the store up to the stacking space shall have to be provided to facilitate unloading of alum cakes or coagulants. For this purpose, there shall be a 5000-mm wide ramp of suitable slope in front of the entrance.

Suitable storage tanks for 5 tons of liquid alum or PAC of pH 1.8 shall be provided over the ground adjacent to the chemical house with suitable facilities for unloading from tankers and pumping the liquid alum/PAC to the coagulant solution tank. The pumps (one in action + one standby) and the pipelines from ground storage tank to the coagulant/alum solution tanks shall be suitable to withstand pH value of 1.8.

The main entrance door to the stair block for laboratory and chlorination room and the door of the laboratory shall be of 1st class C.P. teak wood all through including the frame. The design of the doors shall be got approved by the Engineer-in-Charge. These doors shall be polished as per standard practice as per direction of the Engineer-in-Charge. All other doors and windows shall be of steel. The design of such steel doors and windows shall be got approved by the Engineer-in-Charge.

There shall be a 2500 mm wide covered inter-connecting gangway between the chemical house, the collecting well and filter house at the first-floor level. The gangway shall be provided with SS grilled hand railings with wooden hand rest of approved design.

The roof of the chemical house shall be provided with approved water proofing treatment with adequate arrangements for rainwater drainage. The roof shall be accessible from the staircase of the laboratory, etc. and shall be provided with a 250-mm thick and of 1000 mm height parapet wall. There shall be water tank of capacity 10 m3 over the head room of staircase for use of water in the toilet.

A 1200 mm wide apron of 75 mm thick 1:3:6 cement concrete base laid under brick on edge pavement with 25 mm thick IPS covering and a surface drain of adequate channel width shall be provided all-round the chemical house.

All the basic construction works and finishing works shall be carried out as per specifications as contained elsewhere in the document or as per relevant and latest IS specification as directed by the Engineer-in-Charge.

5.9 Chlorination Chamber

Chlorination

5.9.1 General

In consideration of the quality of raw water from the river Krishna, the treatment process would require both pre-& post chlorination. The chlorinating plant shall be designed to administer a minimum dose of 6 mg/l for pre-chlorination and 2 mg/1 for post-chlorination. Agency shall provide at least four chlorinators of design capacity for pre-chlorination and four chlorinators each of design capacity for post-chlorination. Two of each unit for pre-and post-chlorination shall be in normal operation and the rest will act as standby. The chlorinators shall be of vacuum type with differential vacuum regulator operated by water pressure. They shall be of reputed and approved make having proven records of trouble free service for long periods of use. Vacuum Type Floor Mounted Chlorinators shall be installed in a separate chlorinator room. The capacity of chlorinators shall be sufficient to suit pre-chlorination of 5 PPM and post chlorination of 2 PPM. The room shall be reasonably gas tight and shall be provided with a ventilation system delivering to the roof level of the chlorine storage area. A set of continuously running exhaust fans at floor level shall exchange the air three times per hour with ventilators at 2.0m level. Emergency fans shall exchange it 20 times per hour. The doors of the room shall open outward.

4 nos. (2W + 2S) vacuum type chlorinators of 40 kg/hr shall be provided for pre-chlorination. Similarly, 4 nos. (2W + 2S) Chlorinators of 20 kg/hr shall also be provided for post-chlorination. Each Chlorinator shall be provided with a dedicated injector. Chlorinators shall be of Pivot or equivalent make.

An injector module to suit the capacity of the chlorinator shall be provided with each chlorinator. A spring diaphragm check valves (to close injector suction port when the injector is not operating) a ball check valve or both shall be incorporated in the injector to prevent the back flow of water from the injector into the chlorinator. The injector shall be designed with booster pump system of required capacity.

All parts of the Chlorinators, the injector and its accessories shall be of suitable material resistant to the chlorine (silver, silver plated Hastelloy C, PVC, Teflon, Borosilicate glass, ebonite lined cast iron).

The Chlorinators and their injectors shall be wall mounted with suitable mounting brackets with anchor bolts. All connections, valves and other parts of the Chlorinators shall be easily accessible for cleaning, maintenance and repairs. Pipe connections shall be flexible.

The complete chlorinator and injector units shall be piped and pre-tested as a system with all necessary valves, inlet connections, gauges and orifice control.

There shall be neither reactor towers nor evaporators. The sets along with booster pumps shall be provided for Stage I capacity but the space shall be for the Stage II capacity. The process water for chlorine solution shall be drawn from the pipes coming from the backwash water reservoir.

The Chlorinators shall be adjustable within a range of 1:10 according to the chlorine requirements of the raw and treated water. The tolerance of adjustment is not more than +/-4 %. Pressure gauges, indicating chlorine gas pressure and injector pressure shall be mounted on the front of the chlorinator and calibrated in metric units.

An injector module to suit the capacity of the chlorinator shall be provided with each chlorinator. A spring diaphragm check valves (to close injector suction part when the injector is not operating) a ball check valve or both shall be incorporated in the injector to prevent the back flow of water from the injector into the chlorinator. The injector shall be designed according to the available pressure conditions, which are governed by the available head in the backwash water reservoir at its lowest level. The flow of the injectors shall be controlled with the help of rotameter. If the pressure is not sufficient a booster pump system with small air vessel shall be provided to increase the pressure to the required level.

All parts of the Chlorinators, the injector and its accessories shall be of suitable material resistant to the chlorine (silver, silver plated Hastelloy C, PVC, Teflon, Borosilicate glass, ebonite lined cast iron).

The Chlorinators and their injectors shall be floor mounted with suitable mounting brackets with anchor bolts. All connections, valves and other parts of the Chlorinators

shall be easily accessible for cleaning, maintenance and repairs. Pipe connections shall be flexible.

The complete chlorinator and injector units shall be piped, and pre-tested as a system with all necessary valves, inlet connections, gauges and orifice control. There shall be neither reactor towers nor evaporators. The sets along with booster pumps shall be provided.

All the eight chlorinators shall be installed in the first floor of the chemical house while the manifold of chlorine drums shall be located in ground floor of the same house. The chlorine solution shall be delivered into the collecting well for pre-chlorination and into the filtered water channel for post-chlorination. The two delivery pipe lines shall be inter-connected and an arrangement of isolating valves shall be provided to permit the use of any two of the four chlorinators independently for pre-and /or post chlorination. Agency shall indicate this arrangement in drawings submitted with their tender. The chlorine solution delivery pipe shall be of PVC pipe of approved thickness and the chlorine resisting valves shall be rubber lined diaphragm type.

The pressure water required for the chlorinators shall be fed from the pure water channel in the filter house. Suitable separate pumping arrangement with necessary pipe line and valves shall be provided for transporting water to chlorinators at the required pressure. The velocity in the delivery pipe line shall not exceed 1 m per sec. Extra arrangements shall also be made for obtaining the pressure water for operating the chlorinators from proposed pressure main in the vicinity of the filter house/chemical house. Agency shall include in their cost all pipes, specials and sluice valves from the pressure main to the chlorinators. The chlorine dosing shall be instrumentation and SCADA controlled. Agency shall provide necessary equipment, valves etc. accordingly.

Liquid chlorine shall be drawn from a battery of 1 tonner drums, the withdrawal rate from each drum not exceeding 6 kg/hr. as per relevant rules & regulation and the chlorine gas shall be delivered to the chlorinators through a gas grid. Liquid chlorine withdrawal system shall be complete in all respects including connector valves, tubing and liquid chlorine traps. There shall be two batteries of chlorine drums one for normal use and the other as standby. An automatic changeover panel shall be provided to enable the standby battery to come into service when the first one is nearing exhaustion. This

changeover shall be signaled in the central SCADA control room (C3) and SCADA control room at WTP by means of an audio-visual alarm.

Agency shall provide a duplicate set of gas grid from the chlorine drum room on the ground floor to the chlorination room on the first floor of the chemical house. The two grids shall be interconnected and shall be arranged to permit the use of any one or both. The grids shall be laid above plinth level and shall be readily accessible for inspection and servicing. The grids shall be made up from schedule seamless carbon steel pipe of 5 mm thickness and fittings and shall be provided with necessary valves for isolating and for connecting to the four chlorinators.

Chlorine drum room shall be of adequate area to store 10 (ten) chlorine tonner drums divided into two batteries. Chlorine drum room and chlorine store room shall be provided with adequate chlorine neutralization pit with arrangement of neutralization.

This shall be done in conformity with the explosive department's acts and regulations.

The chlorination room and the chlorine drum room shall each be provided with sufficient number of exhaust fans which shall be fixed near floor levels. Each exhaust fan shall be capable of giving four air changes per hour.

Agency shall also include for the supply of two sets of dry type chlorine gas masks, two sets of self-contained air filled breathing apparatus type chlorine gas mask with two protective suits and two chlorine kits as per standard norms. Chlorine leak detectors with alarm shall be provided in both chlorine drum room and chlorination room. The leak detector shall be SCADA compatible and shall send signal to the SCADA control room. Agency shall supply spare parts that may be required (requirement being specified by the manufacturer) for the maintenance of the chlorinators for two years. They shall also supply of 30 (thirty) chlorine tonner drums with necessary test certificates and filling permissions etc. all complete as per statutory requirements. The Agency shall obtain explosive license from Dept. of explosive, GOI.

5.9.2 Operation of Water and Booster Pumps for the Chlorinators

The water supply shall be made from the internal system. The pressure shall be boosted by two centrifugal booster pumps to be installed in the Chlorine Building, adjoining to the chlorination room.

At least two pumps shall be supplied with isolating valves and the pressure gauges on delivery and suction line and valves by pass with pressure release valve from delivery to suction for each pump. The pump shall be connected to the common pipe fed from the backwash water tank. The pumps shall be identical and suitable for single and parallel operation. The pumps shall be directly coupled to drive motor by flexible couplings. The pump and the drive motor shall be mounted on a common base plate of steel. Foundation or ground bolts shall be supplied for each base plate.

The drive motor shall be of horizontal spindle, totally enclosed fan cooled squirrel cage motor and shall be manufactured, tested and provided with insulation to class E or better. Starting device shall be as per clause 0. The rating of the motor shall be at least 20% higher than the maximum power required by the pump over its operating range. The operating voltage of drive motor shall be 415 volts, 3 phases, 50 Hz.

5.9.3 Chlorine and Solution Pipes

The gas and water piping system shall be designed according to the chlorine and injection water flows and the hydraulic/pressure conditions. The pipes shall be laid as straight as possible on the shortest route from the drums to the Chlorinators. They shall be fixed on well supported trays / brackets and adequately sloped to allow for drainage. All steel supports shall be heavily painted in chlorinated rubber paint.

The connections of the chlorine gas pipes to the cylinders and the Chlorinators shall be coiled for flexibility during operation and maintenance. Each connection shall have a valve, a solenoid valve and a pressure gauge. All pipes and valves of the connection shall be placed out of the reach of gas cylinders hanging on the hook during manipulation. Not more than 4 gas drums shall be connected to a common withdrawal header.

Pipe material for the chlorine dosing plant shall be as given below:

Medium	Construction material	Test pressure
Chlorine gas	Soft seamless copper tube with compressed fittings	25 kg/cm²
Injector water (with or without boosting)	Galvanised iron pipes and fittings, class C	10 kg/cm²
Chlorine solution	Rigid PVC pipes and fittings, class 3, not exposed to open sunlight	10 kg/cm²

After installation, the chlorine gas piping system shall be cleaned and dried. After drying, the system shall be pressurized with dry air up to the test pressure and tested for leaks by application of soapy water to the outside of all joints and connections. Leaking joints shall be repaired, and only when all joints are made leak proof chlorine gas shall be gradually introduced and the system shall again be tested for leaks.

The pipes for water and chlorine solution shall be tested with water with the respective test pressure.

5.9.4 Neutralization Tank

One neutralization tank of reinforced concrete shall be provided in the maintenance bay. The capacity shall be adequate to neutralize full two chlorine tonners. The tank shall be suitably projected above the floor to prevent the entry of floor washings. It shall be filled with suitable neutralizing agent such as caustic soda (NaOH). The opening of the tank shall permit to place the chlorine tonner into it in any position. It's top shall be covered with some thin plywood type cover which can be broken up easily in the emergency by the tonner itself. The tank shall be lined from inside with suitable material so that the chemicals may not have any aggressive effect. The position of the tank shall be such that the tonner can be dumped into the tank easily by using the OHT crane for lifting the damaged tonner.

Alternatively, chlorine scrubber with suitably placed exhaust fan and piping can also be provided with flow of water and caustic soda solution from the top of scrubber. The capacity of exhaust fan shall be suitable for exhaust of full tonner chlorine in gaseous form with chlorine air ratio of 1:3.

5.9.5 Chlorine Leakage Control System & Security Equipment

For the detection of excess concentrations of chlorine in the air of the chlorinator room and the chlorine storage area leak detection devices are to be provided at suitable sites. Two levels of detection are envisaged:

Level of detection of chlorine leakage shall be as given below:

Detection level	Action	Installation site & number

Chlorine concentration at or below the level of human perception: Concentration level 1mg/l, adjustable between 1 and 5 mg/l	Indicator lamp, acoustic alarm at the chlorine plant and at the main control room; automatic start of emergency exhaust fans	1 for drum storage area 2 for chlorinator room
Abnormally high concentrations which could occur on leakage or failure of the chlorinating equipment: Concentration level 5 mg/l	Indicator lamp, acoustic alarm at chlorine plant and at main control room; automatic opening of valve of sprinkler system; closing of chlorine valves, closing of injector water valve	2 for drum storage area

The Agency shall provide following safety equipment in the works, as a minimum:

a) canister type respirators with full face coverage masks suitable for chlorine gaseous atmosphere - min. 2 no.

b) spare canisters for the respirators - min. 2 no.

c) self-contained compressed air breathing apparatus complete with working whistle and two spare air cylinders - min. 2 no.

d) a facility to recharge the compressed air cylinder or from a self-contained machine.

e) protective clothing such as PVC overall and gloves and rubber boots shall be provided - min 2 sets.

This equipment shall be stored in glass fronted non-locking steel cabinets so that any deficiency in the equipment shall be apparent. 15 m hoses DN 1" with jet and spray nozzle and valve are provided near the chlorine drum storage area in non-locking steel cabinets. They are connected to the process water system. The cabinets shall be located at strategic places in the chemical house and near the storage area with view to easy and safe accessibility in case of chlorine leakage.

The Agency shall provide visual and audible alarm system. Flashing warning lights shall be provided over each door of the chlorination room store and near the chlorine drum storage area. The lights shall be RED in color and shall be clearly visible at a

distance of 20 m under normal daylight conditions. They shall be activated automatically from the leak detection devices. Behind the lights a rear engraved perplex label having red letters on a white back ground shall be mounted at each door and at visible place. The lettering shall be a minimum of 50 mm high and one legend shall read in English and the other in Telugu language.

5.9.6 Wear Breathing Apparatus Before Entering When Light Is Flashing

One emergency drum leakage repair kit shall be provided in the workshop or in the chlorinator room.

Number & Location of Security Devices

Equipment Location	Respi-rators	Spare canister	Breathing device	Protect. Clothing	Warn light with hooter	Hose
Chlorination room	2	3	2		2	1
Chlorine drum storage area					2	1
Chemical plant		3	2	5	1	1
Total	**2**	**6**	**4**	**5**	**5**	**3**

5.9.7 Operation and Control of The Chlorine Dosing Plant

A dedicated control panel shall be provided in the chlorination control room.

The operation of the chlorination plant is as follows:

Operation	Pre-chlorination	Post-chlorination
regulation of the chlorine rate	Automatic with manual override, according to flow measuring channel and instructions passed from the control room through PLC on the basis of Raw Water quality	Automatic with manual override, according to flow measuring channel and instructions passed from the control room through PLC on the basis of Raw Water quality
regulation of the process water	Automatic,	Automatic,
stop of chlorine gas flow	Manual	Manual
	Automatic when raw water flow is zero	Automatic when raw water flow is zero
	Automatic when injector stops	Automatic when injector stops

	Automatic when chlorine pressure low (gas drums empty)	Automatic when chlorine pressure low (gas drums empty)
stop of injector water	Manual; automatic when chlorine pressure low (gas drums empty) or in case of leaks	Manual; automatic when chlorine pressure low (gas drums empty) or in case of leaks
stop of chlorine flow at the chlorine drums	Manual; automatic in case of leaks; automatic in case of stop of injector	Manual; automatic in case of leaks; automatic in case of stop of injector
acoustic alarm	Automatic in case of leakage in the chlorinator room or in the chlorine storage area; low chlorine level/ high chlorine level	Automatic in case of leakage in the chlorinator room or in the chlorine storage area; low chlorine level/ high chlorine level
Continuous fans in chlorinator room	Manual; running continuously linked to the emergency power supply system	Manual; running continuously linked to the emergency power supply system
start of emergency exhaust fans in chlorinator room	Automatic in case of leakage in the chlorinator room; low chlorine level linked to the emergency power supply system	Automatic in case of leakage in the chlorinator room; low chlorine level linked to the emergency power supply system
sprinkler system storage area	Automatic in case of leakage in the chlorine storage area; high chlorine level	Automatic in case of leakage in the chlorine storage area; high chlorine level
Start chlorination	Automatic when raw water flow start	Automatic when raw water flow start

* time to drain the filter after stop of supply.

** time required to build up full flow from filters

5.9.8 Civil Works

Civil works for chlorine drum rooms shall be as described above for the Chemical House.

The laboratory shall be fully air conditioned without possibilities of opening of windows. The access to the laboratory shall be from inside the building

A separate chlorine storage room with cradles having capacity for storage of 16 (sixteen) chlorine tonner drums with adequate ventilation, neutralization pits and handling

equipment like HOT crane etc. shall be provided outside the chemical house in conformity with the provision of Explosive Department.

The chlorination chamber shall be a reinforced concrete structure. It shall be fed from the backwash reservoir/filtered water channel. The chlorine solution shall be injected by bottom mounted diffuser disks. The diffuser system and baffle walls installed in the chamber shall be designed to guide the incoming water and to ensure a complete diffusion of the chlorine solution before it leaves the chamber. The outlet of chlorine solution shall be at a depth of 2 m or more. The chlorine solution-feeding unit must be detachable for easy maintenance. There shall be no smell of chlorine at a distance of 10 m from the chamber. The minimum freeboard shall be 30 cm, but the walls shall be extended up to a height so that its top is 60 cm above the general ground level there.

All inner surfaces of the chamber shall be coated with white or light blue glazed tiles (lead free) laid in suitable cement mortar, resistive to the aggressive water. The project logo/water works logo shall be provided on the bottom of the chamber using colored tiles. A tight window with a tight shutter shall allow for the inspection. The chamber shall be equipped with an underwater floodlight to be operated with a switch near the window.

The outlet to the CWR is a wall duct with a flange (puddle collar) for the connection through pipe / channel to the CWR. The chamber shall have a stainless-steel cover, a stainless-steel ladder inside for the access and at least two stainless steel ventilation pipes DN 150 with cowls and wire mesh.

5.10 Alum / Primary Coagulant Solution Dosing

The alum / Primary coagulant dosing shall be made by dosing metering pumps. The solution tanks and dosing devices shall be installed at a level to be in a position to feed into the inlet chamber. This must be also possible in the case of repair of the dosing pipe for lime solution when both diameters are conveyed in one pipe. The diameter of the pipes in the chemical plant and to the injection points shall be a reasonable compromise between a sufficiently wide diameter to prevent clogging and a satisfactory high flow velocity to prevent deposits.

5.11 Pipes and Valves in the Dosing Plant

The pipes, fittings and valves shall be such that any of the alum / Primary coagulant tanks can be used individually with any of the metering devices. The tanks shall be filled from the process water pipe system. Each tank shall have an outlet with strainer to the dosing unit, an outlet for complete drainage and an overflow. The service outlet shall be at least 20 cm above the bottom level of the tank. The entire piping and the fittings shall be in PVC/HDPE pipe 10 kg/cm2 rating of suitable diameter. All valves for solution delivery up to the injection point and for waste water from the tank shall be rubber lined diaphragm valves.

The solution pipe between the solution tank and the dosing device as well as the pipe from the dosing device to the injection point shall be of PVC/HDPE pipe 10 kg/cm2 rating. They shall be connected to the process water circuit so that a rinsing of the pipes between the solution tank and the dosing unit and downstream the dosing unit is possible after each stop of the plant. The valves in the solution pipes shall be installed accordingly.

The overflow and washout pipe shall be connected to the drainage system leading to the recycling tanks.

5.12 Solution Pipes to the Injection Point

The solution pipes to the injection point in the inlet chamber shall be of PVC/HDPE pipe 10 kg/cm2 rating. They shall be laid on pipe racks or trays to be fixed to walls of tanks and buildings or in covered pipe channels so that they are always accessible. They shall not be exposed to direct sunlight. The chemical pipes shall be fixed and jointed in such way that individual runs can be changed without dismantling adjacent pipes. No individual pipe run shall be longer than 5 m. A bypass with valves shall be provided between the pipes for lime and alum solution so that the two diameters can be carried by one pipeline in case of repair or maintenance of the other line. The pipe diameters must correspond to the hydraulic conditions between the chemical house and the injection point.

In case of more than 30m between the dosing device and the injection point, duplicate dosing lines shall be provided. In this case, no bypass shall be provided between the pipes for alum and lime solution.

There shall be washouts at suitable points of the chemical pipelines at distances not exceeding 30 m. The pipes shall be clearly identified throughout the whole run as chemical pipe for alum by means of plates every 20 m and by the color code which is used on the display screen.

5.13 Alum / Primary Coagulant Solution Feeder

There shall be at least 4 (2 working + 2 standby) dosing metering pumps for the alum solution. They shall be connected to both the tanks such that they can be operated individually from each tank. They shall feed into the dosing line leading to the injection point. The control of the flow (outlet) shall be regulated automatically through modulation of stroke length on the basis of inflow rate and quality of raw water. It shall be possible to modulate the dose manually as well. The outlet to the dosing line shall be controlled by a solenoid valve. The inlet and the constant level shall be controlled by a float valve.

The dosing devices and their components shall be fabricated of non-corrosive materials (stainless steel, mild steel with rubber or ebonite coating, fibre glass, HDPE).

5.14 Operation & Control of Alum/ Primary Coagulant Dosing Unit

The operation of the alum/ Primary coagulant dosing unit shall be made from a wall mounted control panel installed in the Chemical room.

Operation	Activity
Filling of solution tanks	water: automatic and float controlled alum bricks: with electric hoist
Stirrers of the solution tanks	Manual Automatic at intervals according to timer settings
Outlet of the dosing device	Manual Automatic when raw water pumps stop and start
Flushing of the dosing pipes after the stop of the dosing unit	Automatic
Handling of chemicals with the hoist	Control unit suspended from the hoist; to be operated from the dosing room

5.14.1 Lime solution dosing

Lime solution dosing facilities shall be provided in the chemical plant at the upper floor opposite to the alum dosing units. The different components are similar to those of the alum dosing plant.

5.14.2 Tanks and agitators

The lime solution tanks shall be similar to those for alum solution but the tanks shall not be lined. The stirrers and the pipes and valves are similar to those of the alum solution tanks except the paddles, which shall be of MS.

5.14.3 Pipes and valves

The pipes, fittings and valves shall be similar to those used for alum. The indication and the colour code shall be different for lime.

5.14.4 Dosing device

Suitable dosing - metering device shall be provided.

5.14.5 Handling of the lime bags

The handling system to bring the lime bags from the ground floor to the troughs in the solution tanks shall be the same as that for the alum bricks. Preferably one hole shall be used and the monorail shall be provided with bends.

5.14.6 Operation and control

The operation shall be similar to the operation of the alum dosing device.

5.15 Weigh Bridges

A 30 MT electronic weigh bridge (SCADA compatible) with following features shall be provided in the chlorination room:

- Heavy load cells for long life and reliable operation.
- Rugged construction to withstand hostile conditions such as high ambient
- chlorine gas.
- Robust and Sturdy Platform.
- Bright and large LED display.
- Minimal levers and knife edges to avoid frequent maintenance
- Computerised model for effective truck management and report generation.
- on a printer.
- RS 232 port for communication
- Weighing capacity minimum 15 tons

Local digital indicator for controlling the changing/ replacement of tonners connected to the chlorine dosing manifold shall be provided. The latter shall be calibrated in a manner to indicate the net weight of the chlorine gas, without the weight of the drums and the other dead weight.

A sprinkler system shall be installed above the whole storage area. It shall cover the storage area and 1 m beyond. It shall be directly connected to the main supply pipe from the backwash water reservoir. The sprinkler system shall have a motor driven valve, which shall automatically open in case of chlorine leakage above a set limit. This valve shall be installed at a place where it can be operated also manually in case of emergency. Open drainage channels in the floor of the storage area shall be connected to the drainage system.

5.16 Laboratory and Sampling System

There shall be one Laboratory for the treatment plant suitably equipped for carrying out physical, chemical and bacteriological tests. As already stated the laboratory shall be located in the first floor of the chemical house. The layout and dimensions of the laboratory room shall be according to International Standards. Tenderers shall supply all the furniture accordingly and all the equipment as listed hereinunder. A 2000 litre capacity R.C.C./brick overhead water tank for water supply to the laboratory are to be provided. The laboratory shall have a size of not less than 15 sq.m. It shall have the equipment, storage space and chemicals for all the chemical and bacteriological routine analysis. The laboratory shall have three metre of working platforms with minimum three sinks. The sampling pipes shall end at one of the sinks. The taps shall be clearly labeled with the type & provenience of the water. At least the following equipment and all required laboratory chemicals / reagents except alum and chlorine are to be provided by the Agency within the scope of work and shall be replenished by him till the end of the O & M period.

The quality of the water entering, passing and leaving the treatment plant shall be monitored via HDPE sampling pipes DN 25 from the following points leading to the laboratory:

- raw water pipe at the inlet chamber (raw water)
- end of the filtered water channel

- outlet of the chlorination chamber (treated water)

The sampling pipes shall lead from the sampling point to small sampling pumps installed at a low area of the pipe gallery of the filters. From there, pressure pipes shall lead to the laboratory to the outlet points.

A separate pipeline shall be provided from the measuring flume for continuous monitoring of turbidity and adjustment of chemical dosing through the online turbidity meter.

A portable direct reading turbidity meter shall be provided for the measuring of the turbidity at the individual measuring points.

The provision shall be kept for two nos. (one working + one standby) online continuous turbidity meters with displays in the central control room and the laboratory of this 190 MLD WTP. Adequate digital/analogue signal shall be provided by these turbidity meters so as to control the dosing of alum / lime and poly-electrolytes

5.16.1 Sampling Table

Agency shall provide and install one sampling table with a granite top. The sampling table shall be provided with three clarity bowls to indicate the clarity of raw water, clarified water and filtered water; a stainless-steel sink; and three faucets with swan necks to give independently samples of raw water, clarified water and final filtered and chlorinated water. Individual supply line of the sampling table shall be marked distinctively as raw, clarified and filtered water. Independent electrically operated pumps shall be provided for collection of samples of raw and clarified water and the third faucet for the filtered and chlorinated water shall be connected to the proposed pressure main. In addition, three similar clarity bowls shall also be provided in the entrance hall of the annexe building at a prominent place and shall have decorative finish.

5.16.2 Laboratory Equipment

All the laboratory equipment shall be of reputed and approved make. Agency shall submit with their offer detailed specifications and catalogues of the equipment they have proposed to supply. All the equipment are to be installed in position and commissioned including supply of all accessories, stands, tables etc. The quoted rate shall be inclusive

of all such installations, supply of all accessories, stands, tables with complete air conditioning arrangements where necessary, excluding laboratory glass apparatus and chemical reagents.

i. One set of Electrical Mono-Pan balance of 100 g. capacity having sensitivity of 1/100 mg. complete with weight box and digital display.

ii. One Distilling Apparatus, electrically heated, with low water cut off and automatic shut off, 1.0 gph. complete.

iii. One Muffle furnace made of high sillimanite Muffle and sillimanite Bricks. The outer body is made of heavy gauge mild steel sheet finished in heat proof and rust proof silver ash hammer stone painting fitted with swing type hinged door with peep holes, temperature up to 1200^0C provided with excess temperature protection and accessories for direct connection to laboratory AC main 220/230 volt, single phase, 50 cycles. Size of the Muffle Chamber 6" x 6" x 12" (150 mm x 150 mm x 300 mm) or close to this size.

iv. One pH Meter of digital display type with a range 0 to 14 in 0.01 PH subdivisions. It shall be compact direct reading type with a built-in voltage stabilizer, a temperature compensator and an anti-parallax mirror. Electrode assemblies shall comprise a glass electrode, calomel reference electrode and a resistance thermometer for temperature compensation housed in an immersion type housing. Operation shall preferably be push button type and the instrument shall be suitable for operating in a temperature range of 0 to 660C - complete.

v. Two Jar Test Apparatus. Each shall be provided with six transparent glass jars, each containing a paddle mixer hanging from a long horizontal shaft through a level gear. The horizontal shaft shall be run by a variable speed motor with the provision of measuring rpm. of paddle mixer R.P.M. of paddle shall be in the range of 0-150 rpm. - complete.

vi. Two Hot Plates, operating on 230W, single phase, 50 cycles, AC, capable of adjusting at different range of 750, 1000 and 1200 watt beating elements - complete.

vii. One Magnetic Stirrer - Complete.

viii. One Dissolved Oxygen Meter - Complete with necessary electrodes.

ix. One frost free Refrigerators, 165 litres (approx) - capacity.

x. Twelve Crucible, Gooch, F 30 ml.

xi. One Water Bath with 8 nos. of hole, electrically operated SS made - complete.

xii. One thermometer general lab engraved stem - 100 to 2600c subdivision.

xiii. One Thermometer, precision - 10 to 1010 C, 1/100 subdivision.

xiv. One Interval Timer, Spring wound.

xv. One stop watch.

xvi. One Chloroscope for measurement of residual chlorine with necessary reagents - complete.

xvii. One electronic turbidity meter (nephelometric method) capable of measuring turbidity in the range of 0-2000 NTU - complete.

xviii. One spectrophotometer, specifications as per instruction of the Engineer-in-Charge along with all necessary testing kit as directed by the Engineer-in-Charge.

xix. All necessary furniture (eg. tables, drawers, sinks, tools etc.) and plumbing (eg. wash basins, water connections at different points etc.) as required in a standard laboratory.

Apart from the above instruments, the agency shall provide laboratory instruments as per the list given below. The total number shall not exceed the number given in the table.

Lab Equipment/ Instruments			
1	pH Meter (Portable) (Digital, Range 0-14pH)	Nos	2
2	Continuous Nephew Turbidity Meter (Range: 0-2000 NTU)	Nos	2
3	Portable Nephew Turbidity Meter (Range: 0-4000 NTU)	Nos	1
4	Dissolved Oxygen meter (Range: 0 - 20 mg/l)	Nos	2
5	Chlorine compactor with accessories- (0.1 to 2.0 PPm/6-8 to 8.4 p)	Set	1
6	Conductivity Meter(Portable) (1Khz/50Hz)	Nos	2
7	Jar Test Apparatus	Set	2
8	Colony counter	Nos	2
9	Binocular Microscope	Nos	1
10	Water Still (Distilled water plant - Cap. 4lits/Hr)-1.5Kw	Nos	1
11	Water Bath (serological-45x45x45 cm)- 1.5Kw	Nos	1
12	Laboratory Electric Oven (45x45x45 cm)	Nos	2
13	Autoclave Vertical-(300x500 mm)	Nos	1
14	Incubator Bacteriological Test	Nos	1
15	B.O.D. INCUBATOR - (87x57x55 cm)	Nos	1
16	Magnetic Stirrer with Hot Plate- 2Lit cap.	Set	1

17	Analytical Balance - (200 gm capacity)	Nos	1
18	Precision Balance - (60 to 360 gm capacity)	Nos	1
19	Electrically Operated Vacuum Pump (single stage with suction flask 1 lit. capacity)	Nos	1
20	Membrane Filtration Assembly	Set	1
21	Frost free Refrigerators, 165 litres (approx)	Nos	1
22	Thermometer general lab engraved stem - 10 to 260 deg C subdivision	Nos	1
23	Thermometer, precision - 10 to 1010 C, 1/100 subdivision	Nos	1
24	Interval Timer, Spring wound	Nos	1
25	Stop watch	Nos	1
26	Chloroscope for measurement of residual chlorine with necessary reagents	Nos	1
27	Spectrophotometer	Nos	1
28	Crucible, Gooch, F 30 ml.	Nos	12
29	Muffle furnace made of high sillimanite Muffle and sillimanite Bricks	Nos	1
30	Wire Basket	Nos	6

5.16.3 Specifications for Laboratory Equipment

Analytical Instruments

a) pH Meter (Digital)

pH range	0-14 pH
Milli volt range	0 to + 1999 mV.
Accuracy	0.01 pH + 1 digit
Reproducibility	0.01 pH
Temperature compensation	0 to 1000c manual or automatic
Power supply	230 V + 10% 50 HZ
Accessories	2 No. of combined electrodes, electrode stand.

b) Continuous Nephelo turbidity meter

The on-line monitoring system shall be designed for the continuous measurement of Turbidity in water.

The full-scale operating range of the system may be selected by the user from 0- 4.000 to 0-4,000 NTU or from 0-10.00 to 0-10,000 PPM (mg/l) of SiO2, and the sensing system shall be capable to operate on water streams with temperature from 0 to 50 °C.

The measured Turbidity shall be displayed on a backlit liquid crystal display on the front of the instrument. The Turbidity monitor shall be suitable for water treatment plants.

The measuring method Shall be Nephelometric.

A light source and a photocell shall be positioned with their optical axes 90° from each other. The emitted light is scattered by particles in the process and received by the photocell, in accordance to standard ISO 7027.

The assembly automatically shall deliver high pressure air to the tip of the sensor to effectively blast accumulated growth from the optical lens.

The Turbidity monitor shall be supplied with the cleaner with arrangement to provide the pressure air to the sensor.

Submersible sensors shall be designed for direct immersion in the tank or flowing stream.

A Suitable length cable shall be potted into the top section of the sensor assembly, and connect directly to the Turbidity monitor.

A separate tubing connection located at the top of the sensor assembly shall be provided for connection of a 10 mt length of plastic tubing between the sensor and the monitor.

The Turbidity sensor assembling shall be mounted to a 1" pipe using a special mounting adapter.

The 1" pipe shall be provided with a bracket assembly to attach it to the tank handrail that holds the sensor at a slight angle in the tank.

Once installed and placed into operation, the Autoclean Turbidity sensor shall provide months of reliable Turbidity measurement in almost any application.

The sensor cleaning frequency shall be user programmable, and units shall be supplied with a default cleaning frequency of once every 24 hours.

The sensor shall have facility to increase this frequency if needed for a specific application.

The installation of the Auto-Clean Turbidity system shall be quick and simple.

It shall be designed to operate with either a retro-scatter (180°) probe or an 90° probe.

The turbidity meter shall allow the user to set up measurement parameters through a user-friendly menu system displayed on the in-built 2 line alphanumeric display.

Measurements can be read directly from the display at any time or downloaded to a computer/printer through the optional RS232 output at user selectable periodic intervals.

The necessary power up arrangement shall be provided to automatically power up turbidity meter to its last settings whenever external power is available.

Specifications

Range	0.0 to 20,000NTU
Display	2 line, 16-character dot matrix alphanumeric liquid crystal display.
Display language	English standard
Parameters displayed	Turbidity (NTU) – default Relative Turbidity Reference (NTU) Relative Turbidity (Turbidity - Relative Turbidity Reference NTU)
Date/Time	default
Reading	updated every 1 second
Averaging period	0.5 second or 10 seconds nominal - user selectable
Range Steps	1 <0.1 to 20NTU 2 <1 to 200NTU 3 <10 to 2,000NTU 4 <100 to 20,000NTU
Resolution	1 0.02NTU 2 0.1NTU 3 1NTU 4 10NTU
Repeatability	2% ± digit on all ranges
Data Logging	User set for one reading every 1 to 90 seconds or minutes. All readings stored in the Notepad.
Notepad	100 readings each with time and date
Setup procedures	Menu driven, including - Calibration - Automatic Logging - Analogue output range selection - Reference Turbidity value - Setting date and time.
Setup memory	Non-volatile EEPROM
Clock	Calendar clock displays date and time. Year 2000 compliant.
Analogue Output	0 - 2 volts full scale corresponding to preset measurement range. Output impedance 600 ohms nominal.
Good Laboratory Practice	All readings as well as calibration constants are stored together with the Time and Date and can be recalled at and time

Power:	
Internal	6V NiMH rechargeable battery
External	230V AC, 50 Hz Supply (with Adapter if necessary)
Power management	Automatic power down when operating from batteries after approx. 5 minutes may be selected. Automatic power up when powered externally. Low battery indication prior to shut down.
Measurement outputs	Inbuilt LCD, analogue output and optional RS232 port
RS232 Port	The RS232 port can output readings on request or at preset intervals of time from 1 to 90 seconds or minutes. The Notepad memory can also be downloaded on request. 9600 baud rate, 8 bits, no parity, 1 stop bit, Xon/Xoff protocol
Operating temperature	0 to 50°C
Operating humidity	0 to 90% RH
Storage temperature	-10 to 60°C
Case rating	IP65

c) Portable Nephelo turbidity meter

The instrument shall be based on the principle of Tyndall effect. The meter shall be direct reading instrument between 0-5000 Turbidity in 4 ranges for accuracy.

Range	1) 0 - 1 NTU 2) 0 - 10 NTU 3) 0 - 100 NTU 4) 0 - 1000 NTU 5) 0 - 5000 NTU
Display	4 - digit Digital display
Accuracy & reproducibility	Within + 2% of FSD in 0-1 & 0 - 1000 NTU (up to 500 NTU) range, + 1 % of FSD in 0-10 and 0-100 NTU ranges.
Detector	Visible range photo cell
Power Supply	230 V AC + 10%, 50 Hz.
Accessories	a) Flat Bottom test tubes -25 mm dia - 4 Nos. b) Cell riser c) Height shield

d) Dissolved Oxygen Meter

The instrument shall be capable of DO and temperature measurement in raw and treated water.

Range : 0-20 mg/l

Temperature	:	0-60^{o} C
Resolution	:	DO - 0.1 ppm
Temp	:	0.1^{0}C
Accuracy	:	DO - +/- 0.2 ppm
Temp	:	+/- 0.2^{0}C

Temperature compensation: 0 to 50^{0}C

Sensor	:	DO - Amperometric (gold/silver)
Temp	:	RTD (PT –100)
Power	:	220 V +/- 10 %, 50 Hz AC
Dimensions	:	76 x 275 x 175 mm
Accessories	:	Operation Manual, Dust cover, stirrer etc.

e) Chlorine Comparator

Specifications:

Comparator shall have capacity to measure the residual chlorine from 0.1 to 2.0 PPM. & pH from 6-8 to 8.4 (Phenol red indicator disc) by movable disc arrangement.

Accessories:

Orthtolidine solution, test tubes, brush & cover etc. & separate movable discs, standardized for measuring Residual chlorine & pH by orthotolidine method and phenol red indicator method, respectively, shall be supplied with the Comparator.

f) Conductivity meter

Shall be a handy instrument for measuring conductivity of various solvents coupled to an amplifier –null detector with a meter used for balancing the bridge circuit.

Specifications

Bridge source	:	1 kHz / 50 Hz
Null detection	:	meter pointer
Conductivity Range	:	1 Micro-mhos to 106 Micro mhos 6 ranges.
Accuracy	:	+ 2%
Accessories	:	unbreakable PVC cell and stand with clamp
Conductivity cell	:	Approx. 1 cell constant
Power requirement	:	230 v, 50 Hz or Battery

Jar test apparatus

Jar testing machine with electrically operated 6 stainless steel paddles, equipped with suitable motor to give rotation from 10 to 100 rpm in all peddles. it shall be provided with gear system of rotation and a speedometer to not the speed. The equipment shall hold 6 glass beakers of 1 litre capacity each at a time. The arrangement of peddles shall be such that they can be lifted to remove the beakers without disturbing the test liquid.

Colony counter

Colony counter with digital display electrically operated suitable for bacterial plate count complete with counting plates and lens etc.

Binocular Microscope

Binocular Research Microscope with built in illumination with variable transformer. Two pair eye pieces 5x10 and four objectives 5x, 10x, 45x and 100x, oil (springs).

Heating Appliances

Water Still (Distilled Water Plant)

Electrically heated with boiling chamber, lid and cooling jacket, made of stainless steel, provided with two automatic ejection type heaters, constant water level device, stout wall hanging brackets, complete with plug, cord & adapter.

Power	:	220 - 230 V AC
Capacity	:	Approx. 4.0 litres per hour
Rating of elements	:	1.5 kW each

Water bath (Serologcal)

Rectangular water bath, shall be completely made of copper, heavily tinned inside and outside finished in enamel.

The cover shall be chrome plated & shall have 12 holes of 7.5 cm Dia. concentric rings (3 sizes of each hole) with lid. The water bath shall have built in constant level arrangement and fitted with Swan type ejection electric heaters.

Dimensions	40 cm x 30 cm x 9 cm
Rating	1.5 kW
Power	230 Volt A C
Accessories	2-Meter-long cord with 3 pin and adopter for power

Electric Oven

Shall be doubled walled with inner chamber of Aluminium sheets and outer body made of MS sheets. The gap shall be filled with good quality glasswool for proper insulation. space for inserting thermometer control system of the accuracy of +/-10C.

Temperature range	room temperature to 250^0C+/-1^0C
Power	220-250 V AC
Chamber size	45x45x45 cm

Autoclave

Autoclave shall be vertical type, sturdy double walled construction with boiler made of stainless steel 18SWG. Sheet & easy to operate. Outer shell shall be made of mild steel finished with enamel point. The boiler & outer shall shall have air insulation. Lid shall be made of stainless steel plate and tightened all-round by wing nuts. Moulded, Jointless gaskets shall be made of Neoprene rubber. It shall be fitted with water level arrangements to indicate water position inside the boiler, pressure gauge, Air /Steam release cock, spring loaded safety valve which can be set at any selected point from 10 psi to 25 PSI +/-3 PSI and drain. ISI marked immersion type heating element heats the water steam to desired temperature & pressure, supplied complete with SS basket, cord & plug to work in 220 volts 50 cycles AC supply.

chamber size (Dia x depth)	300 x 500 mm
Load	2 kW

Incubator 2 Nos. (For Bacteriological Tests)

Incubator made of Aluminium sheet, inner door of glass with 3 adjustable shelves with temperature control system with accuracy of +/- 0.50C. Double wall shall have proper glass wool insulation system. Thermostatically controlled.

size(WxDxH)	61x45x45 cm
operating temperature.	5^0C above ambient to 60^0C
Power	220-250 V AC

BOD Incubator

Suitable to work at 230 V with automatic control heating or cooling circuits according to environmental temperature, made of mild steel wall with enamel paint, inside chamber shall be anodized, adjustable shelves made of Aluminium and full inner view glass doors. Chamber capacity shall be 245 litres. Temperature control device German thermostat.

Chamber size	87x57x55 cm
Temperature range	5 to 50^0C
Operating Sensitivity	+/-0.5^0C

Forced air circulation to maintain uniform temperature with dial thermometer.

Magnetic Stirrer with Hot Plate

Magnetic stirrer with hot plate of 2-liter capacity with separate stirring & temperature control regulator for setting stirring rate & temperature complete with plug, 2-meter-long cord. Adapter and Teflon paddle 1" long (Rotor 3 No) cap. 2 liters, max. speed 1200 rpm.

General

Analytical Balance

Analytical Balance complete with case, weight box, and beam of gun metal. Flat beam sprayed with colorless cellulose lacquer, edges are of best selected agates ground to optical precision case finely polished with two side doors and counterpoised front slide. Case made of teak wood having sunmica base.

Capacity	200 gm
Sensitivity	1/10 mg
Diameter of pan	3 inches slightly concave Nickel Chromium plated
Length of Beam	5 inches
Watch Glasses	2 Nos. light wt. to be provided on each of the pan
Graduation	Graduated into 100 divisions with 0 in centre

Electronic Balance

Readability	1 mg/10 mg
Weighing capacity	60 gm/310 gm
Repeatability(s)	0.2 mg/0.5 mg
Linearity	+/-2 mg/+/-10 mg.
Stabilisation time	5 secs
Power supply	230 V AC +/- 10%, 50 Hz

Facility of piece counting, % weighing, display various weighing units, provision for attachment of printer.

Vacuum Pump Single Stage (With Suction Flask/Litre Capacity).

Electrically operated shall be compact and smooth in operation with effective cooling, high water vapour tolerance and guaranteed ultimate vacuum.

Air Displacement	150 litre per minute
Ultimate vacuum	10 microns Mcleod
HP of motor	0.5 or 1/3
Pump speed	375 rpm approx.
Power supply	220/230 Volt AC

Refrigerator

Minimum 300 litres capacity, of reputed make.

Notes: All the aforesaid instrument shall be supplied along with operation and circuit diagram manual, dust cover, 2 m long cord and plug & related accessories required for the satisfactory working of the instruments.

Miscellaneous

Nuts, Bolts, Studs and Washers

Nuts and bolts shall be of the best quality bright steel, machined on the shank and under the head and nut. Studs, bolts and nuts shall be electro-galvanized. Bolts shall be of accurate length so that only one thread shall show through the nut in the fully tightened conditions. Nuts and bolts shall conform to IS:1363 and IS:1367.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary.

Where there is a risk of corrosion, bolts, nuts and studs shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions. All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel bearing stainless steel.

The Agency shall supply all holding down, alignment levelling bolts complete with anchorages, nuts, washers and packing required to fix the plant to its foundations, bed plates, frames and other structural parts.

The Agency shall procure and keep at site, reasonable excess quantities to cover wastage of those materials, which shall be normally subject to waste during erection, commissioning and setting to work.

Laboratory glass apparatus and chemical reagents shall be separately collected by the purpose and supply of them does not come under the scope of this tender. Approximately 40% of the carpet area of the laboratory are to be covered by tables, fitted with necessary drawers and sinks. The height and top width of the tables shall be 900 mm. and 750 mm. respectively. All the furniture shall have a decorative finish. The furniture shall be of best quality teak wood/NUWUD of approved quality and the top of the tables

shall be acid/alkali & heat resistant and the drawer units shall be provided with SUN-MICA DECOLAM or equivalent make laminate sheets. The laboratory sinks shall be of best quality porcelain make.

5.16.4 Tool Box and Tools

Tenderers shall supply three tool boxes (overall dimensions 1200 mm x 900 mm x 750 mm) made of best quality wood/NUWUD and polished or painted as per direction of the Engineer-in-Charge. The box shall be compartmentalized inside suitable to hold different types of tools separately. The edges of the box shall be protected by aluminum angles and the box shall be fitted with lock and key arrangement. Tenderers shall supply all the tools listed in O&M section.

In addition, Tenderers shall quote separately on their own letter heads for supply of one set special tools and tackles that they feel shall be necessary for maintenance, overhaul or replacement of the electrical and mechanical equipment under this contract. The quotation shall be attached with the Schedule of Prices.

5.17 Color Code for Pipes

All visible pipes in the different units of the plant shall be painted according to a distinct color code. This color code shall also be used for the presentation of the pipes on the mimic panel.

Raw water	dark green
settled/filtered water	light green
treated potable water	light blue
backwash water	Blue
air	yellow
sludge, sludge water	Brown
Chlorine solution	Red
Alum, lime	pink

5.18 SLUDGE TREATMENT

A wastewater recovery system shall be provided to handle sludge from the clarifiers. The sludge handling system shall be designed considering 100 mg/l TSS in raw water at plant Design Net Output capacity. However, design of centrifuge decanter dewatering

machine (including feed pumps and poly dosing system) shall be based on 50 mg/l TSS in the raw water. The calculations of the total sludge production for the design of sludge treatment system shall also include the sludge produced by the coagulant at design raw water TSS and by plant waste water recycled back to the clarifiers.

The sludge treatment process shall comprise:

- clarifier sludge sump;
- thickener feed pumps
- polyelectrolyte dosing;
- continuous thickening;
- thickened sludge pump and sump;
- centrifuge feed pumps;
- polyelectrolyte addition;
- sludge dewatering in centrifuges;
- centrate
- Sludge drying

The sludge from the clarifiers shall drain into the Clarifier sludge sump. From the sludge sump, the sludge shall be pumped to the sludge thickeners, with in-line dosing of a solution of thickener polyelectrolyte to assist the thickening process.

The thickener polyelectrolyte dosing pumps shall be linked to the thickener feed pumps on a one to one basis to simplify the dosing controls. The supernatant from the thickeners shall be returned to the works inlet.

The Thickened sludge from the thickener shall be extracted in a controlled manner with the help of Thickened Sludge Pump which shall discharge the sludge into the Thickened Sludge Sump from where it shall be further pumped to centrifuges machines for dewatering.

The dewatered sludge shall be disposed of at the sludge disposal land provided by the Authority. The centrate shall be discharged to the plant drain for disposal outside the plant.

Provision shall be provided throughout the installation to clear sludge blockage without the removal of pipework sections.

5.19 Sludge Sump cum pump house

Sludge Pump House

5.19.1 General

Notwithstanding the arrangements provided for natural drainage of the plant waste water, there shall be a sludge pump house primarily meant for dealing with the clarifier sludge and in addition, when necessary, dealing with the overflow of filter waste water from the overflow weir at the time of backwashing, and wash water from the collecting well and all the units during emptying in case natural drainage is not feasible. The sludge collected in the sludge well of this pump house shall be pumped to the sludge thickener. A separate arrangement shall be provided in the sludge pump house so that is case of emergency, the accumulated sludge water shall be overflown into the surface drainage system.

The sludge collecting sump of the pump house shall have sufficient capacity not less than 150 m^3. However, the Agency shall design the sump and pump capacity required for proper treatment and disposal of sludge. There shall be 100% standby of the pumps. The pump house shall be operated remotely through SCADA control and locally.

Adequate provisions shall be made to scour sludge accumulated in the sludge pump sump by air and water jet. Water for water jetting may be obtained by pumping clear water from the clear water duct or the proposed underground reservoir. For this arrangement, at least two pumps of adequate capacity shall be provided of which one will be in operation and the other will be a standby. An extra arrangement of the clear water supply may also be made from the proposed clear water main available within 150 M. The offer shall include all piping, fixed jets valves & nozzles etc. For air, two nos. of air blowers of sufficient capacity with fixed air nozzles at the bottom of the sludge pump sump shall be provided. The agency shall design and install sufficient capacity of air blowers with 100% standby along with necessary piping arrangements and nozzles for agitating sludge at the bottom of sludge sump to keep solid particles in suspension.

Each sludge pump shall be completed with driving motors, necessary cast iron sluice and reflux valves and cast-iron piping for suction and delivery including all fittings. Agency shall include for delivery and laying sludge line up to a suitable point of the existing sludge line indicated by the Engineer-in-Charge. The connection of the sludge line with the existing one is also within the scope of this contract. The sludge delivery line of design diameter shall be of SWMS of wall thickness at least 12 mm. The outer

surface of the SWMS pipe shall be covered with 3 LPE/polyolefin coating as instructed by the Engineer-in-Charge. The arrangement of the valves etc., shall be as per direction of the Engineer-in-Charge. The impeller and the casing of the sludge pumps shall be of stainless steel or other similar metal of sufficient strength to withstand the continuous abrasion and other wear & tear for a considerable time of running.

A manually operated chain pulley block of 3 tonne capacity shall be provided for handling the pumps and motors in the pump room.

The specification for pumps and other equipment shall strictly conform to specification of equipment of these tender specifications.

The electric motors, switch gears and other electrical equipment provided in the sludge pump house shall conform strictly to specifications for electrical work given in relevant Section of these tender specifications.

The sump shall be complete with all necessary controls and a set of level electrodes to provide the necessary controls and alarms. Controls shall be provided to prohibit the desludging of a clarifier if there is insufficient storage.

5.19.2 Civil Works

The sludge pump house shall be of R.C.C. underground structure with brick panel walls in the superstructure and shall be provided with pile foundation.

The sludge sump shall be circular in shape and shall be provided with a dry pit at the centre for accommodating sludge pumps and air blowers. The diameter of the pump area shall not be less than 8 m and the volume in the annular space shall be not less than 120 m^3. The floor of the pump shall be placed at a sufficiently low level to receive the discharge of clarifier sludge coming out at the lowest level of the clarifier sludge pipe. The floor of the wet sump around the dry pit shall be given a slope not less than 1 in 12 towards the dry pit where a channel 600mm wide and 400 mm deep shall also be provided. A 2000 mm wide walkway shall be provided to give access to the pump room and R.C.C. steps 1000 mm wide shall be provided from the walkway to floor level of the dry pit. An annular platform of 1000 mm width shall be provided on the outer wall at plinth level excepting the portion over part of the steps. Steps shall be provided to give access to the walkway from ground level. Hand railing, as specified, shall be provided on the walkway platform and one side of the steps.

Adequate skylight and windows shall be provided in the sludge pump house building to admit sufficient natural light. The total shutter area of doors windows and skylights shall not be less than 25% of the plinth area. The windows and skylights shall be provided with grills of approved design. The main entrance door shall be a 1.75 m wide mild steel gear operated rolling shutter.

The roof of the pump house shall be provided with roof water proofing treatment with adequate arrangements for rain water drainage.

Hand railing, shall be of stainless steel SS 316 and walkways, access steps etc. shall be galvanized. Hand railing, shall be of stainless steel SS 316 and walkways, access steps etc. shall be galvanized. The mixer shall be provided with motor protection panel against heating, moisture, etc.

All the basic construction works and finishing works shall be carried out as per specifications of these tender specifications.

5.20 Thickener Feed Pumps

2 (1W+1S) submersible type thickener feed pumps shall be provided. The pumps shall operate at a speed not greater than 1500 rpm. The Agency shall select the rating of the pump to ensure as far as is practical the continuity of flow to the thickener installation. Duty pump shall be manually selected at the wastewater control panel. The action of selecting the duty thickener feed pump shall automatically select the corresponding duty polyelectrolyte dosing pump. The duty status shall not be accepted unless the pump and its corresponding dosing pump are both available.

The pumps shall be automatically controlled by the water level in the Clarifier Sludge Sump and shall deliver wastewater to the thickener.

An orifice plate, or equivalent device, shall be installed in the thickener feed pump delivery line. This device shall be mounted inside the pumping station and shall ensure adequate mixing of the injected polyelectrolyte within the bulk of the wastewater.

A manually operated chain pulley block and running beam shall be supplied for removal of the pumps.

5.21 Thickener Polyelectrolyte/PAC Dosing System

Thickener Polyelectrolyte/PAC solution is needed to be prepared and dosed for aiding sludge thickening. The minimum dosage of polyelectrolyte required for thickening shall be worked out by the Agency, however, for the design, it shall not be less than 5 kg dry polyelectrolyte /ton dry solids.

1 unit of Automatic Polyelectrolyte Solution Preparation system shall be provided, with capacity not be less than 6 kg dry polymer per hour.

Hand railing, shall be of stainless steel SS 316 and walkways, access steps etc. shall be galvanized. The mixer shall be provided with motor protection panel against heating, moisture, etc.

The sump shall be complete with all necessary controls and a set of level electrodes to provide the necessary controls and alarms. Controls shall be provided to prohibit the desludging of a clarifier if there is insufficient storage.

5.22 Continuous Thickener

One picket fence type continuous sludge thickener, with thickened sludge pumps shall be provided to accommodate the variable quantity of sludge and solids loads produced during the different seasons during the year. The thickener shall thicken the sludge to a average concentration of 4 % solids prior to dewatering in the centrifuges.

The sludge thickener shall have a sloping bottom and shall be fitted with a rotating sludge scraper to transfer thickened sludge to a central removal hopper.

The volume in the thickener shall provide a minimum of two hours retention time and storage for one day's sludge production at at design Net Output during the period of 100 mg/l TSS in raw water.

The thickeners shall have a full diameter fixed bridge complete with walkway for personnel access to the centre, access stairs to ground level and handrailing, a motor driven sludge scraper complete with all necessary controls, delivery pipework, a stilling well and overflow steel weir plates. Walkways, access steps etc. shall be galvanized. Handrailing shall be of SS316 material. Underwater Fastener shall be SS316 material.

The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized

for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

The electric motor, gearbox etc., shall be provided with proper shade. The fixed bridge, and the stilling chamber shall be steel coated with Polyurethane, including scrapper mechanism. Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop push button shall be provided. The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

A set of 2 No (1W + 1S) Thickened sludge pumps of fixed speed positive displacement type shall be provided. shall be fixed speed positive displacement pumps. Sludge blanket monitoring shall be provided to control the pumps in an approved manner. Each pump shall be rated to pump the volume of thickened sludge produced by thickener at plant design Net Output during the period of 100 mg/l TSS in raw water.

The Thickener supernatant shall overflow a peripheral weir into a Supernatant sump of HRT not less than 60 minutes. From there it shall be pumped to the raw water channel at the plant inlet with a set of 2 No (1W + 1S) submersible type pumps.

An electromagnetic flow meter shall be provided in the supernatant return pipe to stilling chamber. The supernatant pipework shall be arranged to ensure that the pipework in the region of the flow meter always remains full. Flows shall be indicated, totalized and recorded at the local control panel and at the central HMI.

5.23 Thickened Sludge Storage Tank

One tank shall be provided to store thickened sludge and to act as a sump for the centrifuge feed pumps. The capacity of the tank shall be sufficient to hold 12 hours thickened sludge production at plant design Net Output during the period of 100 mg/l TSS in raw water. The tank shall be fitted with continuous level measurement equipment.

A mechanical submersible mixer shall be provided in the tank, with mixing power not less than 10 w/m3, sized to maintain solids in suspension. Handrailing, shall be of stainless steel SS 316 and walkways, access steps etc. shall be galvanized. The mixer shall be provided with motor protection panel against heating, moisture, etc.

The centrifuge feed pumps shall be fixed speed positive displacement pumps. Each pump shall be rated to pump in 12 hours the volume of thickened sludge to be dewatered

by one centrifuge at a plant design Net Output during the period of 50 mg/l TSS in raw water.

5.24 Dewatering Polyelectrolyte/PAC Dosing System

Dewatering Polyelectrolyte solution is needed to be prepared and dosed for aiding sludge dewatering. The minimum dosage of polyelectrolyte/PAC required for dewatering shall be worked out by the Agency, however, for the design, it shall not be less than 5 kg dry polyelectrolyte /ton dry solids.

1 unit of Automatic Polyelectrolyte/PAC Solution Preparation system shall be provided, with capacity not be less than 6 kg dry polymer per hour.

The Volumetric dry powder feeders (SCADA compatible) shall comprise of powder hopper, screw feeder and pneumatic conveyance system mounted on a galvanized mild steel base. The dosing of polyelectrolyte/PAC shall be controlled through SCADA. The hopper shall be manufactured in 316L stainless steel and shall be fitted with high and low-level probes, anti-bridging mechanism, covers designed for ease of access and isolation valves on the hopper discharge. Screw feeders shall ensure free flowing discharge, avoid compaction and be self-cleaning. Screw feeders shall include anti-condensation heater and be variable speed motor driven. Heated pneumatic conveyance system shall comprise blower, venture educator and heated educator cone. Suction and discharge hoses shall be anti-static.

The dispersion unit shall wet the polymer dry powder and comprise dry powder connection, make-up water connection, dispersion head, solenoid valves and makeup water flow regulator. Dry powder and make-up water connections shall be an integral part of the dispersion head. The dispersion head shall provide clear sight to the operator of the wetting process, be self-cleaning and easily removable. Solenoid valves shall control make-up water supply to both dispersion head and polymer dilution.

Valves shall be controlled by level probes in the solution preparation/ageing tank. The make-up water flow regulator shall be operator set.

The solution preparation/ageing tank shall be manufactured in Plastic (LDPE/ HDPE/GRP), and include holding down points, overflow, drain, inlet and outlet connections, high and low-level probes, outlet pipe work, isolation and solenoid valves.

Agitators shall comprise rotating blades mounted on a vertical shaft coupled to the gear-box output shaft through rigid coupling and driven through a 1,500-continuous duty motor (TEFC) with IP 55 protection coupled to the gearbox by a flexible coupling. Materials of construction for the shaft shall be 316L stainless steel, code of practice IS 9522:1980 and the impeller shall be 316L stainless steel / CF8M, turbine type. The shaft length shall be as required for easy dismantling and installation. The drive unit shall be mounted on girders. The safety factor for the gear box shall be a minimum of 1.5.

A set of 2 (1W+1S) polyelectrolyte dosing pump shall be provided. Polymer dosing pumps shall be hydraulically actuated diaphragm pumps simplex or duplex type, with maximum injection pressure of 5 kg/cm2, complete with PP head, PP / PVC fittings, strainer, inbuilt PRV along with 415 V / 50 C / S suitable motor at 1,000 RPM.

The Pumps shall incorporate sensors that monitor the dosing flow and the diaphragm and provide process stability. The pumps shall be designed to have separation of hydraulics and electronics, to protected process from equipment failure.

The metering pump shall be selected as duty along with its corresponding centrifuge decanter feed pump. The dosing pump shall start and stop simultaneously with the associated duty centrifuge decanter feed pump.

5.25 Centrifuge Decanter

The design of centrifuge decanter dewatering machine shall be based on sludge production at plant design Net Output with 50 mg/l TSS in the raw water. Solid bowl centrifuges decanter shall be used for the sludge dewatering operations. There shall be 4 (2W+2S) centrifuge machines. The dewatering capacity of the centrifuge shall be based on max. 12 hours operation per day. The centrifuges shall produce a dewatered sludge cake of no less than 20% dried solids. At least 97% of the solids shall be in the dewatered cake and less than 3% of the solids shall be in the centrate.

In the event sludge production is more that the design capacity of dewatering machine, the dewatering machine shall be operated for more than 12 hours to compete the dewatering of the sludge production during the day. In the rare situation of sludge production beyond the capacity of 1 machine in 24 hours, due to increase in the TSS in the raw water especially during rainy season, all the dewatering machines may be used.

Operation of each centrifuge and its associated dedicated sludge feed pumps, polyelectrolyte dosing system, and flushing system and other plant shall be automatic once the start-up procedure has been initiated by the operator.

The polyelectrolyte and sludge feed pumps shall not start until the centrifuge has reached its full speed.

The shutdown sequence shall be a reversal of the above-mentioned procedure. After stopping the sludge and polyelectrolyte pumps, the centrifuge shall be flushed out with clean water. This shall be carried out while the centrifuge is still running. Means shall be provided to divert the flushing water to the centrate drain.

The operation of a low-level sensor in the thickened storage tank shall automatically stop the flow of sludge to the centrifuge Polyelectrolyte shall be dosed to the sludge flow via an in-line injection system and mixer designed to achieve rapid and even distribution throughout the sludge. The conditioned sludge shall be delivered into the inlet chamber of the centrifuge.

The pond depth, drum speed and differential scroll speed shall be pre-set at optimum values determined during commissioning trials. The differential scroll speed shall be operator adjustable to allow further optimization of the dewatering process.

- The dewatered sludge shall be taken to the Drying Bed for conversion to sludge cakes and later taken by a truck for disposal as fertilizers / fuel.
- The centrate from dewatering machine shall be drained to the waste water sump from which it shall be pumped to Flash Mixer as a measure of ZLD by re-cycling/re-use.

The centrifuge shall comprise the following components:

- sludge feed system;
- collecting vessel and support frame;
- variable speed drive;
- differential scroll drive;
- centrifuge washing;
- concentrate collection;
- control system.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent

vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected. Flexible connections shall be provided on the sludge fed system and the centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

5.26 Sludge Treatment and Disposal Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status and values associated with the sludge treatment systems;
- duty pump selection;
- annunciate alarms associated with the sludge treatment systems;
- all necessary controls for centrifuge installation.
- The centrifuge manufacturers proprietary control panel/s may be provided in addition to the above providing the requirements for centrifuge status and alarm annunciation is fulfilled locally and at the central HMI.

5.27 Filter Backwash Water Recovery

5.27.1 Backwash water Collection & Pumping

A Filter Backwash Water Collection Sump for holding a total volume of dirty backwash water produced during the washing of two filters, shall be provided to receive the dirty backwash from filters. A set of submersible mixers shall be provided to deliver at least 10 W/m3 mixing power to keep the sludge in suspension in the sump.

A set of four no. of pumps, two duty and two standby, shall be provided to pump out the dirty backwash water and transfer to stilling chamber. An electromagnetic flow meter shall be provided on the common discharge line to measure the flow rate and total flow returned back to the plant.

The Agency shall adequately size the pumps to ensure that filters are not queuing-up for an excessive time for backwash water sump capacity availability for the for the plant operator to complete the filter backwashing in a single shift of eight hours. However, the minimum capacity of each pump shall be such that it shall not take more than 30 minutes to evacuate the 100% of the dirty wash water produced in one filter washing.

The backwash flows shall be set using preset butterfly setting valves in series with isolation valves.

The tank shall be provided with continuous level measurement and a digital high-level alarm.

5.27.2 Backwash Water Handling Power and Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for the:

- display status associated with the backwash water handling system;
- duty pump selection;
- control mode selection;
- annunciate alarms associated with the backwash water handling systems

5.28 Administration and Control Building

The agency shall design, Detailed Engineering and construct Administrative building (G+4 with provision of G+5 foundations) in WTP compound separated by boundary wall from WTP main area and quarter compound. The built-up area of administrative building of each floor shall be 600 sq.m. The **ground floor** shall consist of SCADA control room (C3) of area 180 sq.m, reception of area 50 sq.m and building section 100 sq.m. common toilet block at ground floor of area 20 sq.m. Rest area at ground floor shall be car parking.

First floor shall have a conference room of area 100 sq.m and balance area for office of Executive Engineer (EE). EE office shall consist of EEs chamber with attached toilet and anti-chamber of area not less than 60 sq.m. It shall consist of 3 Dy. EE chambers, 6 AEE cabins and cabins for 10 supporting staff. It shall also consist of toilet block of size 25 sq.m and a store room 15 sq.m.

Second floor shall be of 2 EEs office similar to the first floor EEs office.

Third floor shall have a conference room of area 150 sq.m and balance area for office of the two Chief Engineers (CE). CE office shall consist of CEs chamber, with attached toilet and anti-chamber of area not less than 75 sq.m. and additional CEs chamber attached with toilet and anti-chamber of area not less than 65 sq.m. It shall also consist of the visitors' lobby of area 40 sq.m, toilet block of area 25 sq.m, store room of area 15 sq.m and rest of the area for supporting staff.

Fourth floor shall have an office of the two Superintending Engineers (SE). Each SE office shall consist of SEs chamber, with attached toilet and anti-chamber of area not less than 65 sq.m. Each SE office shall have Technical Assistant (TA) to SEs chamber with attached toilet of area 40 sq.m. It shall also consist of the visitor's lobby of area 40 sq.m, toilet block of area 25 sq.m, store room of area 15 sq.m and rest of the area for supporting staff. There shall be two Dy. EEs chamber, two AEEs cabins & cabins for ten supporting staff in each SEs office.

The supply and installation of office furniture is also under the scope of this tender. The detail layout plan of office shall be finalized in consultation and as per approval of EIC.

The building shall be designed as RCC framed structure resting over DMC bored RCC pile foundation. The agency shall design the building for G+5 construction but they will construct up to G+4 with a provision for pile foundation for G+5 building under this tender. Administrative building shall have lift facility for carrying capacity of 15 persons and shall have two staircases, one main and other for emergency exit. The height of each floor shall not be less than 4.0 m. In the Administrative building, the agency shall provide false ceiling, air conditioning, firefighting.

The roof terrace shall be accessible through main and emergency staircase. The machine room and stair head room shall be minimum 2.7 m height. All windows shall be of anodized aluminum window of approved shade with 4 mm glass.

The finishing of the building shall be as per specification given in this bid document.

Supply of office furniture in all water supply installations as per approval of EIC is under the scope of this tender.

5.29 Electric Substation

The agency shall construct two substations with area of 607.50 sq.m and 649.25 sq.m at Intake well and WTP premises respectively. The substation building shall consist of operator room including SCADA, battery room, switch gear room, toilet block. The height of the building shall be minimum 4.0 m.

The floor level of the substation building at Intake well shall be at the same level of pump floor level of Intake pump house. The substation building shall be of RCC framed structure resting on DMC bored RCC pile foundation. The flooring of substation building shall be of Kota stone. Finishing of the building shall be as per specification given in this bid document.

The floor level of the substation building at WTP shall be 0.5 m above FGL. The substation building shall be of RCC framed structure resting on DMC bored RCC pile foundation. The flooring of substation building shall be of Kota stone. Finishing of the building shall be as per specification given in this bid document.

5.30 Staff Quarter

Two No staff quarter (G+4) building with lift (5 persons) each having 8 No quarters, one for Group C employee and one for Group A&B employees. The built-up area of group C employee shall be of 100 sq.m and for group A&B shall be of 120 sq.m.

The floor level of the staff quarter building at WTP shall be 0.5 m above FGL. The staff quarter building shall be of RCC framed structure resting on DMC bored RCC pile foundation. Each quarter shall have two bedrooms, one attached toilet and one common toilet, kitchen, drawing cum dining, balcony. The Agency shall submit detailed plan for approval to EIC. Finishing of the building shall be as per specification given in this bid document.

5.31 Transformer Yard

The agency shall construct two transformer yards of built-up area 160 sq.m and 200 sq.m at Intake well and WTP premises respectively. The transformer yard at Intake well will be at same level 0.5 m above the substation floor level. The floor level of the transformer yard at WTP shall be 1.0 m above FGL.

The details of the yard shall be finalized at the time of Detailed Engineering in consultation with EIC.

5.32 Chief Engineer Bungalow

The agency shall design, Detailed Engineering, construct (G+1 storied) bungalow for Chief Engineer of built-up area of 150 sq.m in each floor with boundary wall, gate, internal lighting, storm water drainage, internal roads etc. The building shall be of RCC with M20 grade framed structure 250 mm thick brick fill wall. At ground floor, there shall be a covered car parking facility, servant quarter, kitchen, hall, toilet. The rise and thread shall be of 150 mm and 250 mm. The height of the room shall be minimum 3.3 m. At first floor, there shall be three bed rooms with attached washroom, lobby. There shall be a staircase up to the roof. The finishing work of the building shall be of premium quality. The agency shall provide false ceiling in all rooms and halls.

5.33 Plant Superintendent Bungalow

The agency shall design, Detailed Engineering, construct (G+1 storied) bungalow for Plant superintendent of built-up area of 120 sq.m in each floor with boundary wall, gate, internal lighting, storm water drainage, internal roads etc. The building shall be of RCC with M20 grade framed structure 250 mm thick brick fill wall. At ground floor, there shall be a covered car parking facility, servant quarter, kitchen, hall, toilet. There shall be a staircase up to the roof. The rise and thread shall be of 150 mm and 250 mm. The height of the room shall be minimum 3.3 m. At first floor, there shall be three bed rooms with attached washroom, lobby. The finishing work of the building shall be of premium quality. The agency shall provide false ceiling in all rooms and halls.

5.34 Miscellaneous

a) Cable glands and lugs

All cable glands shall be made from brass and shall be of double compression type.

All cable lugs shall be of tinned copper, crimping type.

b) Cable trays

Cable carrier system shall comprise of site fabricated ladder type cable trays made from structural steel and painted duly with two coats of red oxide and a final coat of enamel

paint. The construction of the cable trays shall be as per the site requirement and generally in line with the drawing enclosed.

c) Civil works

All civil / structural works, required for electrical installation is included in the Agency scope. However, some of the major items are listed below

- Foundations for Lighting Masts / poles.
- Road Crossings by RCC Pipes
- Excavation, cable protection tiles, sand filling, back filling etc. for directly
- buried cables and earthing conductors.
- Any other minor civil works required such as making openings in wall, floor etc.
- Built up trenches for indoor cabling.

All openings made by the Agency for laying of conduit / cable / earthing strip etc. shall be made good at no extra cost.

d) Local PB Stations

a) Construction	Outdoor type weatherproofs
b) Push Buttons	On, Off

Instrumentation and Control Systems

The requirements of the Instrumentation, Automation and Control for the Treatment Plant are stipulated in separate chapter. The requirement of works and their specifications shall be in accordance to the stipulations in the Chapter.

Signal and Control Cables

All digital signal cables, control cables and 240V AC power supply cables shall be of 1.5 sq.mm. solid copper conductor, single or multi core, armored type (CYWY) of 650/1100V grade.

All analog signal cables shall be of 1.5 sq.mm. stranded copper conductor, single or multi twisted pairs, screened type.

All instrumentation cables viz. power, digital signal and analog signal shall be laid in GI conduit. The cross- sectional area of the conduit shall be minimum 2.5 to 3 times the cross-sectional area of cables to laid through.

Minimum clearance of 300 mm shall be kept between signal cables and electrical power cables when running parallel. Crossing or overlaying of the cables shall be avoided.

Sharp bends or zig zag laying of the cables shall be avoided at all the places. All signal cables shall have shield earthing at control panel end only.

Double compression type brass cable glands shall be provided for all the cables while terminating at instrument, junction box and control panel.

Wherever there are cable trays, they shall be provided with proper supports and cables shall. be clamped in the trays properly and no cable shall be kept loose or hanging.

Junction Box (JB)

Weather proof junction boxes shall be provided for all signal. and control cables wherever required. All junction boxes shall be mounted properly and shall have chrome plated rail mounting type terminal block arrangement. Wherever possible use of instrument power supply junction boxes as well as signal junction boxes shall be made to enable use of multicore as well as multipair cables respectively between the control panel to JBS. From JB onward the individual cables to field equipment shall be laid through flexible GI conduit. The general arrangement of power supply JB and signal JB shall be like the sketch enclosed. Minimum 3 circuits in case of power JB and 20% terminals in case of power shall be provided for future use, if required.

All junction boxes shall be of weather proof type (IP65) as per IS:2147.

Filter Operating Consoles:

It shall be a Panel mounted with instrumentation elaborated in the section on Filter Beds. All instruments shall be of flush mounting. It shall be constructed in MS Sheet of minimum 2 mm thickness painted with Epoxy Paint of approved color. The panel shall have instruments mounted for viewing and operation at an appropriate level. The Panel shall have no sharp edges and the drawing of same shall be got approved from PHED before manufacture.

Local control panels

Local control panels wherever required shall be provided standard vertical or slanted panel type only depending upon the number of components viz. control switches, indicating lamps, metres etc.

Sheet of local panel shall be of MS and thickness not less than 2 mm.

Local control panel after having the pre-painting treatment and two coats of red oxide, shall be painted with final paint shed of 631 as per IS:5. The control panel shall have bottom entry for cables, hinged type lockable door arrangement and easy access for

wiring. Mounting arrangement for the control panel shall be suitable for the application and location and easily accessible for the operator.

Site Calibration

All field instruments shall be calibrated at site under supervision of supplier's Engineer. Standard calibration procedures shall be followed for calibration. All reference equipment such as pressure gauges, scales etc. shall be certified from authorized / approved agency. All such certification shall be in the scope of Agency.

For all instruments, standard calibration documentation shall be prepared at the time of calibration.

All Calibration and recalibration shall be performed in the presence of the Engineer-in-Charge or his representative till handing over of the plant shall be done by the Agency.

Loop Drawings

Loop drawings shall be prepared for all control loops and field instruments. Any change in the loop drawings at the time of installation as per requirement at site shall be documented and approved by the Engineer-in-Charge before execution.

Checks and Loop Checking

Cable continuity shall be checked before cable laying and after cable termination for all the instruments. Loop checking shall be conducted for all the analogue and digital loops before system testing. Any damage or fault shall be immediately located and rectified. All the instruments and control panel shall be isolated from the power supply while cable laying and termination. Each instrument shall be checked for its functions before putting them into operation. All control loops shall be checked in manual mode first and then they shall be put in to the auto loops. All instruments shall be provided with proper earthing.

5.35 Documentation

Agency shall provide following set of documents and drawings

i. Instrumentation Schedule
ii. Instrument schedule
iii. Instrumentation Cable schedule
iv. Loop drawings
v. Technical Parameters for each instrument (Data Sheet)

vi. Control panel drawings (GA Drawing & Control room layout) and control panel wiring
vii. P&I Diagram for Water Treatment Plant
viii. Equipment layout and plant layout indicating location of each instrument
ix. Calibration and test reports for each instrument (shop and site)
x. Pre-commissioning check list for equipment and instruments

5.36 Civil Works

5.36.1 General

The civil works shall be carried out as per specifications defined in Chapter of "Specifications for Civil Works" in accordance with the Indian Standard. In case of any variation between the specifications, the specifications given in document shall prevail.

The Agency shall use sulphate resistant cement for all RCC works below ground level. The main building and the chemical house shall be designed as a RCC framed structure. All masonry shall be either in stone or bricks of class designation 100 in 1:4 cement sand mortar. For all masonry walls RR or CR stone masonry in mud mortar thickness not less than 60 cm shall be provided in place of PCC at km-4 head works. Above the mud mortar layers, the RR/CR masonry shall be provided with a DPC course at plinth level.

The thickness of the external walls and load bearing walls shall not be less than 30 cm for stone masonry and 25 cm for finished brick masonry. The partition walls shall not be less than half brick thickness.

The general requirement of material, specifications, sampling of materials, standards to be followed & testing criteria shall be as per provisions laid down in the Section of "Technical Specifications for Civil Works".

5.36.2 Doors & Windows:

As a general guideline, the total area of doors and windows shall be not less than about 25 % of the floor area. Doors to the pump and compressor room and to the chemical storage room shall be of the rolling shutter type with manual operation from inside. They shall be 4 m wide and 3.5 m high so that a truck can enter, (backside first). A standard door shall be provided for entry of the operators. Doors in dangerous areas

(chemical house, main distribution panel room) shall open to the outside. The chlorinator room shall have two doors.

All outer doors and those of dangerous areas shall have a self-closing device.

The types and locations of the doors and windows shall be approved by the Engineer-in-Charge.

All the external walls shall have aluminum section glazed window as per specification provided in Chapter of specifications of civil works. The other walls may have steel glazed windows shutters of standard rolled steel section joints mired and welded with steel lugs 13 * 3 mm, 10 cm, long with fixed wire gauge of 14 mesh * 24 gauge to the metal frame of rolled section by metal beading 20 * 3 with suitable screw at not exceeding 150 mm distance and square bars or other flat welded, embedded in cement concrete block 15 *10* 10 cm of 1:3:6 (1 cement :3 coarse sand :6 graded stone aggregate 20 mm nominal size) or with wooden plugs and screws or with fixing clips or with bolts and nuts as required including providing and fixing of plain glass panes 4 mm thick with glazing clips and special metal sash putty of approved make or metal beading with screws complete including priming coat of approved steel primer, partly fixed and partly openable [Fixed area not to exceed 33%].

5.36.4 Sanitation Facilities:

A lavatory shall be provided near the laboratory and control room. It shall have an area of about 5.00 sq.m. It shall be equipped with Indian type water closet, urinal, flushing cistern for WC, wash basin, mirror, toilet shelf etc. The disposal (in septic tank soak pit etc.) shall be made at least 15m away from the main building. The disposal system is part of the contract.

5.36.5 Walkways and Access Stairs

Unless otherwise specified all individual units shall have concrete walkways of a width of 1.0 m surrounding it. The walkways shall have railings of 1.0 m of stainless steel tubes of diameter 32 (pillars and upper railing) and 25 mm (lower railing). The walkways shall be accessible from the upper floor of the control building and by means of 1m wide stairs at suitable places (filters, mixing chamber). Walkways shall link the following units:

5.36.6 Internal water supply

The water supply of the whole treatment plant shall have two circuits:

a) Process water

The agency shall make necessary arrangements for process water supply by providing pumps at suitable location in filter house. The pump shall draw water from filter water channel.

- preparation of the chemical solutions
- injectors of the chlorinators
- sprinkler system in the chlorine drum storage area
- supply points for desert coolers and cooling system
- flush toilets

b) Drinking water

The Agency shall provide the drinking water facilities with cooler within the campus in all buildings in all floors.

5.36.7 Finishing

a. Painting of metallic surfaces

If not otherwise stated metallic surfaces shall receive one initial coat in the manufacturer's workshop. After arrival of the equipment on site, the same shall be inspected and damaged portions shall be cleaned and given the primer and under coat of similar paint. After erection, all metal work shall be painted as follows:

Painting of metallic surfaces

All mild steel railing, mild steel ladders, pipes for water supply, grit iron plates	Galvanization, chromate primer, and two coats of approved oil paints, finishing coat of approved oil based paint of approved shades.
Submerged metallic parts and their projections above water level	Two coats of bituminous paint

Metal parts above water level or in dry places	Primer of red oxide, two under coats and one finishing coat of an approved oil based paint and of approved shades
All indoor fixtures, instruments and similar equipment on panels etc	Chromium or copper nickel plating

Coating of the pipes and the plant equipment is to be provided according to the specifications and following the color code.

b. Final Finishing:

The Agency shall ensure that the entire building along with all its installations are in a finished and in new and fully operative condition when handed over. He shall have repaired and remove all signs of damage that might have been done during installation and fixing of equipment. He shall also see that the entire exterior has been finished properly and the entire site is cleared of all extra construction material, debris and excavated soil. This shall have to be done to the satisfaction of the Engineer-in-Charge.

5.37 Miscellaneous Requirements

Name Plates, Signboards, Nomenclature

Each item of the plant shall have permanently attached to it in a conspicuous position a name plate, on which shall be engraved or stamped the manufacturer's name, type and serial number, manufacturing year, details of the design capacity etc. Such labels shall be of non-hygroscopic material to be approved by the Engineer-in-Charge- in -Charge. Near or on each item of the plant a plate with the name and nomenclature (code) of the item according to the project nomenclature shall be fixed. It shall be visible from a distance of several metres.

The Agency shall also provide bilingual signboards and instruction tables of durable material throughout the plant for the purposes of operation, maintenance and security:

- Danger and caution signs (English and local language)
- Preventive maintenance schedules (local language)
- Operation instructions (local language)
- Unit names (English and local language)
- Name plates at the doors to the units (English and local language)

Signboards and plates shall be appropriately sized in relation to the relevant item and its surroundings. Details of the proposed inscription, size, material and colors shall be

submitted to the Engineer-in-Charge for approval before any tables are manufactured. They shall be compatible with the instructions in the operation manual.

All cables shall be provided with clip-on identification numbers on both ends and at all terminations in between, for identification. The nomenclature shall correspond to the electrical as-built drawings.

5.38 Ancillary Works

The Ancillary Works in connection to the Water Treatment Plant are as follows:

i) Raw Water Supply

ii) Roads Inside the Plant Boundary

iii) Electric Supply

iv) Drainage System of Plant

v) Area Drainage System

vi) Treated water outlet up to filter water reservoir.

vii) Building work.

Raw water supply connection has been elaborated in the specification

1. Roads

Plant internal roads as required shall be provided. Minimum road width shall be 6 m & 4 m with 1 m wide shellers on both sides of the road. Adequate provision shall be made for Guard Rails, retaining walls, cross drainage structures and Crash Barriers based on the site requirements. The schematic arrangement of the minimum length of proposed road is shown. Actual road arrangement shall be decided by Engineer-in-Charge during Detailed Engineering.

6 Semi Underground Reservoir

The specification is given in Chapter on General Requirements, para under SUGR.

7 Clear water Pump house

The specification is given in Chapter on General Requirements, para under CWPS.

8 Cushion Tanks (Elevated Service Reservoirs)

The agency shall design, detail engineering and construct ELSRs with unique aesthetic view. The ELSR shall have unique architectural design with decorative artefacts outside camouflaged with surroundings which gives a pleasant look and resembles a signature structure of the Amaravati capital city. The ELSR with complete architectural design shall be prepared and submitted along with 3D view to the Authority for appreciation/modification and approval from the Engineer in charge.

All the RCC Water Retaining structures shall be designed as per IS: 3370 -2009.

The concrete grade for the water retaining members shall be M30. The steel used for reinforcement shall be Corrosion resistance high yield strength deformed bars confirming to IS: 1786 (with latest revision).

i. Capacity of the reservoir shall be the volume of water stored between the full supply level and the invert of the outlet pipe. Due allowance shall be made for any dome or obstructive structure inside the reservoir and floor, while calculating the net capacity of the reservoir.
ii. Free board shall be minimum 500 mm.
iii. Design shall be based on accepted norms and methods of design and the provision contained in the latest versions of IS: 456, IS:3370, IS:1893, IS:875 and all other relevant codes etc.
iv. Grade of RC concrete: RCC M-30
v. The design calculations and drawing shall be worked out in either metric or in S.I. unit.
vi. The water retaining component/ member including member subject to condensation like Roof Slab shall be designed as un-cracked section with M-30 grade concrete.
vii. Foundation of the structures should be with Pile foundations
viii. For access into the overhead tank there shall be RCC stair case with RCC landings at suitable intervals. The width of the stair and landing shall not be less than 800 mm. The stairs shall be provided with SS railings of approved design for a minimum height at 800 mm with two rows of horizontal runners at each side holding the vertical posts. Inlet & outlet pipe shall be as per pump motor & field requirement. Overflow pipe dia shall be more than inlet dia. 150mm dia wash out pipe shall be provided. Each pipeline shall be provided with required puddle collars,

expansion joint, duck foot bend, DI/DF valves, valve chambers etc., as required for completeness. The limit of contract of each pipeline for Tank is up to foundation trench from outer face of staging shaft/column.

ix. The roof of the overhead tank shall be provided with hand rail at the edges by means of Stainless Steel posts and railings for a minimum height of 800 mm with two rows of horizontal runners holding the vertical posts.

x. The overhead tank shall be provided with suitable ventilation arrangement at the roof. The openings of the ventilators shall be protected with mosquito proof wire net of SS wire net of SS wire mesh.

xi. One lightening arrestor shall be provided on the roof of the elevated tank as per IS: 2309. The same shall be suitable earthed with aluminium tape conductor as per I.S. specifications.

xii. Reservoir Management System (RMS) shall be provided at the inlet of ELSR and Bypass management system (BMS) shall be provided with in the WDC compound at suitable location.

xiii. There shall be one electromagnetic flow meter within the WDC compound at suitable location.

xiv. Two Nos. of S.S lockable hinge type manhole covers of minimum 600mm dia. with frame shall be provided on the roof of the elevated reservoir.

9 Clear water pipelines

The specification for all pipeline under this package is given [redacted]

10 SURGE PROTECTION DEVICES

10.1 Surge Analysis

The Agency shall undertake surge analysis to determine the extent of surge pressures or other adverse hydraulic conditions that may occur during the operation of rising mains.

The Agency shall undertake the following tasks as an integral part of the surge analysis for each system:

- Construct a mathematical model of the system using internationally recognized transient simulation computer software. The network model shall be as detailed as

possible incorporating high and low elevation points along the pipeline and detailed piping manifold in pump station area.

- List all the steady state scenarios under which the system will operate;
- List, with reasons, the most adverse surge conditions under which the system will operate;
- Determine maximum and minimum surge pressures along the system that can occur due to system operation with and without cavitation conditions. The case with cavitation conditions must capture high and low surge pressures by simultaneously limiting low pressures to vapor pressure at all nodes considered in the mathematical model.
- Add surge protection system to the network model and determine the maximum and minimum surge pressures for the most adverse surge conditions. The network model used for studying the effectiveness of surge protection system shall also include all air venting valves, though they are not normally considered as part of the surge protection system.
- Verify the adequacy of the surge protection system for other important operating scenarios such as new pipe roughness condition, power failure during single pump operation, and pump start up conditions.
- The surge simulations must be carried out for at least 10 times 2L/c value where L is the total length (m) of the pipeline and c is the average celerity (wave speed) in m/s. Results presented shall indicate the total simulation time, e.g., pressure variation graph w.r.t. time at some specific locations along the pipeline.
- Computational time shall be at a minimum of 0.005 seconds to capture all the pressure spikes arising from air valve slam conditions, NRV Slam Conditions and any other rapidly varying slam pressures. The report generated by the surge analysis software shall be attached to demonstrate the use of all small computational time steps.
- Surge Protection System shall be suitable for the Thickness of Pipeline used for the Project. Thickness of the pipeline must be capable of withstanding both highest and lowest negative pressures in accordance with the appropriate Indian or AWWA standards.

- Prepare a Surge Analysis Report providing full details of tasks as mentioned above, including sufficient data sheets, figures, and analysis output etc. from the transient simulation computer software to allow the vetting authority to undertake a detailed review of the Surge Analysis Report.

The Report shall be Vetted by Competent Authority such as any NIT/any IIT/IISC Bangalore and if they suggest additional simulations and/or changes to the protection methods, the Agency shall incorporate all the necessary changes as agreed mutually by client and Agency and resubmit the report.

Surge protection system shall comprise of bladder vessels only or along with any or all of the following equipment depending on the recommendation of surge analysis to prevent the positive and negative surges in the pipeline.

Surge protection system comprises of bladder vessel and surge suppression valve must be in working condition for projects in India.

The work done certificate shall be signed by an officer not below the rank of Executive Engineer-in-Charge of the concerned division and in case of Sub Contract the Certificate shall be counter signed by the Engineer-in-Charge of the Concerned Division.

Surge Monitoring System comprises of Data Logger, Pressure Transmitter to be supplied to enable to study the surge effect**.**

10.2 TECHNICAL SPECIFICATIONS OF SURGE PROETECTION EQUIPMENT

Supplying erecting commissioning of Three Stage Surge Suppression Valve operation:

The Valve shall be able to take high air intake capacity and Discharge the Air in Controlled Way by predesigned Small Orifice to allow the re-joining of columns slowly.

SPECIFICATION:

- **Air Intake**:

The Valves shall offer very high air intake capacity with nominal orifice size for ex. 6" valve shall have a large orifice of 6" along with better aerodynamic design to reduce the obstruction of air flow through the valve.

- **Sealing:**

The models shall be equipped with a two-stage sealing, a soft EPDM seal and Bronze seat. As float approaches the orifice it meets first the rubber seal and as pressure increases the seal is pushed and the float seats on the Bronze seat. This ensures low minimum sealing pressure of 2 meters and long-life maintenance and leakage free operation.

- **Float design:**

Floats shall be made of polycarbonate, and shall be tested for 100 bar bursting pressure for all pressure ratings of the valves. The float design shall offer long term maintenance free operation and resistance against drowning effect of float against orifice. The float design and the air valve body design shall offer better protection against pre-mature closing of the valve. The spherical hollow design of the float will offer less resistance which leads to high flow capacities and also avoids accumulation of debris.

- **Air discharge and surge suppression**:

The Surge Suppression Disc shall be used in Surge Suppression Air Valve. The following parameters are emphasized for the purpose of simulation:

Air Intake Orifice:

Both the models offer nominal size of orifice for ex. 6" valve has a large orifice of 6" offering very high intake capacity due to less frictional losses.

Air Outlet Orifice (Surge Suppression orifice):

Manufacturer shall develop standard Surge Suppression orifice sizes for each size for Customization of specific requirement as per the hydraulic analysis.

- **Switching pressure:**

This denotes differential pressure required to switch from large orifice to Surge Suppression orifice during air release. **The Valve Shall have Surge Suppression Disc operating from a differential pressure less than 2 KPA (20cm) of water column.**

Technical Specification for ARI surge suppression High Flow Combination Air Release Valve Material of Construction

• Body & Cover	:	Ductile Iron ASTM A 536/EN 1563
• Float (Kinetic)	:	Polycarbonate/Polypropylene
• Float (Automatic)	:	Polypropylene
• Seal	:	Rubber E.P.D.M.

- O-Ring : Buna-N
- Bolt and Nut : Galvanized Steel
- Working Pressure : 16 Kg/cm^2

Design, manufacture, Supply, erection, commissioning & Testing at site and supply of Bladder type air vessels

The surge tank shall be vertical, Bladder type vessel suitable for use of with water. The tank, supports & anchor bolts shall be designed & with stand confirm to Indian / international standards.

Surge Tank

The surge tank shall be vertical, bladder type vessel suitable for use with raw Water. Nitrogen shall be used to avoid the corrosion. Nitrogen pressure shall measure and communicated to SCADA. Each Surge tank weight shall be measured through weighting sensor installed at surge tank leg and the same signal shall be transferred to SCADA

Tank Sizing.

Surge Tank Design and Materials

1. Materials for the tank, design, and shop fabrication and inspection shall comply with pressure equipment standards (IS/ASME/BS 5500/CODAP)
2. Minimum design pressure shall be as stated in this section of the Specifications, Perform hydrostatic testing in shop. Test pressure shall be 150% of the design pressure of the tank.
3. Provide a ½ inch threaded connection at the top of the tank to contain a gas charging valve and pressure gauge. Tank shell will be constructed of deep drawn carbon steel double welded domes and side shells with double welded seams. Tank shall be equipped with a heavy-duty butyl rubber bladder. The Precharge pressure will be located between the shell of the tank and the bladder. The side manhole shall be removable to allow inspection and maintenance of the bladder. The bladder shall be sized to conform to the inner shape of the vessel. Bladder surge tank shall be of the vertical configuration.

Bladder tank shall be equipped with a Hydro Control Level Gauge Equipment with Output 4/20MA.

Bladder Manufacturing

Service Conditions

Surge tank hydraulic performance conditions and design data shall be as shown below.

Minimum Capacity: As per Scope of work mentioned elsewhere in the bid document

Minimum Design Pressure: 16 Bar

Minimum Test pressure: 1.5 times of * test pressure

Tank Installation

The surge tank shall be installed in accordance with the manufacturers/Suppliers suggested procedures. All supports, piping, valves, and related appurtenances shall be provided and installed by the Agency at no additional cost to the Owner. Surge tank connected through flexible or expansion joint.

Painting and Coating

All painting and coating shall be completed at the factory. Field painting and coating will not be accepted. The tank interior shall be painted with anti-corrosion epoxy paint with a uniform layer thickness of no less than 100 microns, the tank exterior shall be painted with 3 coat zinc based epoxy to a minimum thickness of 406 microns.

MATERIAL SPECIFICATIONS FOR BLADDER TYPE SURGE VESSEL

SHELL	:	Carbon Steel SA 516 Gr 70/Equivalent
ELLIPTIC CAP	:	Carbon Steel SA 516 Gr 70/ Equivalent
BLADDER	:	BUTYL
COATING INSIDE	:	Sand Blasting SA 2.5
		1 Coat Food Epoxy Thickness of 200 micron
COATING OUTSIDE	:	Sand Blasting SA 2.5
		Zinc Epoxy Dressing
		Lacquer RAL 2002
		Total thickness 406 microns
LIFTING PAD	:	Carbon Steel SA 516 Gr 70/ Equivalent

OUTLET	:	Carbon Steel SA 516 Gr 70/ Equivalent
DESIGN TEMP.	:	60^0C
POSITION	:	Vertical
LOAD CELL	:	Hydro Control Level Gauge Equipment with output 4/20 MA

Supplying, erecting and commissioning of Pressure Relief Valve Specification:

Valve shall be able to relieve the excess pressure than the set pressure.

The Valve Shall be with Rapid-action piston for Fast Opening/Closing action to facilitate stable and accurate control of pressure.

Valve shall have Low head loss at high flow rates,

Valve shall be strong, lightweight and corrosion proof surfaces, which resist cavitation damage, thus increasing service life and reducing operation & maintenance cost.

Valve shall have Linear flow, Low turbulence to minimize cavitation, and allow high flow velocities with low noise and vibration.

Valve shall have "Soft closure" feature to prevent water hammer.

Multi-Valve modular configuration Full redundancy enabled. Individual valves can be possible to separately removed for maintenance or replacement which reduces down-time and maintenance costs & allows maintenance work to be done without halting water flow.

MATERIAL OF CONSTRUCTION:

Valve Body	:	Reinforced fiberglass nylon or Polypropylene

Pistons, Bushing, Front and Rear Cups: Reinforced fiberglass nylon or Polypropylene

Main seal	:	NBR, VITON or EPDM rubber, Shore index: 80
O-rings	:	NBR or EPDM rubber, Shore index: 70
Clamps, bolts	:	Stainless steel

Multi-Valve manifolds: Spheroid iron with polyester or epoxy coating/Coated Steel

Pressure Rating	:	PN 16

Inspection and Testing of all equipment will be done as per the approved Quality Assurance Plan from Engineer-in-Charge.

11 Site development

The agency shall develop all the sites for installation of water supply infrastructure as per specification given hereunder. Existing GL and FGL of different sites are given in table below:

WDC No	Description of WS infrastructure	Location (LPS village)	Area	Existing Ground Level	Finished Ground Level	Remarks
1	Cushion Tank	Penumaka	6737.50	19.94	20.21	
2	Cushion Tank	Undavalli	9071.93	18.69	20.88	2 & 3 in one campus
3	Cushion Tank	Undavalli		18.69	20.88	
4	Cushion Tank		5305.55	19.42	21.80	
5	Cushion Tank	Venkatapalem	5485.81	19.69	21.57	
6	Cushion Tank	Venkatapalem	5013.45	19.77	20.44	
7	Cushion Tank	Mandadam	3834.53	21.63	21.60	
8	Cushion Tank	Mandadam	5355.49	19.88	21.36	
9	Tapping point to startup area					
10	Cushion Tank		11091.23	20.45	21.42	10 & 12 in one campus
11	Cushion Tank	Lingayapalem	7103.33	20.67	21.81	
12	Cushion Tank			20.45	21.39	10 & 12 in one campus
13	Cushion Tank		2355.55	21.54	22.06	
14	Cushion Tank	Rayapudi	3300.00	21.77	22.81	
15	Cushion Tank	Borupalem	4800.00	22.23	24.35	
16	Cushion Tank		4800.00	22.63	23.18	
17	Cushion Tank	Borupalem	5184.15	23.14	26.50	
18	SUGR		5055.50	33.50	33.50	
19	Cushion Tank	Abbarajupalem	5209.75	23.01	23.71	
20	Cushion Tank	Rayapudi	6095.50	22.22	22.86	
21	Cushion Tank		5929.00	24.25	25.03	
22	Cushion Tank	Thulluru	10268.61	29.50	30.50	22 & 24 in one campus
23	SUGR	Ananthavaram	5234.72	40.50	41.00	
24	SUGR	Thulluru		29.50	30.50	22 & 24 in one campus

25	Cushion Tank	Thulluru	6120.00	25.77	26.36	
26	Cushion Tank	Nelapadu	3925.62	22.29	23.21	
27	Cushion Tank		6132.84	20.47	22.13	
28	Cushion Tank	Velagapudi	5398.00	20.96	21.12	
29	Cushion Tank	Mandadam	6339.15	20.02	21.00	
30	Cushion Tank		7218.01	19.71	20.62	
31	Cushion Tank	Yerrabalem	6303.00	18.86	19.51	
32	Cushion Tank		5044.46	19.09	19.82	
33	Cushion Tank	Venkatapalem	5089.66	19.11	19.41	
34	Cushion Tank		5400.00	19.21	19.55	
35	Cushion Tank	Mandadam	3806.21	19.54	21.12	
36	Cushion Tank	Mandadam	6417.09	19.89	21.20	
37	Cushion Tank		4181.25	20.72	20.65	
38	Cushion Tank		6003.32	20.37	21.22	
39	Cushion Tank		7034.93	22.45	23.14	
40	Cushion Tank	Shakamuru	4344.89	23.40	23.90	
41	Cushion Tank		5702.26	26.55	27.50	
42	SUGR	Nekkallu	3825.99	33.00	33.50	
43	SUGR	Ananthavaram	6670.42	39.00	39.50	
44	SUGR		5930.88	40.00	41.00	
45	SUGR		5948.35	32.00	32.50	
46	SUGR	Nekkallu	6217.54	31.50	32.00	
47	Cushion Tank	Nekkallu	4726.35	26.09	27.27	
48	Cushion Tank	Kuragallu	7567.23	22.19	22.69	
49	Cushion Tank	Yerrabalem	4457.74	18.36	19.30	
50	Cushion Tank	Navuluru	4911.86	22.32	22.91	
51	Cushion Tank		5360.20	28.28	28.20	
52	Cushion Tank	Navuluru	6362.50	18.71	19.50	
53	Cushion Tank	Kuragallu	8789.37	18.63	19.25	
54	Cushion Tank		7274.40	19.52	20.24	
55	Cushion Tank	Nidamarru	6595.06	22.99	24.50	
56	Cushion Tank		8140.67	21.20	22.13	
57	Cushion Tank		5679.99	20.15	20.59	
58	Cushion Tank	Nidamarru	6600.00	25.43	26.09	
59	Cushion Tank	Nidamarru	3438.97	29.41	29.40	
60	Cushion Tank	Nidamarru	4724.35	25.40	25.50	

11.1 Site Clearance

The building areas in the sites shall be cleared of all trees, shrubs or other vegetation, rubbish, slush etc. and other objectionable matters. If any roots or stumps of trees are met during excavation, they shall also be removed. Where earth fill is intended, the area shall be stripped of all loose / soft patches or top soil containing objectionable matter

before filling commences. Any structure or services existing at the site shall be removed / rerouted with the permission of the Engineer-in-Charge. Existing wells, pits, marshy areas etc. shall be filled up with earth of approved quality.

The Agency shall be deemed to have visited and carefully examined the sites and surroundings and to have satisfied himself about the nature of the existing structures, underground services, general site conditions, and the site for disposal of surplus materials, debris etc and all other items affecting the work.

Green Building Requirements like preserving top soil; erosion control etc shall be followed.

Claims due to ignorance of site conditions will not be considered after submission of Bid.

11.2 Site Grading

The table given above is indicating grade levels based on the preliminary survey work. The Agency shall conduct a study on the site grading to fix the grade levels at various locations of the plot based on the detailed topographical survey conducted at site by him, and the information given by Engineer-in-Charge to match the overall master plan and infrastructure master plan.

The Agency site grading proposal may consider optimum use of locally available earth in addition to achieving the above objective. Fills shall normally be made up of CNS material capable of being compacted up to 95% Modified Proctor density. In case earth has to be borrowed from outside the plot boundary, the same shall be arranged by the Agency himself. The Agency shall fill earth in layers not exceeding 150 mm and each layer shall be consolidated properly to get optimum dry density.

Earth from Swamps, marshy as well as bogs, expansive type of clays, peat, organic material, material susceptible for combustion, material which will react with other material already used in work shall not be used as borrow material.

12 Boundary wall & Security cabins

The Agency shall design and construct RCC framed 250 mm thick brick filled decorated boundary wall with ornamental gates made of MS angle, flat, square bar, sheet. Security cabins of floor space 10 sq.m shall be provided in all the water work sites like Intake well, WTP, WDC compounds.

The height of the boundary wall shall be 1.8 m above the finished ground level. Height of the MS gates shall be of 1.8 m. There shall be atleast two ornamental covered gates sufficient to provide access to heavy vehicular trucks in Intake well & WTP compound. There shall be atleast one ornamental covered gates sufficient to provide access to heavy vehicular trucks in WDC compound. The gates shall preferably be made of MS bars, flats and plates welded together. The design of the entire work shall be submitted to the Engineer-in-Charge for approval. The location of the gates shall be as instructed by the Engineer-in-Charge. The Agency shall also provide plaster finish over both the sides of boundary wall and two coats of decorative weather coat exterior paint on the surface of the entire boundary wall. The entire WTP compound shall be divided in three premises (one for main WTP premises, second one for staff quarters premises and third for administrative building premises) by boundary walls. All the above three premises shall have boundary walls and separate access gate from main road. All gates shall be provided with MS gates. The MS gates at WTP site and Intake well site shall be electrically operated and access control gate. In addition to MS gate, the gate of main WTP premises and administrative building premises shall provide with electrically operated remote-control boom barrier.

13 Internal road network

All internal roads shall be of cement concrete (M30) with minimum reinforcement as per relevant IS codes.

13.1 Internal drainage

The Agency shall design, make detailed Engineer-in-Charge and construct storm water drains for disposal of rain water from the compound of all water work sites like Intake well, WTP & WDCs. The Agency shall also connect the internal drains with the city storm water drain outside the premises at suitable location. The storm frequency shall be one in five years. The Agency shall submit layout and design of storm water drainage

network to the Engineer-in-Charge for approval. The storm water drainage system shall consist of underground RCC NP3 pipelines, manholes, gully pits/catch pits etc. The storm water drainage system shall be so designed so as to make the discharge of the water into the outlet channel by gravity alone. The Agency shall make proper arrangement to discharge the water into the existing drainage system of the vicinity. Necessary permissions have to be obtained from the competent authority by the Agency to discharge the same into the existing drainage system. He shall also satisfy himself about the adequacy of the existing drains. The Agency shall design, make detailed Engineer-in-Charge and construct proper sewerage system for disposal of sewage from toilet/wash room provided inside the different buildings of WTP, Intake well cum pump house, WDCs etc. Sewer line shall be of DWC HDPE pipeline and manholes shall be RCC. The specification for Storm water drain and sewerage system are given elsewhere in the bid document.

14 Landscaping

Providing Landscape architecture in this project includes intake well-cum-raw water pumping station campus, WTP campus and WDCs/GLSR - 8 No. Other than the buildings and built-up areas in these campuses, landscaping shall be provided to the rest of the spaces available for landscape development.

14.1 Specific Objectives

The landscape component in this project shall be designed to achieve the following specific objectives:

- Landscape shall add to the beautification of the space.
- Ample landscaping, using low maintenance, low water use native plantings that evoke the visual character of the surrounding area and the city landscape.
- Wide landscape buffers to mitigate impacts to the proposed planned development activities around the buildings and built-up areas in each campus.

  Landscaping practices that shall integrate and go beyond the conservation and efficient use of water, soil and vegetation.

14.2 Provisions

For landscaping, Agency shall provide the following in planning and construction:

a) Given Amaravati capital city's climatic conditions of high rainfall during south-west monsoon, heat wave during summer, variable humidity and wind factors, as well as varying soil characteristics, etc., plants including ornamental plants, mosquito repellent plants, dust and pollution- arrest plants shall be selected with an understanding of the microclimate conditions and they shall be grouped in appropriate hydro and plants variety zones.
b) A Grading Plan for the available space shall be prepared which shall include maintaining land slope towards the natural drainage and no erosion of soils.
c) Grass turf with soft grass variety shall cover the entire landscape areas. Before placement of grass turfs and plants, good soils shall be provided with appropriate bio-fertilizers and other nutrients.
d) Landscape area shall be covered with flower gardens at suitable places. Flower plants which sustain year-round shall be selected.
e) Landscape areas shall be covered with sprinkler irrigation. Depending on the landscape area of the campuses, one or more water fountains shall be provided.
f) Walkway/inner roads in the campus shall be curvilinear and aesthetically designed with colorful inter-locking tiles.
g) A few sit-outs, waste bins, few artifects, signs mentioning interesting plants' name shall be provided
h) Entire landscape architectural plan shall be prepared and such drawings, 3-D view and detailed specification shall be submitted to the Engineer-in-Charge for approval.

Daily maintenance of the landscaped areas shall continue through the 2-year DLP and 8-year O&M period.

SECTION – IV
Technical Specification for Electrical Works

1.1. LIST OF DRAWINGS TO BE SUBMITTED AFTER AWARD OF CONTRACT

Following drawings, calculations & schedules shall be submitted for approval before procurement, fabrication and Installation of equipment at site.

(A)	Drawings
1.0	Single Line Diagram of Complete and individual Electrical System
2.0	Electrical Substation Layout of Intake well, WTP and clear water pumping station showing Panel locations, Transformer locations, 33kV Centralised Switchgear Panel location, 6.6kV Centralised Switchgear/MCC Panel location, LT Main PMCC Panel Location and Trench Layout.
3.0	33kV Centralised Switchgear Panel / 6.6kV Centralised Switchgear/MCC Panel a. General arrangement drawing shall indicate the overall dimensions, net weights, and the general constructional features. b. Certificates of type tests carried out on Switchgear Panel of similar rating in the last three years. c. General arrangement drawing of the Switchgear Panel showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights etc. d. Foundation drawing with position of foundation bolts and depth. e. Schematic power and control wiring diagrams with control, interlocks, instruments, space heaters, bus bar rating with material, Current transformers, potential transformers etc.
4.0	33kV/6.6kV, 6.6kV/0.415kV, 33/0.415KV Oil Filled/dry type transformers a. General arrangement drawing shall indicate the overall dimensions, net weights, quantity of oil, crane requirements for assembly and dismantling of transformers and the general constructional features. b. General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of, crane lift for un tanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc. c. Rating, diagram and terminal marking plates, complete with polarity and vector group.

	d. Control wiring diagram for marshalling box. e. Foundation drawing with position of foundation bolts and depth.
5.0	Neutral Earthing Resistor a. General outline drawing but with binding dimensions and weights. b. Detailed outline drawing showing plan, front elevation, end elevation, inner view, locating dimensions of cable entries, terminal details, structure/floor fixing details and weight of the neutral earthing resistor. c. Schematic diagram of resistor with taps, terminal box connections, terminal details, ohms, current and voltage rating, voltage class of the stand insulators. d. Details of Temperature coefficient of resistance.
6.0	Main LT PMCC/MCC's, UPS/Lighting DB's a. Dimensional layout drawing b. Complete assembly drawings of the switchboard/distribution board showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc. c. Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings. d. Schematic power and control wiring diagrams with control, interlocks, relays, instruments, space heaters, starters with Bi-metallic relay ratings and contactor ratings, busbar rating with material etc. e. Feeder operation logic
7.0	LT Capacitor bank with Automatic power Factor Correction Relay a. Dimensioned general arrangement drawings of capacitor and capacitor control panel b. Justification for number of steps for switching c. Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation, side view, sectional view and foundation details d. Complete schematic and wiring diagrams for capacitor control panel
8.0	Variable Frequency Drives a. Dimensional details with mounting Arrangement b. Schematic power and control wiring diagrams with control, interlocks, relays, instruments, space heaters, starting time and current, relay ratings, contactor ratings, bus bar rating with material etc.
9.0	Battery & Battery charger with DC Distribution Board

	a. Dimensioned general arrangement drawings b. Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation d c. Complete schematic and wiring diagrams
10.0	Cabling system a. Details of Installation of Cables in Trenches/Tunnels, on cable trays, racks directly buried etc., at all locations inside the Chiller plant. b. Cable routing layout inside and outside the plant. c. Bill of quantities of cables, lugs and glands. d. 33kV & 6.6kV Cable termination and mounting Kit Layout drawing.
11.0	Earthing & Lightning Protection system a. Details such as material, sizes, etc. of the earth conductor and electrode pits b. Earthing layout drawing showing routing of main grid inside and outside the plant with interconnection of equipment earthing to the grid and earth pits
12.0	Lighting System a. Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc & Detailed lux level calculations. b. Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures, receptacles etc. c. Internal road Lighting and Area lighting layout with type of mounting details and fixture details. d. Street Light pole details with Foundation details.
(B)	**Calculations** a. Transformer Sizing Calculations b. Fault level and Voltage Dip Calculations c. Neutral Earthing Resistor sizing Calculations d. Co-ordinated protection study. e. Sizing of capacitor banks f. HT & LT cable sizing g. UPS & Battery Sizing Calculations h. Building Lightning Protection and Earthing Sizing Calculations

	i. Room wise Lighting Calculation as per Lux level given in IS 3036 Part-I. j. Protection matrix with supporting calculations for all electrical equipment
(C)	**Schedules** a. Cable Schedule b. Load & Power Consumption Schedule c. Protection Relay Setting Schedule d. Junction Box Schedule

1.2. PRIMARY POWER SOURCE

The Power supply for Intake, WTP will be arranged by laying 33kV underground cables from 220KV GIS substation nearest. The incoming 33kV cables will be terminated on the 33kV RMU inside Intake and WTP premises.

1.3. POWER SUPPLY ARRANGEMENT INSIDE THE PLANT

The overall power supply arrangement for intake and WTP shall be as per Single line diagram.

1.4. GENERAL DESIGN CRITERIA

The 33kV Substation at Intake well is going to be developed in modules as per the growth of water supply load. There shall be a 33kV Centralised Switchgear Panel, in-comers sized for the total load Requirement of all the Phases of intake well. All the Outgoings of the 33kV Centralised Switchgear Panel & respective Transformers are added according to the Phase wise growth Requirement of the Plant.

33kV System

a)	Nominal voltage	33kV
b)	Number of phases	3
c)	Frequency	50 Hz
d)	Connection	3 Wire
e)	Maximum Fault Level	1600 MVA

6.6kV System		
a)	Nominal voltage	6.6kV
b)	Number of phases	3
c)	Frequency	50 Hz
d)	Connection	3 Wire
e)	Maximum Fault Level	500 MVA

LV System		
Voltage	:	415V Nominal
Frequency	:	50 Hz
Connection	:	4 wire
No load transformer voltage	:	433 V
System earthing	:	Solidly earthed
Maximum fault level	:	36 MVA

All Plant shall, unless otherwise specified, be capable of continuous operation at a voltage level in the range of 90% to 110% of the relevant nominal voltage and a frequency variation of plus 3 % to minus 3% with a maximum combined tolerance of 10%.

AC Control, Lighting and Space Heating

Voltage	:	240 V
Phases	:	1
Frequency	:	50 Hz
Connection	:	2 wire (Phase & Neutral)

Power Transformers

- The 33kV substation will have of 33kV / 6.6kV Transformers.
- The transformers shall be sized considering 20% contingency of total working load while arriving at the final capacity of transformers. Two nos. of transformers are provided in substation such that under normal condition one transformer will be standby. Under fault on one transformer, the healthy transformer shall have capacity to take entire load so as to have 100 % standby. The transformer shall be designed such

that at any point of time maximum loading on any single transformer shall not exceed 80% of full load capacity.

Distribution Transformers

- There will be 1nos of 6.6kV / 0.415kV Transformers.
- The transformers shall be sized considering 20% Contingency of total working load while arriving at the final capacity of transformers. The transformer shall be designed such that at any point of time maximum loading on transformer shall not exceed 80% of full load capacity.

33kV & 6.6kV Switchgear

- 33kV & 6.6kV switchgear will be sheet metal enclosed with draw out type vacuum circuit breakers for incoming and outgoing feeders, for the HV motors and auxiliary transformers.
- The switchgear degree of protection will be IP 4X.

LV Switchgear

The 415V switchgear will be of compartmentalized and modular construction. Fuse switches and starters will be of a fixed construction whilst main air circuit breakers will be withdrawable type. The degree of protection will be IP 54 for indoor installation and IP55 for outdoor installations. The switchgear will be designed for a fault level of not less than 25 MVA at 415 V.

System Protection

A microprocessor based protection system for the various parts of the power supply system is proposed.

The following protection systems will be used:

33kV & 6.6kV Transformer feeder

HV Side

- transformer differential relay;
- inverse definite minimum time overcurrent relay with instantaneous over current element;
- instantaneous earth fault;
- Bucholz/ gas pressure relay with alarm and trip contacts;
- winding temperature indicator with alarm and trip contacts;
- oil temperature indicator with alarm and trip contacts;

- magnetic oil level with alarm contact.

LV Side

- inverse definite minimum time earth fault relay;
- restricted earth fault relay and Stand by earth fault.

33kV & 6.6kV Incoming Outgoing Feeders

- inverse definite minimum time phase overcurrent relay;
- inverse definite minimum time earth fault relay;
- potential transformer fuse failure relay;
- under voltage relay.

6.6 kV Feeder to Distribution Transformer

- inverse definite minimum time overcurrent with instantaneous over current element;
- instantaneous earth fault relay and standby earth fault.

415 V Incomer Feeder

- Overload, Earth fault and short circuit protection;

LV Motors

Motors less than 15 kW

- overload protection by three phase thermal (bimetal) relay.
- Single phasing preventer.

Motors 15 kW up to 132kW

Electronic motor protection relay providing the following protection for

- Overload;
- Earth fault;
- Phase currents out of balance.
- Single phasing preventer.

Motors 132kW and above

Comprehensive motor protection relay providing the following protection for

- Overload;
- locked rotor;
- Over current;
- Earth fault;

- Phase currents out of balance.
- Over voltage & under voltage;
- phase loss/reversal;
- Negative sequence;
- Protection for repeated and prolonged starts;
- restart inhibition;
- No load running;
- Single phasing preventer.

Switchgear Equipment / Instruments

33 kV Incoming & Outgoing Feeders, 6.6kV Feeders Incomers

- ammeter on all 3 phases;
- voltmeter with selector switch;
- kW meter;
- kWh meter;
- power factor meter.

6.6kV Outgoing Feeders

- ammeter on all 3 phases;
- kWh meter;
- power factor meter.

6.6 kV Feeders to Distribution Transformers

- ammeter on all 3 phases;

415V Incomer Feeders

- Ammeter on all 3 phases;
- Voltmeter with selector switch;

6.6KV Motor Starters

VFD Starters for all HT and LT pumping motors.

Each motor shall be provided with a press to lock and twist to release type local emergency stop button with mushroom head.

Pump Drives

Where practical all pumps shall be provided with the following additional protection:

- run dry protection,

- over pressure

L.T Capacitor Bank and Power Factor Correction

- The capacitor banks provided shall be of bus connected type with Automatic Power factor correction, the system shall be designed such that a power factor of not less than 0.95 is maintained.
- Automatically controlled multistage power factor correction shall be provided. 2 Nos. PFC panels providing no less than 8 No PFC stages per panel shall be provided each connected to one bus section of the distribution board. The PF on each half of the board shall be monitored and corresponding PFC capacitors switched in and out automatically in discrete stages in order to maintain a set point PF value.
- The breakers and cables in capacitor circuit shall be designed for taking extra loading of 35%.

H.T Capacitor Bank and Power Factor Correction

- The 6.6kV capacitor banks provided if any shall be of 6.6kV Motor connected type with Automatic Power factor correction, the system shall be designed such that a power factor of not less than 0.95 is maintained.
- The breakers and cables in capacitor circuit shall be designed for taking extra loading of 35%.

Cabling

- HV Power Cables
- HV cables for use on 33kV & 6.6kV shall be XLPE insulated aluminium conductors.
- LV Power Cables
- LV multicore cables for use on 415 V and 240 V power supply system shall be XLPE / PVC type with aluminium conductors for sizes 6 sqmm and above and Copper Conductors for sizes below 6sqmm.

Cable Rating

- All power cables shall be sized for continuous current carrying capacity and permissible voltage drop at an ambient temperature of 50 degrees C. Due consideration shall be taken of cable grouping, method of installation and local variations in ambient conditions. Further, for cables controlled by circuit breakers, due consideration shall be given to the fault level.

- LV cables shall be sized for a minimum fault clearance time of 0.5 second for incoming feeders and 0.16 second for equipment feeders & HV Power cables shall be sized for fault clearing time of 1 sec.

  In general power cables will be sized to limit the maximum voltage drop of 5 % from transformer secondary to motor terminal.

Cable Installations

Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. These shall be used to route cables along walls, below beams and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made while sizing the cables.

Building Services

Lighting

All internal and external areas shall be provided with lighting. The illumination levels to be achieved shall be as follows:

Area	Illumination Level (Lux)
Pump house	200 Lux
Machinery service area	200 Lux
Offices	300 Lux
Control rooms	300 Lux
Cable basement	100 Lux
All other indoor areas	100 Lux
Outdoor platforms and walk ways	50 Lux
Building entrance	100 Lux
Outdoor plant areas	30 Lux
Outdoor transformer yards	
- General	30 Lux
- On equipment	40 Lux
Roads (secondary)	40 Lux

- Luminaires for internal lighting shall comprise LED type only. Assure that minimum illumination levels are maintained following momentary power dips which could extinguish the discharge lights for several minutes.

- Ceiling fans shall be provided in offices, control rooms and they shall be connected to local lighting circuit.
- The internal lighting installation shall be installed using single core, PVC insulated copper cable enclosed in galvanized iron conduit. Lighting in external areas shall be installed using multicore armoured cable.

Ventilation Fans

- Variable speed ventilation ceiling fans shall be provided in offices, control rooms, control areas and switchgear rooms. One fan shall be provided for each 10 m2 or part thereof of the area concerned.
- Where fitted, ceiling fans shall be connected to the local lighting circuit.
- Small Power Outlets
- Switched single phase three pin 5 A and 15A receptacles shall be provided throughout. In offices and control rooms they shall be the decorative type and industrial type in all other areas.
- Unless required to be provided in greater numbers to power specific Plant items the number of

Such outlets shall be as follows ;

- 5 A type one outlet per 5 m or part thereof of perimeter in offices;
- 5 A type one outlet per 20 m or part thereof of perimeter in all other areas;
- 15 A type one outlet per 20 m or part thereof of perimeter in offices;
- 15 A type one outlet per 20 m or part thereof of perimeter in all other areas.
- 32 A switched three phase and neutral receptacles shall be provided in plant areas where appropriate i.e. adjacent to areas where flooding is likely to permit the use of portable sump pumps. The Agency shall install ten such outlets at various locations throughout the plant.
- The location of outlets shall be approved by the Engineer-in-Charge. The spacing of 5 A and 15 A outlets shall be arranged to suit the intended location of equipment, desks etc.
- Receptacles for outside areas shall have a degree of protection of IP 55.

System Earthing

- An earthing system comprising earth electrodes and conductors shall be established at each substation and transformer. The two networks will be interconnected.

- The earthing system will be designed to give a combined earth resistance value of not greater than 1 ohm. In order to be sure of obtaining suitable final values, soil resistivity shall be measured at the various sites during the detailed design phase of the work.
- In outdoor substation areas the main earth electrode conductors shall be located, to ensure potential gradients occurring at the surface during fault conditions are kept within allowable limits.
- Materials used for earth electrodes shall be designed to suit the ground conditions and shall either be plain mild steel or Galvanised steel.
- The fault clearing time will initially be taken one second for the 33kV, 6.6kV and 415V systems.
- The maximum temperature allowed for steel welded joints will be taken as 500oC with an ambient of 50oC. Main Equipotential bonding conductors shall be galvanized steel.
- Circuit protective conductors will comprise either the armouring of the supply cable or, for major loads such as main switchboards and large drives the supply cabling plus an additional suitably sized single core copper cable.
- The neutral point of the 33kV/6.6kV transformer secondary windings shall be earthed through Neutral Earthing Resistor.
- The neutral point of the 6.6kV/0.433kV transformer secondary windings shall be solidly earthed.

  For Transformer Neutral Earthing, Copper conductors shall be used.

TECHNICAL SPECIFICATION FOR 36kV RING MAIN UNIT

General

- The RMU for the compact substation shall be 5 way/7 way, 36kV, extendable type, free standing, outdoor, metal clad SF6 insulated Ring Main Unit (RMU) along with metering, PTs, CTs etc.
- The outdoor type RMU shall be extendable type and stand alone.
- Two numbers, fault making / load breaking, motor operated, line side switches, fitted with indications for phase and earth fault along with associated CTs. The load break switches shall be connected via underground XLPE Cables.
- Outgoing feeder of RMU shall have, Tee-off, spring operated, Circuit breaker with sealed for life vacuum interrupter complete with meters, CTs, Protective and auxiliary

relays to control desired number of transformers or equipment with complete arrangement to connect the tee-off circuit breaker to the 33kV side of the power transformer.

- The springs for closing the load break switches & tee-off circuit breaker shall be motor operated.
- The opening & closing for the load break switches as well as tee-off circuit breaker shall be carried out electrically from remote via SCADA, besides local / hand operation. Built in compact battery [with no maintenance of any type] with charger shall be part of supply for this purpose.
- The breaker shall have necessary over current and low sensitivity earth fault protection on the delta connected, 33kV side of the transformer. Further the protections on distribution transformer shall operate this breaker with required alarms. It shall have basic metering features also to monitor these in RMU.
- RMU shall also be equipped with necessary Remote Terminal Units, transducer's etc. complete in all respects, since these RMU's shall be having provision for SCADA with remote control. The provision for requisite control & indications shall be provided in the RMU's & substations.
- Fault passage indicators, Feeder Remote Terminal Units, with self-healing feature, communicating with each other in the Ring circuit shall ensure automatic isolation of faulty cable and restoration of supply in case of cable fault in the system, using Fibre-Optic based communication.
- There shall be continuous monitoring of supply on 36kV cables via capacitive voltage indicators.
- The RMU shall be complete in all respects including elbow type cable termination arrangement [with shrouds] in air from bottom, gland plate, double compression glands, foundation channels, bolts, inter connection arrangement etc.
- The external dimensions shall be identical throughout the length of the board.
- The operation of any of the switching functions shall be simple with only three possible positions viz. closed, open and earthed. The earthing switch shall be placed on cable side. The earthing of cable is to be done by an independent fault making switch.
- All the necessary safety interlocks between switching devices, earthing switch and cable box covers shall be integrated.

- The accessories and LV auxiliaries (i.e. motor mechanism, coils, auxiliary switches etc.) shall be the same for the entire range of switching functions, load break switches or circuit breakers. They can be installed on site without any dedicated tool and training.
- Any other item not included above but required to complete the works shall be deemed to be included in RMU, without any financial liability to the purchaser.

Standards

Unless otherwise specified, all equipment and material covered in this specification shall conform to the latest applicable Indian / IEC Standards. Equipment complying with any other international standards will also be considered if it ensures performance of equipment equal to or superior to Indian Standards. Copy of such a standard shall also be supplied.

S. No	Standard Number	Description
1	IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications
2	IEC 62271-200	High-voltage switchgear and control gear - A.C. metal-enclosed switchgear and control gear for rated voltage above 1 kV and up to and including 52 kV.
3	IEC 62271-103	Switches for rated voltages above 1 kV and less than 52 kV
4	IEC 62271-100	High-voltage switchgear and control gear – Part 100: High-voltage alternating current circuit breakers.
5	IEC 62271-102	High-voltage switchgear and control gear – Part 102: High-voltage alternating current disconnectors and earthing switches
6	IEC 61958	High-voltage prefabricated switchgear and control gear assemblies – Voltage presence indicating systems.
7	IEC 60529	Degrees of protection provided by enclosures (IP Code)
8	IS:722	A.C. electricity meters
9	IEC 60044-8	Instrument transformers – Part 8: Low Power Current Transducers
10	IEC 60044-1	Instrument transformer – Part 1: Curent transformer
11	IEC 60044-2	Instrument transformer – Part 2: Voltage transformer
12	IEC 60255	Electrical relays
13	IS: 5	Colours for ready mixed paints and enamels
14	IS:1248	Electrical Indicating Instruments
15	IS:1554	PVC insulated cables up to and including 1100 volts
16	IS:4794	Push Button Switches
17	IS:6005	Code of practice for phosphate coatings of iron and steel
18	IS:2099	Bushings for alternating voltages above 1000 V
19	IEC:62271-202	Pre-Fabricated Substation
20	IS:13118, IS:3427, IEC:60694.	Switchgear cubicles
21	IS:9920, IEC:60265	Ring main unit

S. No	Standard Number	Description
22	IS:10118	Code of practice for selection, installation and maintenance of Switchgear
23	IS: 1180	Distribution Transformer
24		Indian Electricity Rules
25		Indian Electricity Act
26	IS:13072	Sulphur hexafluoride for electrical purposes

Technical Particulars (Standard Values)

The Ring Main Unit (RMU) shall consist of three phase, two load break switches and one or two (depending type no. of outgoings) tee-off VCB, Circuit Breaker Compact Unit, SF6 insulated and sealed for life complying to latest version of IEC 622-71-200

a. Rated system voltage (kV) 36

- Rated current for load break switch [A] up to 630 Amps
- Rated current for tee-off Breaker [A] up to 630 Amps
- Nominal system voltage [kV] 33
- System Earthing Solid

b. Basic Insulated level

- Lightning Impulse withstand voltage (kV) As per Indian Standard
- Power frequency withstand voltage for As per Indian Standard

One minute (kV rms)

c. Frequency (Hz) 50

d. Bus bar rated current (A) upto 630 Amp

e. Rated short time symmetrical three phase current 20

(kA for 3 sec for load break switches & tee-off breaker)

f. Earth switch for load break switches (kA for 3 sec) 20

g. Earth switch for tee-off breaker (kA for 3 sec) 20

h. Rated making current (kA peak) 65

i. Rated breaking current for circuit Breaker [kA for 3 s] 20

j. Rated breaking current for circuit Breaker [kA for 1s] 25

k. Filling & rated gas pressure <1 bar, gauge

l. Internal arc test [kA for 1 sec] 20

m. Interrupting time in millisecond less than 40

n. Operating Duty: O-0.3s-CO-3min-CO

o. Degree of protection for enclosure IP 54

p. Paint thickness (micron) 60

Notes:

- Type, routine, internal arc test reports shall be supplied by the Agency along with tender.
- RMU for CSS shall be non-extendable type and RMU for outdoor distribution shall be extendable type.

Storage [without heaters, in humid environment]: from 0°C to +50°C

- Operation : 0°C to +50°C
- Partition class : PM
- Main HV circuit : IP67
- Front connection in cable box, suitable for armored, XLPE insulated Aluminium cable, as per calculated & specified size. Termination with elbow type plugs in bushings with insulating boots.

Load Break Switch

- The switch shall be combining the functions of a load break switch, disconnector and associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on cable side.
- The mechanism shall be anti-reflex, lever-operated type, with intuitive operation and clear mimic panel indications.
- Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided.
- Switch shall have a provision for remote opening and closing through SCADA also. Earthing switch operation shall be locally.
- It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard. Switch shall not be damaged even when closed on a dead short circuit for the permitted period of short circuit.
- Each load break switch shall be of the triple pole, gang operated, with quick break contacts.

Circuit breaker for Transformer

- The Circuit Breaker shall have a switch disconnecting the circuit breaker with an associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on transformer side. Circuit Breaker shall have a provision for remote opening and closing through SCADA. Earthing switch operation shall be locally.
- It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard.
- Circuit breaker shall be opened with a push button and closed with the “closing lever”. The mechanism shall be anti-reflex, lever-operated type, with intuitive operation and clear mimic panel indications. Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided. The circuit breaker and load break switch can be locked in the open, close or earth position by 1 to 3 padlocks of ESI size.
- Breaker shall not be closed when cable cover is open.
- In case of fault the breaker shall be tripped through a self-powered relay.
- Circuit Breaker Interrupting Unit:
- Tee-off Circuit breaker shall have Vacuum interrupting arrangement.
- The design & construction of the Vacuum circuit breaker shall be compatible with the latest Vacuum circuit breaker technology.
- The Vacuum interrupter bottles shall be completely maintenance free & mechanically strong for 30 years life. Test certificate to be provided.
- Suitable interlock shall be provided against breaker operation in the event of loss of Vacuum.
- Circuit breaker shall allow low chopping current level.
- Graph showing short circuit Vs tripping permitted for Circuit Breaker.
- Duty Requirement:
- The circuit breaker shall be totally restrike free under all duty conditions and shall be capable of performing the duties satisfactorily.
- The circuit breaker shall meet duty requirement for any type of fault location, also for line charging current. The operating duty of the circuit breaker shall be as follows:
- O-0.3s-CO-3min-CO

- The circuit breaker shall be suitable to break the required induction current in accordance with the BIS / IEC standard. The value thereof shall be clearly specified at the time of offer.
- The circuit breaker shall meet its duty requirement in case of application for controlling U/G cables, power transformer.
- The rated transient recovery voltage for terminal fault and short line faults shall be as provided in the relevant IEC / BIS.
- Constructional Details:
- Complete switchgear including bus bars shall be contained in an earth screened stainless steel tank, filled with SF6 gas, degree of protection not less than IP-67, as per requirement of IEC standards. To prevent gas leakage the gas pressure shall be maintained low within one atmospheric gauge. The filled gas shall provide the required insulation and also current breaking for load break switches.
- There shall not be any condensation of SF6 gas on internal insulating surface of the circuit breaker and Load Break Switches. Temperature compensation shall be provided and the system shall be an integral part of breaker.
- SF6 gas shall be sealed for life in the compartment so as to satisfy “Sealed Pressure Systems” requirement of IEC-60694 (Clause 5.15.3). Throughout the life of the equipment there shall not be any “topping up” of SF6 gas. The rated life of the equipment must not be less than 30 years as per IEC-60694. During this operational life of the switchgear, absolutely no gas filling is required. The container shall be evacuated before gas filling and it shall be diffusion-tight. The design of the RMU housing shall be such that in the event of an internal arc fault, the safety of the operator shall be ensured. All the safety requirements as required in IEC 62271-200 shall be provided.
- The switchboard when charged must not have any access to live parts so as to endanger the life of operating personnel.
- The RMU shall be so designed that the position of different devices is visible to the operator in front of the switchboard. The operating switches, handles etc. shall be at a height at which these or easy to operate, without any extra effort. All the items in the equipment shall be identified with long life labelling, cautions etc. The labelling must clearly indicate the required function.

- All the items in the equipment shall be identified with long life labelling, precautions etc. The labelling must clearly indicate the required function.
- There shall be operation counters for Load Break Switches and breaker with a provision to sound an alarm when the permitted operations are approaching.
- It shall be possible to lock the operating mechanism in any of the three positions when the contacts have fully homed and also to independently lock the “ON” and “EARTH” positions. The position “ON”, “OFF” and “EARTH” of the switch shall be clearly indicated such that the direction of movement of the operating handle(s) from one position to another is readily apparent.
- The operating mechanism shall be maintenance free without the need of any lubrication during its life time of 30 years. The operating mechanism shall undergo a mechanical endurance test as specified in IS/ IEC 62271-200.
- The ring main shall be dust, moisture & vermin proof and suitable for indoor or outdoor installation. All the cabinets shall be free standing floor mounting type and shall be provided with double hinged doors with padlocking arrangements.
- All door panels, removable covers shall be gasketed all round with neoprene gaskets. All louvers shall have screen and filters. Vent opening shall be covered with mesh and so arranged that hot gases or other material shall not be discharged, injuring operating personnel or surrounding apparatus and cables.
- Metal enclosure unit shall comprise of rigid welded structure frame enclosed completely by metal sheet of thickness not less than 2 mm. The sheet shall be cold rolled with smooth finish, levelled & free from flaws. However, the structural frame & all load bearing members of the enclosures shall have a minimum thickness of 2.5 mm or more. All members shall be properly braced to prevent webbing.
- Ring main design shall comprise full compartmental execution having separate vertical sections for each circuit having internal barriers. Compartment with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuit. The ring main cubical compartment shall be provided with hinged doors on the front with facility for padlocking door handles.
- All corresponding components of circuit breaker / load break switch cubicles of same ratings shall be interchangeable with one another.

- The board shall be wired with the connection brought on to the terminal boards for remote operation.
- The equipment shall also be as compact as possible so as to occupy minimum space in the sub-station room. Such type of equipment will have preference.
- Temperature rise in the unit shall not exceed as prescribed in IS/IEC.
- Minimum clearance between the phases and between live parts & grounded objects in the switchgear/ load break panels shall be in accordance with IEC.
- Operating Mechanism:
- Circuit breaker as well as load break switches shall be provided with suitably designed spring charged motor operated mechanism. It shall be possible to charge the spring manually, if required. The closing/ opening shall be through remote or through locally operated push button or operating switch.
- It shall be "trip free" mechanically under every method of closing (except during closing for maintenance).
- The operating mechanism shall be such that the failure or any auxiliary spring will not prevent tripping. When the circuit breaker is already closed it shall not cause damage to the breaker or endanger the operator.
- The breaker / load break switch shall also be hand operated, if so required.
- Electrical as well as mechanical indicator shall be provided to show open & close positions of the breaker / load break switches. It shall be located in a position where it will be visible to a man standing on the ground with the mechanism housing closed. An operation counter shall also be provided with each breaker / load break switch.
- Working parts of the mechanism shall be of corrosion resisting material. Bearings, which require grease, shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or required adjustment with repeated operation of the breaker / load break switch. The mechanism shall be maintenance free.
- The closing mechanism shall be able to be operated by one man standing on the ground & direction of rotation of the handle for charging / closing shall be clearly defined.
- Arrangement shall be made to de-couple/ trip the motor in case of failure of limit switch to cut out motor when the springs are fully charged and annunciation for this shall be provided.

- The mechanism shall be complete with opening spring, closing spring, auxiliary contacts & all other necessary accessories to make mechanism a complete operating unit. A continuous sequence of closing and opening operation shall be possible.
- Besides the requirements of auxiliary switches used by the manufacturer, at least 4 NO + 4 NC shall be provided for the use of the purchaser.

RMU to be Maintenance free

- The RMU's life and its operation must not be affected by environmental conditions such as foggy atmosphere, extremes of cold, seismic conditions such as corrosive / winds, 100% relative humidity (condensing type) with hot and humid environment, temporary flooding etc.
- The equipment shall be of "fit & forget" type requiring little maintenance, (practically no maintenance), during its life.
- RMU shall have reliable switching devices and maintenance free drives.

Insulating Medium

- The RMU shall comply with the requirements of IEC standard for "Sealed Pressure System", for which no filling of gas is to be carried out during the life span of the switchgear. The SF6 gas shall be as per IEC-60376 / IS:13072 and shall be suitable for its application in the switchgear. It shall continue to have high insulating and arc quenching properties throughout the switchgear life of 30 years.
- The SF6 gas shall be self-regenerating after the interruption of arc due to breaking load currents. The gas tank shall have material in the tank to absorb the moisture from SF6 gas.
- The use of organic seals on the equipment, grease and oil in the drives requiring periodic maintenance are not to be used.

SF6 Gas Monitoring & Pressure Relieving

- SF6 gas in the RMU tank shall be constantly monitored through a gas pressure indicator, which shall be duly temperature compensated. In case the pressure is not adequate it shall block its operation and give a warning to isolate the RMU.

- The pressure sensors shall feed a microprocessor based analysing unit. By this system the gas pressure (temperature compensated) shall be recorded to measure the dielectric strength of the gas in the compartment.
- A loss of gas shall be signaled via two contacts one to initiate the low alarm of gas and second to trip the whole system.
- If the gas pressure exceeds the permissible limit, such as during short circuit clearing, the pressure relief device shall operate in the underside of the module. This area must be partitioned from the cable connection apartment.

Voltage indicator lamps, phase comparators and Monitoring of RMU Bus Voltage

- It shall be possible for each of the functions on the RMU to be equipped with a continuous voltage indication, to indicate whether or not there is voltage on the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp shall be provided to indicate live cables. Three outlets can be used to check the synchronization of phases with the use of an external device. This device shall be in compliance with IEC 1958 standard. Besides this the voltage monitoring of bus bar shall be provided continuously.

Earthing of RMU Circuits

- The cables in the RMU on the load break switch sides shall be earthed (only when these are dead) through integral earthing switch having the short circuit capacity of the RMU.
- The earthing switch shall be mechanically interlocked so that it can only be operated when the main switch is in open condition and circuit is fully de-energized. Necessary voltage monitoring device in such a case shall be provided.
- The earthing switch shall be operated through the main circuit mechanism and manual closing shall be through a fast-acting mechanism.
- Mechanical interlocking system shall be provided to ensure that the switch is turned to 'OFF' position before being turned from 'ON' to 'EARTH' condition.
- Cable box interlocking is to be provided to ensure that before the removal of the unit cable box cover, the unit earth is applied.

General Earthing Requirement:

- All metal parts not intended for carrying current shall be connected to duplicate earthing system and suitable terminals shall be provided on each equipment or part of equipment in conformity with the relevant standards.
- The earth continuity conductor shall be of tinned copper and shall have sufficient cross-sectional area so as to afford a low resistance path for the full fault current corresponding to the circuit breaker ratings.
- The size of earth continuity conductor shall be adequate, so as to restrict the temperature rise to the limit without causing any damage to the earth connection, while short circuit current flows through it for the short time rating of the equipment.
- The size of earth continuity conductor shall be as large as possible to reduce to the barest minimum the potential rise of the metal frame of the circuit breaker.
- No sweated / riveted joints in current conducting path shall be permitted.
- Cable end Termination box
- Cable-end termination box shall form an integral part of the equipment. The cables shall be convenient to install.
- There shall be elbow type connection for cable termination with insulating boots. The boots shall form part of supply.
- Each Cable compartment shall be provided with three bushings to terminate the incoming and outgoing 33kV or 6.6kv, 3 Core or single core cables as the case may be. There shall be minimum 700 mm height from the base of the mounted switchgear so that the cables can be bent and taken vertically up to the bushings. The Cable termination shall be done by Heat Shrinkable Termination method so that adequate clearances shall be maintained between phases for Termination.
- The arrangement for earthing the termination point of cables shall form a part of supply and shall be of adequate rating. The standard size of 33kV XLPE cable being used is as specified for load break switches as well as for the tee-off transformer.
- The cable mounting arrangement on the load break switches shall be over the trench and no special arrangement is required for installation of the cables and their terminations. These shall enter directly from the cable trench through cable glands in gland plate to the load break switches. The ring type air insulated CTs shall be provided.
- All of the cable boxes shall be air insulated suitable for dry type cable terminations. Compound filled cable boxes are not acceptable.

- The cable boxes at each of the two ring switches suitable for accepting H.V. cables approaching from below or as per site requirement. The tee-off circuit breaker shall be suitable for either of the following termination arrangements:
  - ✓ Direct coupling to a transformer flange
  - ✓ Cable entry from below via a tee-off cable box
  - ✓ Cable entry from above via a tee-off cable box
- The extended function shall be suitable for cable entry from either above or below only.
- Double compression type, chrome, plated cable brass glands shall be provided in the gland plate, with necessary cable clamping and earthing arrangement.
- Support frames shall be provided whose height shall be such that cable connections can be conveniently made after allowing for bending radius of cables.

Note: The XLPE, outgoing & incoming 33kV power cables to LBS are not in the scope of the RMU manufacturer. However, elbow type termination kits for these cables (including two sets, of new cable termination tools) are included in the scope of supply.

Testing of Cables:

- It shall be possible to test the core or the sheath insulation of the network cables while the RMU remains energized at rated voltage. It shall be preferable to carry out the phase by phase testing through a built-in-facility without necessity to have access to cable compartment. The maximum test voltage shall be less than 38 kV DC for 10 minutes.
- Any cable test access facility which requires the use of an additional loose devise shall not be acceptable.
- Any switching unit, load-break switch or circuit breaker, shall be able to receive a dedicated device for cable testing, allowing the cable test bench to be connected from the front of the cell without opening the cable compartment. This cable test device must be fully interlocked with the earthing switch.

Bushings:

- Bushing shall be homogeneous, free from laminations, cavities & other flaws or imperfection that might affect the mechanical or di-electric quality & shall be tough and impervious to moisture.
- Silicon type bushings shall be used.

- Bushings shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be subjected.
- When operating at normal rated voltage there shall be no electric discharge between the conductors & bushings, which could cause corrosion or injury to the conductors, insulators or supports by the formation of substances produced by chemical action.
- All iron parts shall be hot dip galvanised (not less than 75 micron) & all joints shall be airtight. Surfaces of the joints shall be smoothened up. Bushing design shall be such as to ensure a uniform compressive pressure on the joints.
- All current carrying contact surfaces shall be sliver plated; silver plating shall not be less than 1 mil in thickness.
- The creepage distance of the bushings shall be suitable for condensing type humidity atmosphere atmosphere.
- Bushings shall be tested for type tests & routine tests in accordance with stipulation of IS: 2099. Routine as well as type test reports in conformity with above IS shall be furnished to the purchaser.

Caution Notice:

- Caution name plates shall be provided at all points where such safety requirements are to be met as per Indian Electricity Rules.

Safety Interlocks:

- Disengagement of a circuit breaker or switch shall not be possible unless it is in open position. Suitable interlocks shall be provided.
- The position of the circuit breaker, whether in open or close position shall be indicted through suitably designed fail-safe mechanical indicators.
- The operating position of circuit breakers or isolators, either on bus-bar side or for earthing, shall be clearly indicted by a reliable indicating device.
- Integral earthing facility, when provided, shall be suitable to make earthing connections only when the associated circuit breaker is in tripped position. The current rating of earthing facility shall be commensurate with the short circuit rating of the circuit breaker.
- Metering, Protection, Indication & Auxiliary Switches

General Requirements for Instruments:

- Multifunctional Measuring instruments, with an accuracy of 0.5S or better shall be of digital type, with minimum 3 line LED display and conforming to relevant IS / IEC & shall be of an approved type & design suitable for tropical climate and condensing type humidity. Measurement shall include voltage, current, pf, kW, kVA, kVAR and neutral current. It shall have RS 485 communication port.
- All instruments shall be back connected and instruments cases shall be earthed.
- The instruments safety factor shall be equal to or less than 5.

Protection:

- The protection on the circuit breaker shall comprise the following arrangement:
- The Tee-off, Circuit breaker unit fitted with 3 protection CTS of suitable ratio and burden [considering power transformer rating], a low burden trip coil and auxiliary switch assembly allowing the use of a self -powered, numerical relay with an open protocol having three over current and one sensitive earth fault elements. The relay shall be housed within a cubicle box, accessible from the front. This relay shall also communicate with Feeder Remote Terminal Unit.
- The protection curves and all other settings shall be adjustable in software through lap top, which when viewed from the front clearly show the unit settings. (Note DIL type switches are not acceptable). The protection setting range and minimum pick up current shall be in accordance with the protection of transformer rating.
- Typically, the primary settings may be in the following range:
  - ✓ Overcurrent : 20A to 200A
  - ✓ Earth Fault : 2A to 50A
- The relay shall give local indication of a fault operation and shall differentiate between overcurrent and earth fault.
- It shall be possible for the relay to perform a self-check.
- Other auxiliary relays to give trip / alarm [local as well as remote] in case of operation of transformer protections, gas leakage, ON, OFF & Earth status of RMU load break / breaker, spring charged etc. shall be provided.
- Besides the requirements of auxiliary switches used by the manufacturer, at least 4 NO + 4 NC shall be provided for the use of the purchaser.

Instrument Transformers:

The instrument transformers required for the switchgear shall conform with the respective standards specification.

Voltage Transformers

The Voltage Transformers (VT) shall be of dry compound epoxy insulated. The VT shall be protected on their primary sides by current limiting fuses. On the secondary side, the circuit shall be protected by MCB's. Provision shall be so made that the primary fuses can be handled only in the drawn-out position. The particulars of the voltage transformer are:

Type	:	Cast Resin.
Rated Voltage	:	33000 / □3 110 / □3 110 / □3 Volts
Accuracy Class	:	1.0
Burden	:	50 VA or as per system requirement.

Note: Agency shall design the voltage transformer as per system requirements, and alternate arrangement, if any, shall also be considered.

Current Transformers:

- The CT's shall be cast resin ring type, suitable for metering and protection requirements, air insulated and shall be able to withstand the thermal, dynamic and mechanical stresses resulting from the maximum short circuit and short time current rating of the switchgear. CT shall be suitable for continuous operation at 130% of its rated current.
- CT's shall have polarity marks engraved on each transformer and at the associated terminal blocks. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks by the use of shorting type terminals.
- CT ratio, burden, accuracy [1.0 for metering and 5P for protection] and other requisite parameters shall be suitable for the self-powered relay. CT calculations in this regard shall be submitted.
- Control of the RMU
- Remote & local operation of the RMU's line switches and Circuit breaker shall be provided using motors fitted to the operating mechanism.

- The provision of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or Circuit breaker.
- The Agency shall provide all necessary equipment for remote control and monitoring of the RMU
- Feeder Remote Terminal Unit (FRTU) For RMU
- Make of FRTU shall be same as that of the RMU manufacturer. It shall have peer to peer communication and with the remote switchgear / SCADA at the controlling substation through fiber optic cable to initiate the required switching operations.

Main Requirements:

- FRTU cubicle shall be equipped to meet the following main requirements for compact substation. It shall be possible to mount it on wall if required.
- Monitoring and control of 33kV LBS and VCB feeders
- In conjunction with FCI, detection and isolation of faulty cable for phase to phase and phase to earth cable short circuits and automatically ensure supply restoration in less than 60 seconds.
- Multifunction measurements.
- Transmit data to the remote control centre.
- The system shall have necessary redundancy in communication.
- To incorporate self-healing grid logic for faster restoration of supply even in the absence of control centre SCADA.
- Data storage.
- Provision for Maintenance
- FRTU shall be capable to monitor and control 5 ways RMU.
- Chronological time stamped event recording.
- Data storage, in the event of mains failure, shall be for at least 8 hours. The minimum storage shall be for about 40000 events.

Control unit:

- Control Unit shall perform all the required control and monitoring functions as isolated unit or as part of Compact Substation and shall be equipped with a remote and local control mode switch on its front panel.
- Operation in Local Mode:

- Transmission of data for remote measurements and time-stamped events shall not be disturbed.
- Opening and closing operation after validation.
- Inhibition of opening / closing from remote.
- Operation in Remote Mode:
- Transmission of measurements and time stamped events.
- Local electrical control shall get blocked.
- Opening and closing operation from remote control centre.
- All data shall be available locally on the front panel of the enclosure and remotely from the control centres. LBS / breaker open and close status can be had from the front mimic of FRTU respectively with the green / red LED indication. It shall be possible to retrieve and display the time-stamped events recorded at the enclosure locally as well as at the remote-control Centre on a lap top computer.

Power Supply:

Compact, built in sealed for life 12V battery with a long life and no maintenance of any kind for 5 to 7 years or more along with charger [to be supplied 230 V, 50 Hz from CSS and in case of stand-alone RMU supply arrangements shall be made by manufacturer] is to be provided in the unit. The supply shall be conditioned to provide power at required voltage for motor operation and communication for local and remote SCADA. The transmission output shall be able to supply a conventional radio [without battery power of RTU] to inform the remote control centre of a battery failure. Power from the unit shall be sufficient to supply control power to all the switch cubicles in the CSS, radio and the electronics in the enclosure. The standby power unit shall be with a minimum autonomy of at least 8 hours for 10 opening and closing cycles. The battery shall be checked at regular intervals by the slave station and an alarm shall be generated and transmitted to the remote control centre in the event of a fault. The unit shall be protected against overvoltage and over loads.

Time-tagged data archiving:

- All the archived data shall be retrieved locally and remotely by means of the configuration and operating software supplied with the control unit. The data shall also be downloaded locally or remotely to a PC as a .CSV file.

- Event and measurement time-stamping shall be accurate to one millisecond [ms] and the discrimination between two events shall be 10 ms.
- Communication with the remote control centre
- FRTU shall have IEC 870-5-101 / 104 protocol to transfer information to control center SCADA and Modbus protocol to communicate with field MFM [Multifunction Meters] on RS485. The Modbus protocol shall be open. Security & communication package provider shall only lay the fibre optic cable for the same and further connections, repeaters, boosters and any other communication equipment shall be included in the scope of supply.
- It shall be possible to configure each measurement to be transmitted spontaneously to the remote control centre with 100% redundancy. Failure of one channel shall have an automatic changeover to second channel.
- Data shall be configured using a PC connected to the control unit via an Ethernet and / or USB port. It shall also be possible to configure data remotely.

Software

The software shall not require a special license and it can be used and copied freely.

Indications

The slave stations shall process at least the following information for remote indication and for local display purposes:

- Open / closed position of each LBS
- Earth status
- Absence of AC voltage,
- Local / remote control operating mode,
- Detection of phase-to-phase or earth fault current flow,
- Load current measurement
- Charger fault
- Battery fault
- motor drive DC supply fault
- Internal fault
- Detailed diagnosis of the status of the uninterruptible power supply (charger, batteries).

- Indications for LT side status of switches, alarms as required.
- Erection / construction / Operating Tools and Tackles
- Each RMU will be provided with operating lever and other such equipment which are necessary for the normal operation of the equipment. It shall also include any spring charging handles for the manual charging of closing springs. The tenderer shall separately list out in the tender in the given schedule, sets of tools required for initial erection/construction and subsequent maintenance. The price of those shall be included in the cost of equipment.
- An anti-reflex mechanism on the operating lever shall prevent any attempts to re-open immediately after closing of the switch or earthing switch.
- All manual operations will be carried out on the front of the switchboard.
- The effort exerted on the lever by the operator shall not be more than 250 N for the switch and circuit breaker.
- The overall dimensions of the RMU shall not be increased due to the use of the operation handle. The operating handle shall have two workable positions 180o apart.

Mimic Diagram:

- The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicted in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

Labels and Marking of Connections:

All apparatus, control gear and the apparatus mounted thereon shall be clearly labelled, indicating where necessary, their purpose and the 'ON' 'OFF' and 'EARTH' position. The labels shall be clearly lettered on enamelled surface or other approved materials. Brass shall not be used for labels. Each phase of alternating current and connections shall be coloured to distinguish phases, neutral and earth. The colouring shall be red, yellow, blue, black and green respectively.

Bus Bars:

- Bus bars shall be of uncoated tinned conductor grade electrolytic copper.

- The tenderer shall furnish calculations establishing thermal and dynamic adequacy of bus bar sizes with reference to its short circuit ability. The bus bar shall be integrated completely into the gas filled compartment including the coupling chambers between two adjacent modules.
- The insulating ability of the entire bus bar system shall be monitored along with the gas filled cladded compartment of the module. The bus bar size shall be so chosen so as to limit the current density to within permissible limit and if the fault current restricts the current density less than that, then lesser density shall be used. Calculations shall be submitted for this purpose.

Temperature rise:

The temperature rise and the maximum temperature on any part of the equipment when in service at site under continuous full load condition or under short circuit shall not exceed the permissible limit as per relevant IEC or IS: 13947. This shall not be exceeded when corrected for the difference between the ambient temperature at site and the ambient temperature specified in the relevant standard.

RMU Indications

Indication of spring charge, ON, OFF trip etc shall be provided by means of LED which shall be fed from control supply arrangement designed by Agency If LED's are provided, the indicating lamps shall have covers of following colours.

Red	closed position of breaker/ load break switch
Green	open position of breaker /load break switch
Blue	spring charge condition of breaker / load break switch
Amber	auto tripped position of breaker
Yellow	Earth position

Terminal boards and Secondary Wiring

- Connection to switchgear, operating mechanism indicating relays and all instruments shall be deemed to form a portion of equipment of panel.
- Panel connections shall be insulated and shall be healthy and securely fixed to back of the panel. The wiring must run on porcelain or non-rusting metal cleats or metal flexible tubes as may be approved by Engineer-in-Charge. All wiring in the vicinity shall be

insulated and shall run in non-rusting flexible tubes from terminal boards conveniently situated. All control connections instruments and relay wires shall be provided with numbered ferrules at each terminal and the numbering shall be in accordance with an approved system. All wiring diagrams shall be clearly marked with the numbers corresponding with those on the ferrules of the individual cores. Each set of current and voltage transformer secondary connection shall be complete and shall be earthed at one point only. Each such earthing shall be made through links which can be opened for insulation testing.

- All the internal control wiring shall be through fire-resistant tinned stranded copper wires of 1.5 mm2 and for CT circuits these shall be with 2.5 mm2. The strands in the copper wire shall not be less than 48.
- The CT circuits shall be provided with isolating type of links, to check the current in the CT circuits during testing. Similar it shall be possible to isolate PT's without disconnecting wires to check & test the meters. All CTs must have provision for shorting through link.
- The air insulated control cabinet shall have provision for lighting.
- As the equipment is to be installed in a tropical and humidity zone, the air insulated control cabin shall be provided with suitable space heater of PTC type.

Type and routine tests

All the routine and type tests shall be carried out as per relevant IEC / Indian Standard. For type test certificates Engineer-in-Charge may consider test certificates at its absolute discretion.

All the routine tests on the switchboard shall be witnessed by the Site Engineer-in-Charge or its authorized representative.

The following type & routine test certificates shall be supplied / carried out on the RMU:

- Impulse withstand test
- Temperature-rise test
- Short-time withstand current test
- Mechanical operation test
- Checking of degree of protection
- Switch, circuit breaker, earthing switch making capacity.

- Switch, circuit breaker breaking capacity.
- Internal arc withstand test.
- Checking of partial discharge on individual components.

In addition, for switches, test reports on rated breaking and making capacity shall be supplied.

For earthing switches, test reports on making capacity, short-time withstand current and peak short circuit current shall be supplied.

The routine tests carried out by the manufacturer shall be backed by test reports signed by the factory's quality control department. They shall include the following:

- Conformity with drawings and diagrams,
- Measurement of closing and opening speeds & times
- Measurement of operating torque
- Checking of filling pressure
- Checking of gas tightness
- Checking of partial discharges on individual components
- Dielectric testing and main circuit resistance measurement

All of the major type tests shall be certified by an independent authority and an internationally acceptable test house for the tests carried outside the country of manufacture.

Configuration of Ring Main Unit

- Each non / extendable ring main unit shall comprise of three or four configurations, with a continuous bus bar, SF6 insulated, sealed for life, CTs and PTs as per requirement, pad locks for locking with a universal key, complete in all respects.
- The main items of RMU are given below any other item not specifically mentioned but required for the successful operation of the equipment shall be deemed to be included without any financial liability to purchaser.
- Each load break switch panel shall be equipped with rating of 36kV, 630 Amps. 25kA / 3s, Gang operated, SF6 insulated, manual / motor operated, fault making, load breaking switch, along with associated bus bars, CTs, PTs [as required] and the same shall consist of the following main items:
  - ✓ Metal clad in door type weather proof housing.
  - ✓ 36 kV, 630 Amps, fault making, load breaking, manually/motor operated, self-aligning, gang operated.

- ✓ One set of 630 Amp, bus bar as specified.
- ✓ Isolating plug & socket for main & auxiliary contacts if required.
- ✓ Mechanical interlocks to prevent switching on with cable in earthed position.
- ✓ One set of triple pole gang operated cable earthing contacts.
- ✓ Load Current measurement.
- ✓ Air Insulated cable box for Cable end termination suitable for 3 core, 36kV or 12 kV, XLPE armored cable of specified size, with AL conductor, along with glands, suitable Gland plate and Cable support.
- ✓ Mechanical On/Off/Earth/Test Indicators.
- ✓ Cable Testing Sockets
- ✓ Capacitive Voltage indicator lamps.
- ✓ Cable clamps
- ✓ Feeder Remote Terminal Unit [FRTU]
- ✓ Fault Circuit Indicator along with CTs.
- ✓ Indicating lamps & auxiliary contacts.
- ✓ Auxiliary relays (if required).
- ✓ Interlocked earthing arrangement.

- Tee-off Circuit Breaker Panel, with SF6 insulation, suitable for transformer feeder shall be equipped with minimum 36kV, upto 630 Amps, 25 kA, for 3 sec rated circuit breaker with associated C.Ts, PTs, spring operated mechanism, bus bars, compete with instruments, relays, terminal blocks. It shall comprise of the following main items:
  - ✓ Metal clad / indoor type weather proof housing
  - ✓ Vacuum circuit breaker, trip free
  - ✓ One set of 630 Amps. Bus bars (integral part with load break bus bar).
  - ✓ CTs for protection & Metering to match the transformer – 3 Nos.
  - ✓ 3-overcurrent & one earth fault IDMT relays, direct operating.
  - ✓ Termination suitable for connection to 11/0.433 kV transformer of specified rating.
  - ✓ Multifunction meter
  - ✓ P.T. 33000/□3 - 110/ □3 - 110/□3, as required.
  - ✓ On/Off indicator
  - ✓ Mechanical interlocks
  - ✓ Tripping, closing coils.

- ✓ Indication lamp & spare auxiliary NO/NC contacts.
- ✓ Auxiliary relays for alarm and trip for transformer protections
- ✓ Earthing arrangement duly interlocked.
- ✓ Mechanism with spring charging motor.

- The common system for the above shall consist mainly of:
  - ✓ Channels, nuts, bolts, glands, gland plates, inter connecting arrangement of tee-off breaker with transformer, cable termination kits & supporting arrangement of cable, with the load break switches etc.
  - ✓ Cable termination kits to be included for each RMU.
  - ✓ Gas monitoring device for sealed gas unit.
  - ✓ Pad locks for locking the panels.
  - ✓ Handles for normal operation, spring charging & other tools required for normal operation.
  - ✓ Arrangement of control supply for breaker / load break closing / tripping, motor charging indications etc.
  - ✓ All the necessary indicating lamps.
  - ✓ SF6 pressure monitoring unit.
  - ✓ Analysis unit for dielectric monitoring of SF6 gas.
  - ✓ Any other item not included above but required for the operation shall be deemed to be included though specifically not mentioned, without any financial liability to purchaser.

Two sets of cable termination and jointing tools for all the substations at various locations. Any other item mentioned in text or any other item required for successful operation but not included here shall be deemed to be included.

TECHNICAL SPECIFICATIONS FOR POWER AND AUXILIARY TRANSFORMERS

These specifications are intended to cover design, manufacture, testing/inspection before dispatch, packing, and transportation to site, erection supervision, testing and commissioning of 33/6.6kv & 33/0.415KV Step-down outdoor/indoor type ONAN transformers complete with all accessories / fittings and spare parts as specified herein.

Applicable Standards

The power and Auxiliary transformers shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Power Transformer	IS:1180/BS:171/IEC:76
Fittings and Accessories	IS:3639
Auxiliary Transformer	IS:1180
Loading of oil immersed transformer	IS:6600/BS: CP.1010/IEC: 54
Oil	IS:335/BS 148/IEC:296
Bushings for > 1000V, AC	IS:2099/BS:223/IEC:137
Bushings for ≤ 1000V, AC	IS:7421
Degree of Protection	IS:13947 (Part 1) / IEC:947-1
Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS 1271/BS:2757/IEC:85
Climate Proofing	BS: CP1014

Features of Construction

The transformer tank shall be made from high grade plate steel, suitably reinforced by means of stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant and oil insoluble paint. Adequately sized manholes shall be provided for easy inspection and maintenance. All joints which may have to be opened from time to time in the course of operation shall be of a design to permit them to be made easily oil tight in reassembly. Steel bolts and nuts exposed to atmosphere, shall be galvanised. The tank cover shall be suitably sloped so that it does not retain rain water.

Lifting lugs and eyebolts shall be so located that a safe clearance is obtained between sling and transformer bushings, without the use of a spreader. Transformer of rating above 500 KVA shall be equipped with detachable or separately mounted radiator banks. Transformers of rating 500 KVA and below shall be provided with fixed type radiators.

When transformers are provided with separately mounted radiators, flexible joints shall be provided on the main oil pipes connecting the transformer tank to the radiator banks to

reduce vibration and facilitate erection and dismantling. The interconnecting pipes shall be provided with drain plug and air release vents.

The transformer tank, radiators and conservator shall be designed taking into account the loss of thickness due to shot blasting. The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain oriented, silicon steel laminations coated with insulation varnish. The steel laminations shall be of "core" type.

Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.

Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated.

The frame work and clamping arrangements of core and coil shall be securely earthed inside the tank by copper strap connection to the tank. Windings shall be of suitably insulated copper wire or copper strip. The Windings shall be fully shrunk under vacuum before assembly. High voltage end windings shall be suitably braced to withstand short circuit stresses and stresses set up by surges. All taps shall be provided on the HV winding. The core and coil assembly shall be dried out and impregnated under vacuum.

Cable boxes shall have sufficient space for segregating the cable cores and to give adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary cable lugs and armour grips. All auxiliary wiring from current transformers, buchholz relays, winding temperature indicators, etc., shall be marshalled to a separate weatherproof and verminproof marshalling box with an independent access cover. The marshalling box shall be complete with necessary cable glands and cable lugs. The marshalling box and components shall comply with the requirements specified for control cabinets indicated elsewhere in this specification.

Painting

The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned (seven tank process) of all scale and rust by shot-blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting non-fading, paint of shade No. 631 as per IS:5.

Metal parts not accessible for painting shall be made of corrosion resistant material.

Interior surfaces of mechanism chambers and marshalling kiosks shall receive three coats of paint after proper cleaning. The final coat shall be of a light coloured anti-corrosion paint.

All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

In case finish paint chips off or crinkle during transit or installation, the supplier / Agency shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the supplier / Agency.

The following treatments shall be applied:

External surfaces

All steel surfaces shall be sand-blasted in accordance with DIN 55928 Part 4 (equivalent to SIS 055900), and shall then be painted in the following sequence:

One (1) primer coat 60 µm

Two-component epoxy zinc-phosphate

One (1) intermediate coat 60 µm

Two-component epoxy micaceous iron oxide

One (1) top coat 40 µm

Two-component polyurethane

Total coating thickness (dry-film incl. tolerances) min. 160 µm

The final coat of painting shall be of pore-free and homogeneous quality and shall be of uniform shade of colour.

DETAILED DESCRIPTION

Tank:

The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality. The tank and the cover shall be of welded construction.

Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.

All beams, flanges, lifting lugs, braces and permanent parts attached to the tank, shall be welded and where practicable, they shall be double welded.

The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760 mm of Hg. Inspection hole(s) with

welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc. The weight of cover shall be easily lifted by a single person, whenever required. All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions. Special attention shall be given to the methods of making the hot oil-tight joints between the tank and the cover as also between the tank cover and the bushings and all outlets to ensure that the joint can be remade satisfactorily and with ease, with the help of semi-skilled labour. Where compressible gaskets are used, steps shall be provided to prevent over-compression.

Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment. The completely assembled tank shall be fully vacuum proof.

Tank Cover

The transformer top shall be provided with a detachable tank cover with bolted flanged, gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water. Neoprene/cork/hemp type gaskets are not acceptable.

UNDER CARRIAGE

The transformer tank shall be supported on steel structure with detachable forged steel flanged wheels suitable for moving the transformer completely filled with oil. Rail gauge shall be 1676 mm in both directions. Flanged wheels shall be spaced accordingly. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication. It shall be possible to swivel the wheels in two directions, at right angle to or parallel to the main axis of the transformer.

Jacking pads shall be provided on the transformer. It shall be possible to change the direction of the wheels through 90 degree when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions.

Suitable hydraulic jacks (4 nos.) for lifting the transformer shall be supplied by the supplier / Agency, for each rating.

CORE

The magnetic circuit shall be constructed from high grade cold rolled non-ageing grain oriented silicon steel lamination with low loss, such as of W17/50; max 1.05W/Kg. The laminations shall be free of all burns and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000 V for one minute. The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.

All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding. The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation. The core clamping structure shall be designed to minimize eddy current loss.

The framework and clamping arrangements shall be securely earthed. The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.

Oil ducts shall be provided where necessary to ensure adequate cooling. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.

The design of magnetic circuit shall be such as to avoid static discharge, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination which may cause local heating. The supporting frame work of the cores shall be so designed as to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.

The construction is to be of ‘core’ type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.

The earthing of core shall be done at the top of the cover, with removable link so as to test the same.

INTERNAL EARTHING

All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.

The top clamping structure shall be connected to the tank by a copper strap. The bottom clamping structure shall be earthed by one or more of the following methods:

- ✓ By connection through vertical tie-rods to the top structure.
- ✓ By direct metal to metal contact with the tank base.
- ✓ By a connection to the top structure on the same side of the core as the main earth connection to the tank.

The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out of the top cover of the transformer tank through a suitably rated insulator. A dis-connecting link shall be provided on transformer tank to facilitate disconnections from ground for IR measurement purpose.

Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

WINDING

Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

All low voltage windings for use in the circular coil concentric winding shall be would on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.

Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

Materials used in the insulation and assembly of the windings shall be insoluble, non catalytic and chemically inactive in the hot transformer oil and shall not soften or the otherwise affected under the operating conditions.

Varnish application on coil windings may be given only for mechanical protection and hot for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal coil and prevent evacuation of air and moisture and impregnation by oil.

Winding and connections shall be braced to withstand shocks during transport or short circuit

Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated. Terminals of all windings shall be brought out of the tank through bushings for external connections.

The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.

The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.

Coils shall be made of continuous smooth high grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.

Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances.

The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.

Tappings shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.

Magnitude of impulse surges transferred from HV to LV windings by induction and capacitance coupling shall be limited to B.I.L. of LV winding.

INSULATING OIL

The insulating oil for the transformers shall be of LHV / MHV grade, generally conforming to IS:335.

The quantity of oil required for the first filling of the transformer and its full specification shall be stated in the bid. The bidder shall quote the price of transformer complete with first filling of oil plus 10% extra. However, the rate of transformer oil in Rupee per litre shall be quoted separately also. The transformer oil shall be supplied in non-returnable containers / drums.

The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.

The gaskets of neoprene or similar type such as cork, which can be damaged by over-pressing or not acceptable.

VALVES

Valves shall be of forged carbon steel upto 50 mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.

All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the supplier / Agency shall supply the same.

Each transformer shall be provided with following valves on the tank:

- ✓ Drain valves so located as to completely drain the tank.
- ✓ Two filter valves on diagonally opposite corners, of 50 mm size.
- ✓ Oil sampling valves not less than 8 mm at top and bottom of main tank.
- ✓ One 15 mm air release plug.
- ✓ Valves between radiators and tank.

Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.

BUSHING

All porcelain used in bushings shall be homogeneous, non-porous, uniformly glazed to brown colour and free from blisters, burns and other defects.

Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration.

Bushing shall be designed and tested to comply with the applicable standards.

Liquid / oil-filled bushings shall be equipped with liquid level indicators and means for sampling and draining the liquid. The angle of inclination to vertical shall not exceed 30 degree.

Oil in oil-filled bushings shall meet the requirements of the transformer oil standards.

Bushing rated for 400A and above shall have non-ferrous flanges and hardware.

Fittings made of steel or malleable iron shall be galvanised.

Bushing shall be so located on the transformers that full flashover strength will be utilised.

Minimum clearances as required for the BIL shall be realised between live parts and live parts to earthed structures.

All applicable routine and type tests certificates of the bushings shall be furnished for approval.

Bushing shall be supplied with bimetallic / terminal connector / clamp suitable for fixing to bushing terminal and the PURCHASER'S specified conductors. The connector /clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 45° degree centigrade over an ambient of 50°C. The connector / clamp shall be designed to be corona free at the maximum rated line to ground voltage.

Bushing of identical voltage rating shall be interchangeable.

The insulation class of high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the low voltage winding.

Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.

CURRENT TRANSFORMER

The current transformer shall comply with the requirements of latest issue of IS:2705. The reports of all type and routine tests as stipulated in the Indian Standards shall be furnished for approval to the purchaser. Each current transformer shall be subjected to routine tests as specified in the Indian Standards.

All technical particulars of current transformers as called for in bidding schedule shall be furnished with the bid. The parameters given for the current transformers in the specification may be modified before final approval of drawings but these changes shall not affect the cost of the transformers.

All secondary leads, including tappings shall be brought out to a weather proof outlet box near on the current transformer. The supplier / Agency shall carry out conduit wiring from this outlet box upto the transformer marshalling box or control cabinet.CT shorting terminals shall also be provided in the marshalling box.

Current transformer name plate shall be mounted on the equipment adjacent to the terminal box.

CABLE BOX AND CABLE BOX BUSHINGS

Cable boxes are to be suitable for operating outdoor and suitable for vertical arrangements of cables ascending to the box from below. Cable boxes for the transformers shall be with the disconnecting chambers so that the transformers with accessories can be removed for servicing for repair without disconnecting the cable connections.

Boxes shall be suitable for aluminium conductor, XLPE insulated armoured and PVC sheathed cables of sizes approved by Purchaser.

Compression glands and lugs shall be provided suitable for PVC cables.

The design and construction of the cable box shall be such as not to permit the entry of moisture into the box.

Supports for cable boxes shall be provided by the tenderer.

Suitable draining plug shall be provided with each cable box.

Suitable earthing arrangement for cable armouring shall be provided.

MARSHALLING BOX

Sheet steel vermin proof, well ventilated and weather proof marshalling box with watertight hinged and padlocked door of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have slopping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55. The sheet thickness shall not be less than 2mm.

The schematic diagram of the circuitry inside the marshalling box be prepared and fixed inside the door under a propone sheet.

AUXILIARY POWER SUPPLIES

The following power supplies shall be available at site

- ✓ AC, 3 phase 433 volts 50 Hz earthed.
- ✓ AC, 1 phase 240 volts 50 Hz earthed.
- ✓ 220 volts DC ungrounded.

ON LOAD TAP CHANGER

The transformers shall be provided with an On-Load Tap Changer (OLTC) of well reputed such as Easun MR and of proven make as per technical requirement for varying the effective transformation ratio while the transformer is ON Load and without providing phase displacement. The salient features of the OLTC shall be as under:

The tap changing mechanism shall be suitable for automatic, remote control operation from remote control panel in the control room in addition to being capable of local manual as well as local electrical operation.

The On Load Tap Changer (OLTC) shall include the following:

An oil immersed tap selector and arcing switch on arc suppressing tap selector provided with ohmic or resistor type high speed diverter switch, for reduction of make and break arcing voltages, overloads and short circuits.

Diverter switch shall be with snap action mechanism with energy accumulator mounted directly on the diverter switch.

Separate oil compartment

Easy removable diverter switch unit.

Motor driven mechanism

Control and Protection devices

Local tap changer position indicator

Manual operation device

Make of OLTC – Esun MR Indigenous make (type test certificates from (CPRI).

voltage rating -36 KV (as appropriate)

Current rating – 300 A

Control voltage – 110 Volt (AC)

The on-load tap changer shall be designed so that the contacts do not interrupt arc within the main tank of transformer. The tap changer selector and arcing switch on arc suppressing tap selector switch shall be located in one or more oil filled compartments. The diverter switch shall be provided with gas vent and buchholz relay. It shall be designed so as to prevent the oil in tap selector and diverter switch compartments from mixing with the oil in transformer. The barrier board between OLTC and the transformer tank shall be made of silicon bonded rasin paper (SBRP).

The tap changer shall be capable of permitting parallel operation with other transformers of the same type. The transformer shall give full load output on all taps without exceeding the limit of permissible temperature rise in oil and winding. The manual operating device shall be so located on the transformer that it can be operated by a man standing at the level of transformer track. It shall be of robust construction and shall be capable of frequent operations. It shall not be possible to operate the electric drive when the manual operating gear is in use.

Necessary interlocks blocking independent control when the units are in parallel shall be provided.

The controls shall be so arranged as to ensure that when a tap change operation has commenced, it shall be completed independently of the operation of control relays or switches. Local or remote-control switch shall cause one tap movement only, until the control switch has returned to the off position between successive operations. Under abnormal conditions such as may occur when the Agency controlling one tap change sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Limit switches shall be provided to prevent over running of mechanism.

The transformer and the tap changing equipment shall be designed to permit full rated operation with tap changing equipment temporarily installed in any intermediate position. Details of out of step protection provided for the taps shall be furnished in the tender.

The control scheme for the tap changer shall be provided for independent auto/non-auto control of the tap changer when the transformers are in independent service. Voltage regu-

lating relay shall be designed for maximum operational simplicity for regulating the secondary voltage of power transformer with OLTC. The required dead band settings are set by setting the nominal value and lower and upper levels independently.

In addition, provisions shall be made to enable non-auto/automatic parallel control also so that the tap changers of two or more transformers will be operated simultaneously when one unit is in parallel with another so that under normal conditions the tap changer will not become out of step and this will eliminate circulating current. Additional features like "Master/Follower" and visual indication, during the operation of motor shall also be incorporated.

A mechanical tap position indicator shall be provided on the tap changer in addition to remote indication equipment in the control room on remote control cubicle of OLTC. Necessary interlocks, for independent control when the units are in parallel shall be provided.

The whole of motor drive unit comprising the motor and its control gear including Agency, indicators, local electrical push buttons, five-digit operation counter, handle for manual control etc. as well as terminals for the control and indication wiring shall be housed in a dust proof kiosk mounted on a tap changer. A heating element with thermostat and MCB shall also be provided in kiosk. Arrangement shall be made for padlocking the kiosk. Tap position indication shall be visible by a number appearing in a small glass window on the front of the kiosk. For remote indication, digital type instrument shall be provided on the panel.

Any enclosed compartment not oil filled shall be adequately ventilated. All Agency, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.

The oil in the compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a pipe connection from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate oil buchholz relay with trip contacts shall be provided for the On-Load Tap Changer chamber. Each tap changer shall also be provided with a Pressure Relief Valve outside OLTC to protect against sudden pressure development in OLTC.

Each compartment in which the oil is not maintained under conservator head shall be provided with a suitable direct reading oil level gauge.

A permanently legible lubrication chart shall be fitted with the driving mechanism chamber.

Local electrical control switches and the local operating gear shall be clearly labelled in suitable manner to indicate the direction of operation of tap changer.

The remote-control panel of OLTC gear to be installed in the control room shall match in colour and dimensions sheet steel size etc. with the purchaser's transformer control panel for which details would be furnished to the successful tenderer.

In addition to the fittings, auxiliaries and accessories considered necessary by the tenderer the following shall be provided.

FOR LOCAL ELECTRICAL CONTROL

Raise lower selector switch with an intermediate 'OFF' position.

Auxiliary transformer (if necessary) along with MCB's and links.

Step by step contactor

Thermal over-load relay for the motor

Reversing contactor

ON/OFF automatic trip air circuit breaker for motor supply

Local / Remote change-over selector switch.

FOR REMOTE ELECTRICAL INDEPENDENT CONTROL

All equipment listed in (I) above.

Tap position indicator for mounting on control panel in the control room.

Signal lamp and buzzer, for indicating "Tap Change in Progress".

Raise lower switch push button type with intermediate off/position for remote control.

Emergency stop button (push button type) with visual indication.

Visual and alarm indication for non-completion of operation within pre-set time.

Provision of interlocking system for blocking independent control when the units are to run in parallel by providing interlocking phase sequence selector switch.

All audio-visual indications shall be brought to the Remote Tap Changer Cubicle (RTCC) panel.

DC supply isolators, DC supply 'ON' indicator & DC failure, booth along with cancellation.

All equipment and their connections in RTCC panel shall be properly marked. The buzzer / bell (industrial type) shall be provided.

Voltage regulating relay for automatic operation.

HV side and LV side digital voltmeters.

VOLTAGE REGULATOR RELAY FOR OLTC

Voltage Regulator Relay for OLTC shall have the following characteristics:

Input Voltage (nominal value)	95 to 130 V
Rated Frequency	50 Hz
Band width	+0.6 to +6% of nominal value
Time delay circuit	10 to 180 seconds
Integral response	to be switched on
Under Voltage blocking	70 to 90%
Line drop compensator	0 to 25 V
Current path of LDC	1 A

Note: If OLTC built-in feature is available in the main relay, separate voltage regulating feature may not be provided.

Circuit Tap Changer

The off-circuit Tap changer (wherever specified and required) shall be operable by means of an operating handle brought outside the tank and operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The tap changer contacts and connections shall be accessible through an access hole having bolted gasketed cover.

FITTINGS

The following fittings shall be provided on the transformers:

- Conservator with isolating valves, oil filling hole with cap and drain valve. The conservator vessel shall be fitted with constant oil pressure diaphragm oil sealing system.
- Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts.
- Prismatic/toughned glass oil level gauge.

- Silica gel breather with oil seal and connecting pipe complete with first fill of activated silica gel or Alumina mounted at a level of 1300 mm above ground level.
- A double float type Buchholz relay with isolating valve, bleeding pipe and a testing cock, the test cock shall be suitable for a flexible (pipe connection for checking its operation). A 5-mm dia. cooper pipe shall be connected from the relay test cock to a valve located about 1.25 meters above ground level to facilitate sampling of gas with the transformer in service. Interconnection between gas collection box and relay shall also be provided. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden oil surge. These contacts shall be wired upto transformer marshalling box. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.
- Pressure relief device the necessary air equilizer connection between this and the conservator with necessary alarm contacts.
- Air release plugs in the top cover.
- Inspection cover, access holes with bolted covers for access to inner ends of bushing, etc.
- Winding temperature (hot spot) indicating device for local mounting complete in all respects. Winding temperature indicator shall have two sets. of contacts to operate at different settings:
- To provide winding temperature ‘high alarm’.
- To provide temperature too high ‘trip’.
- Dial thermometer with pocket for oil temperature indicator with one set of alarm and one set of trip contacts and maximum reading pointer.
- Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.
- Jacking pads
- Haulage lugs
- Protected type mercury / alcohol in glass thermometer and a pocket to house the same.
- Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.
- Top and bottom sampling valves.
- Drain valve with pad locking arrangement.

- Rating and connection diagram plate.
- Two numbers tank earthing terminals with associated nuts and bolts for connections to purchaser's grounding strip.
- Bi-directional flagged rollers with locking and bolting device.
- Marshalling Box (MB)
- Shut off valve on both sides of flexible pipe connections between radiator bank and transformer tank.
- Cooling Accessories:
- Requisite number of radiators provided with:
- One shut off valve on top
- One shut off valve at bottom
- Air release device on top
- Drain and sampling device at bottom
- Lifting lugs.
- Air release device and oil drain plug on oil pipe connectors:
- Terminal marking plates for Current Transformers and Main Transformer.
- Neutral earthing to be brought down through tinned copper strip to purchaser's earthing grid via support insulators on tank.
- On load tap changer (OLTC), motor operated, complete in all respects, with separate oil chamber from main tank and provided with:
- Operating handle (for manual operation).
- Surge relay.
- PRV.
- Silica gel breather.
- Conservator.
- Magnetic level gauge for low level alarm.
- Motor, terminals, heater with thermostat, lighting etc complete in all respects.

CONTROL CONNECTIONS AND INSTRUMENT AND WIRING TERMINAL, BOARD AND FUSES

- Normally no fuses shall be used anywhere instead of fuse MCB's (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC fuse can be accepted.
- All wiring connections, terminal boards, fuses MCB's and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along with wire.
- Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC or non-rusting metal cleats of the compression type. All wiring to a panel shall be taken from suitable terminal boards.
- Where conduits are used, the runs shall be laid with suitable falls, and the lowest parts of the run shall be external to the boxes. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.
- When 415-volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 415 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper colour code for Red, Yellow, Blue wirers shall be followed.
- All box wiring shall be in accordance with relevant IS. All wiring shall be of stranded copper (48 strands) of 1100-volt grade and size not less than 2.5 sq.mm.
- All wires on panels and all multicore cables shall have ferrules which bear the same number at both ends, as indicated in the relevant drawing.
- At those points of interconnection between the wiring carried out by separate Agency, where a change of number cannot be avoided double ferrules shall be provided on each wire. The change of numbering shall be shown on the appropriate diagram of the equipment.
- The same ferrule number shall not be used on wires in different circuits on the same panels.
- Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.
- Stranded wires shall be terminated with tinned Ross Courtney terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire

terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.

- All circuits in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.
- Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 No.) copper wire of strip having a cross section of not less than 2 sq.mm where strip is used, the joints shall be sweated. The copper wire shall have green coloured insulation for earth connections.
- All wiring diagram for control and relay panel shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.
- Terminal board rows shall be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.
- Terminal boards shall be placed with respect to the cable gland (at a minimum distance of 200 mm) as to permit satisfactory arrangement of multicore cable tails.
- Terminal boards shall have pairs to terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards. CT terminals shall have shorting facilities. The terminals for CTs shall have provision to insert banana plugs and with isolating links.
- All fuses shall be of the HRC cartridge type and these shall be properly labelled, wherever these cannot be replaced by MCB as normally only MCB’s shall be used.
- All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.
- The schematic diagram shall be drawn and fixed under a transparent prispane sheet on the inner side of the marshalling box cover.

- As a rule, the fuses shall be replaced by Miniature Circuit Breakers (MCBs) in the control and other supplies.
- To avoid condensation in the MB, a space heater shall be provided with an MCB and thermostat.
- Suitable 11 W, CFL light shall be provided in the Marshalling Box for lightning purpose.

RADIO INTERFERENCE AND NOISE LEVEL

Transformers shall be designed with particulars care to suppress at least the third and fifth harmonic voltages so as to minimise interference with communication circuits. Transformer noise level, when energised at normal voltage and frequency shall be as per NEMA stipulations.

Performance Requirements

Transformers shall operate without injurious heating at the rated KVA at any voltage within ± 10 percent of the rated voltage of that particular tap.

Transformers shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.

Transformer for two or more limits of voltage or frequency or both shall deliver its rated KVA under all the rated conditions of voltage or frequency or both; provided an increase in voltage is not accompanied by a decrease in frequency.

Transformers shall operate below the knee of the saturation curve at 110 percent voltage to preclude ferro-resonance and non-linear oscillations.

Transformers shall be capable of operation continuously, in accordance with the applicable standard loading guide at their rated KVA and at any of the specified voltage ratios. Under these conditions, no limitations by terminal bushings, on-load tap changers or other auxiliary equipment shall apply.

The neutral terminal of windings with star connection shall be designed for the highest over current that can flow through this winding.

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave form distortion and any possibility of high frequency disturbances reaching a magnitude as to cause interference with communication circuits.

The Engineer-in-Charge reserves the right to reject the transformer if the same does not meet the specification requirement subject to tolerances as per IS:2062. The rejected transformers shall be replaced by transformers complying with the requirements to this specification at the Agency cost.

If the commissioning of the project is likely to be delayed by the rejection of a transformer, as mentioned under (h) above, the Engineer-in-Charge reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Agency cost.

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2025. The values of load- losses and No-load losses shall be within the values given in latest edition of CBIP manual for transformer ratings less than or equal to 2000kVA.

Cost loading shall be done for capitalization of losses at time bid evaluation for all transformer rating above 2000kVA as per Formula given in CBIP manual.

On Load Tap Changing Gear for Power Transformer

The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e., 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.

Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments, shall pass through the Buchholz relay before entering the conservator.

Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handles.

OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP55 protection which shall include:

Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).

Motor starting contactor with thermal overload relays, isolating switch and HRC fuses.

Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.

Control switch: Raise/off/lower (spring return to normal type).

Remote/local selector switch (maintained contact type).

Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.

Limit switches to prevent motor over-travel in either direction and final mechanical stops.

Brake or clutch to permit only one tap change at a time on manual operation.

Emergency manual operating device (hand crank or hand wheel).

A five-digit operation counter.

Electrically interlocked reversing contactors (preferably also mechanically interlocked).

240V, 50 Hz. AC space heater with switch and HRC fuses.

Interior lighting fixture with lamp door switch and HRC fuses.

Gasketted and hinged door with locking arrangement.

Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.

Necessary relays, contactors, current transformers etc.

Control Requirements for OLTC

The following electrical control features shall be provided:

Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.

Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.

Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.

Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

Automatic Control of OLTC

Automatic OLTC control shall include the following items:

Voltage setting device

Voltage sensing and voltage regulating devices.

Line drop compensator with adjustable R and X elements.

Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.

Adjustable dead band for voltage variation

OLTC Panel

The OLTC remote control equipment shall be suitable for 110V DC supply and shall be housed in an indoor sheet steel cubicle to be located in a remote-control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively. Earthing bus shall be of 25 x 6 mm copper.

Control switch : Raise/Off/Lower(spring return to normal type)

Auto/manual selector switch (maintained contact type)

Tap position indicator

Facia type alarm annunciators with “accept” and “lamp test” facilities.

A.C. supply failure

Drive motor auto tripped

Tap change delayed

Necessary auxiliary relays

Lamp indications for:

Tap change in progress

Lower limit reached

Upper limit reached

Cable glands for power and control cables

240V rated panel space heater with ON-OFF switch

Fluorescent type interior lighting fixture with lamp and door switch

HRC fuses

Terminal blocks

Internal wiring

Earthing terminal

Off Load Tap Changing Mechanism for Auxiliary Transformer

Off circuit tap changing mechanism shall comprise the following

Operating handle of wheel, accessible from ground level

Tap position indicator

Pad locking arrangement

The tap-changer connections and contacts shall be accessible through an access hole having a bolted gasketted cover

Fittings and Accessories

The following fittings and accessories shall be provided with transformer

Inspection manhole in the cover.

Lifting lugs for both the transformer and the core.

Two earthing terminals on opposite ends of the transformer tank.

Name plate, rating plate and diagram plate.

Detachable radiator banks, complete with top and bottom shutt-off valves, air release plug, drain valve and lifting lugs, suitably located thermometer pockets for measuring inlet and outlet oil temperature and one grounding terminal for connection of grounding conductor.

Fins of the radiators shall not have sharp edges but shall be rounded shape.

Conservator, complete with filling plug, sump and drain valve, and a shut-off valve on the pipe connection between transformer tank and conservator, to permit removal of the conservator. The conservator shall be designed to maintain an oil seal through a temperature range of 100 Deg C.

Oil level indicator with minimum marking.

Weather proof dehydrating breather with activated alumina or silica gel as the dehydrating agent.

Magnetic type oil level gauge with low oil level alarm contact, mounted on the conservators with waterproof and dustproof terminal box.

Gas detector relays with separate alarm and trip contacts complete with shut-off valves.

Separate drain valve, oil sampling valve with plug and top filter valve shall be provided on the tank.

Explosion vent with diaphragm for relieving pressure inside the transformer. The device shall be rain proof after operation. For transformers of 500 KVA and above an equaliser pipe connecting the pressure relief device to the conservator shall be supplied.

Separately mounted, water proof and dustproof marshalling box housing the oil temperature indicator and winding temperature indicator with alarm and trip contacts and marshalling facilities for electrical devices mounted on transformer.

For transformers rated 500 KVA and above. Adequate number of air vents for relieving trapped air during oil filling and during maintenance.

Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.

Four jacking pads for lifting the transformer with jacks.

Pulling eyes and skids for the movement of the transformer.

Bidirectional wheels for movement of the transformers.

Accessories for clamping the wheel mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2g.

Noise level of transformers shall be less than 80 dB.

Transformer shall be supplied complete with insulating oil required for first filling plus 10% excess oil.

Drawings and Data

The following drawings shall be submitted for the Authority's Approval:

General outline drawing as submitted at the Biding stage but with binding dimensions and weights within 2 months of award of contract.

General outline drawings showing plan, front elevation, and side elevation, with all fittings and accessories, locating dimensions of cable entries, earthing terminals, foundation/floor fixing details, jacking pads and weights of the following within 4 months of award of Contract.

OLTC (Local and Remote) cabinets

Marshalling box

Cable boxes

Disconnecting chambers

Maintenance and Operating Instructions

- Height of centre line of HV and LV connectors of transformers from the rail top level
- Painting procedure.
- Complete CT details including VA, class, ALF, resistance, magnetization characteristic curves, dimensions fixing arrangement etc. of neutral and phase side current transformers (as applicable).
- Specification of the insulating oil.
- GA drawings / details of bushing and terminal connectors.
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- Magnetization characteristics curves of PS class neutral and phase side current transformers, if applicable.
- Interconnection diagrams.
- Over fluxing withstand time characteristics of transformer.
- GA drawing of marshalling box.
- Control scheme / wiring diagram of marshalling box.
- Technical leaflets of major components and fittings.
- As built drawings of schematics, wiring diagram etc.
- Setting of oil temperature indicator, winding temperature indicator.

- Completed technical data sheets.
- Details including write-up of tap changing gear.
- H.V. cond. bushing.
- Bushing Assembly.
- GA of HV & LV cable Box.
- Radiator type Assembly.
- Detailed wiring/schematic drawings for ONAF operation of the transformer.
- Motor Drive (circuit diagram plus parts list etc.)
- Earthing and Insulation of Core
- Locking Facilities and Accessories for Valves
- Construction of Globe Valves and Gate Valves
- Factory Test Procedure and Test Schedules for Factory Tests
- Commissioning Test Procedure and Report
- Operation and Maintenance Manual including Test Reports
- Outline of Radiator
- Outline of Fan Unit
- Mechanical Protection of Auxiliary Wiring and Capillaries

All drawings/documents, technical data sheets and test certificates / results / calculations shall be furnished.

Bushings Plan, elevation, terminal details, mounting details, make and type number, current and voltage rating, creepage distances and principal characteristics.

Rating and diagram plates

OLTC cabinets: schematic circuit diagram and actual detailed wiring diagram giving terminal numbers within 5 months of award of Contract.

Marshalling box terminal connections wiring diagram.

TESTS

The Transformers shall be completely factory tested before despatch in accordance with the standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification.

ROUTINE TESTS

Transformer routine tests shall include tests stated in latest issue of IS:1180. These tests shall also include but shall not be limited to the following:

- Measurement of winding resistance.
- Voltage ratio on each tapping and check of voltage vector relationship.
- Impedance voltage at all tappings
- Magnetic circuit test.

After routine tests, each core shall be tested for 1 minute at 2 KV between all bolts, side plates and structural steel work. Immediately prior to the dispatch of the transformer, the magnetic circuit shall be pressure tested for 1 minute at 2 kV A.C. between the core and the earth.

- Load losses.
- No load losses and no-load current
- Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt/R1 mt)
- Induced over voltage withstand test.
- Separate source voltage withstand test (applied potential).
- Tan delta measurement and capacitance of each winding to earth (with all other windings earthed) & between all windings connected together to earth.
- Dissolved gas analysis test
- Measurement of acoustic noise level
- Measurement of Zero sequence impedance.

All routine & type tests shall be done free of cost. If it is to be done on the cost basis, the same may be indicated in the schedule of prices and delivery and this will be taken into account for evaluation of prices.

TYPE TESTS

Moreover, in addition to the routine tests, the transformer shall be subjected to the following type tests:

- Lightning Impulse Test

This test shall be carried out in accordance with clause 12 of the latest issue of IS: 1180. The bidder shall quote separate price for lightning impulse test on HV and LV windings. (One limb only).

- Temperature Rise Test

The temperature rise test shall be carried out in accordance with IS:1180. The Temperature rise shall not exceed the values stated elsewhere in the specification.

TEST WAIVAL, PROCEDURES AND COSTS

The purchaser, at his option, may waive impulse tests provided type test reports of impulse tests carried out on essentially identical units in their factory in India are furnished by the manufacture.

No load losses and exciting current shall be measured at rated voltage, rated frequency and at 90% and 110% of rated voltage, both before and after the lightning impulse tests.

The method of test loading shall be described in the test report for determination of both average and hottest spot temperature. Where the winding temperature equipment is specified, data shall also be included for calibration of hottest spot temperature indicator.

Resistance of each winding of each phase shall be measured at principal and at all the taps and corrected to 75°C.

Impedance voltage shall be measured at principal and at all taps.

No load Loss Measurement at 415 Volt.

The bidder shall indicate separately the cost of each of the following types tests:

Lightning impulse test separately for HV and LV winding

Temperature rise test

TESTS ON TRANSFORMER TANK

Vacuum Test: One transformer tank of each size shall be subjected to the vacuum pressure of 760 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 KN/m2 (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) without affecting the performance of the transformer.

Pressure Test: One transformer tank of each size together with its radiators, conservator vessel and other fittings shall be subjected to pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m2 (5 1b/sq.in) whichever is lower measured at the base of the tank and will be maintained for one hour. The permanent deflection

of flat plates after the excess pressure has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999).

The pressure relief device shall be subjected to increasing oil pressure. It shall operate before reaching the test pressure specified above. The operating pressure shall be recorded. The device shall seal off after the pressure in excess has been relieved (routine test).

Oil leakage test: All tanks and oil filled compartments shall be tested for oil tightness by oil of a viscosity not greater than that of insulating oil to IS: 335, at the specified ambient temperature and subjected to a pressure equal to the normal pressure plus 35 KN/m2 square (5 1b/sq.in) measured at the base of the tank. This pressure shall be maintained for a period of not less than 12 hours, during which time to leakage shall occur.

TEST ON ASSOCIATED EQUIPMENT

Porcelain bushings, bushing current transformers, wherever provided, winding temperature indicating devices, dial thermometers, buchholz relays, ON LOAD tap changer, coolers, control devices, insulating oil and other associated equipment shall be tested by the supplier /Agency in accordance with relevant IS. If such equipment are purchased by the supplier/ Agency on a sub-contract, he shall have them tested to comply with these requirements.

SEQUENCE OF TESTING ON ASSEMBLED TRANSFORMER

Unless otherwise agreed, the sequence of testing shall be as follows:

- Ratio and vector group
- Winding resistance measurement
- Tan Delta & Insulation resistance measurement
- Separate source voltage withstand test
- Measurement of Iron losses
- Load losses and impedance voltage measurement
- Lightning impulse test
- Temperature rise test
- Induced voltage withstand test
- Tests on OLTC

TEST MEASUREMENTS

The zero-sequence impedance, insulation power factor and capacitance for each winding and between windings shall be measured and recorded.

Certified test report and oscillograms shall be furnished to the Purchaser / Consultants for evaluation as per the schedule of distribution of documents. The Contactor shall also evaluate the test results and rectify the defects in the equipment based on his and the Purchaser's evaluations of the tests without any extra charges to the Purchaser. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.

The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testings.

WITNESSING OF TESTS AND EXCESSIVE LOSSES

The Purchaser and / or his representative reserves the right to witness any or all tests, or to accord waival at its sole discretion.

The Purchaser reserves the right to reject the Transformer it losses exceed the declared losses beyond tolerance limits as per IS or if temperature rise of oil and winding exceed the values specified elsewhere. (See clause 3.5.0).

SITE TESTS

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

- Dry out test
- Megger test
- Resistance measurement of windings
- Ratio test
- Phase relationship test
- Tap changer test
- Buchholz relay alarm & surge operation test
- Low oil level alarm
- Temperature Indicators
- Marshalling kiosk

- Protective relays
- Magnetising current
- Tests on OLTC
- The following additional checks shall be made:
- All oil valves are in correct position closed or opened as required.
- All air pockets are cleared.
- Thermometer pockets are filled with oil.
- Oil is at correct level in the bushing, conservator, divertor switch, tank etc.
- Earthing connections are made
- Colour silica gel is blue.
- Bushing arcing horn is set correctly and gap distance is recorded.
- CT polarity and ratio is correct.

LOSSES AND DAMAGES

LOSSES

Transformers with lower losses shall be preferred. The bidder shall indicate the values of load and no-load losses of the transformer in his bid. Losses quoted shall be firm, without any tolerance. If nothing is indicated regarding tolerance on losses, it will be considered that losses are subject to tolerance. In case no ceiling is specified, these will be taken as per IS and the offer shall be loaded as per Table 7 of latest issue of IS: 1180 or Table 1 of IEC 660076-1.

Capitalization of losses

For total cost evaluation, the capitalized cost of losses will be taken into account as per the following:

Capitalized Cost of transformer = Initial cost of Cost of transformer + Rs. 564.53 x Wi + Rs. 312.03 x Wc

Where: Wi = Iron loss in Watt

Wc =Copper loss in watt

The no load loss in Watts at rated voltage & frequency and the load loss in kW at rated voltage, rated frequency, rated output and 75 Deg C shall be quoted and these shall be guaranteed.

Liquidated damages for increase in losses:

Penalty shall be applied to the successful bidder in case he is unable to achieve the quoted guarantee figures at the following rates:

For each Watt of excess of no-load loss	Rs. 565/-
For each Watt of excess of load loss	Rs. 312/-

REJECTION

The Purchaser may reject any transformer if during tests or service any of the following conditions arise:

No load loss exceeds the guaranteed value by 15% or more.

Load loss exceeds the guaranteed value by 10% or more.

Impedance value exceeds the guaranteed value by + 10% or more.

The difference in impedance values or any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.

Oil or winding temperature rise exceeds the specified value.

Transformer fails on impulse test

Transformer fails on power frequency voltage withstand test.

Transformer is proved to have been manufactured not in accordance with the agreed specification.

INSTRUCTIONS MANUAL

Eight sets of the instruction manuals shall be supplied atleast four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer. The manuals shall include amongst others, the followings particulars:

- Marked erection prints identifying the components, parts of the transformer as despatched with assembly drawings.
- Detailed dimensions, assembly and description of all auxiliaries.
- Detailed views of the core and winding assembly, winding connections and tappings, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.
- Salient technical particulars of the transformer.
- Copies of all final approve drawings.

- Detailed O&M instructions with periodical check lists and proforma etc.

COMPLETENESS OF EQUIPMENT

All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the supplier /Agency without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the Purchaser under any circumstances.

All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it will be presumed that all the provisions of the specification are complied with by the bidder.

TOOLS & TACKLES

All the necessary tools and tackles required for normal operation shall be supplied by the supplier / Agency.

COMMISSIONING

The equipment shall be commissioned as per CBIP manual, IS 10028 and manufacturer's recommendations. All the as built drawings / manuals shall be pre-requisite for release of payment for final payment.

Specific Technical Particulars of 33kV/6.6kV Transformers shall be as follows:

Description	Unit	Technical Particulars
Make		As per Preferred Makes/Manufacturers
Type		As per Specification
Applicable Standards		As per Specification
Rated output	KVA	(*)

Description	Unit	Technical Particulars
Quantity required	Nos.	2
Transformer location		Outdoor

No load transformer ratio	kV/kV	33kV / 6.6kV
Number of phases		3
Rated frequency	Hz	50
Impedance at all taps	%	Value as per IS 1180
Number of winding / material of conductor		Two/Copper
Type of cooling		ONAN
Tap changer		Full capacity, OLTC on HV side with local marshalling box and Remote Tap Changing panel
Tap range	%	+ 5 % to -15 %
Tap step	%	1.25 %
Terminal connection HV terminals Primary HV terminals Secondary		Cable box suitable for 33kV XLPE, Al. Conductor armoured cables (*) Cable box suitable for 6.6kV (UE), XLPE, Al Conductor armoured cables (*)
Current Transformer On HV Secondary		(*)

Description	Unit	Technical Particulars
On HV Secondary Neutral i. Restricted Earth Fault ii. Over current earth fault backup protection		Class PS Accuracy Class 5P20 Accuracy
HV Secondary Neutral earthing		HV Secondary Neutral shall be brought out the cable box for forming the 3 Ph, 4-wire system and outside the cable box by 6.6kV Single core Unearthed cable upto Neutral Earthing Resistor & from Neutral Earthing Resistor for direct connections to

		earth by means of 6.6kV (UE), 1C, XLPE, Cable (*)	
Insulation of Windings		H.V.(Primary)	H.V.(Secondary)
One-minute power frequency withstand voltage (dry and wet)	kV (rms)	70	20
1.2/50 microsecond full wave impulse withstand voltage		170	60
Insulation of bushings		H.V.(Primary)	H.V.(Secondary)
Rated Voltage of bushing	kV	36	7.2
One-minute power frequency withstand voltage (dry and wet)	kV (rms)	70	20 20
1.2/50 microsecond full wave impulse withstand voltage	kV (peak)	170	60
Minimum creepage distance	Mm	25mm/kV on 36kV	25mm/kV on 36kV
Vacuum withstand capability of transformer main tank with bushings, radiations, fitting and accessories		250mm of mercury	250mm of mercury

Specific Technical Particulars of 6.6kV/0.415kV Transformers shall be as follows:

Description	Unit	Technical Particulars
Make		As per Preferred Makes/Manufacturers
Type		As per Specification
Applicable Standards		As per Specification
Rated output	KVA	(*)
Quantity required	Nos.	3
Transformer location		Indoor
No load transformer ratio	kV/kV	6.6/0.415kV
Number of phases		3
Rated frequency	Hz	50
Impedance at all taps	%	Value as per IS 1180
Number of winding / material of conductor		Two/Copper

Type of cooling		ONAN	
Tap changer		Full capacity, Off-Circuit type on HV side with local marshalling box and Remote Tap Changing panel	
Tap range	%	+ 5 % to -5 %	
Tap step	%	2.5 %	
Terminal connection HV terminals LV terminals		Cable box suitable for 6.6kV XLPE, Al. Conductor armoured cables (*) Cable box suitable for 650/1100 V XLPE,Al. Conductor armoured cables (*)	
Current Transformer			
On LV		(*)	
On LV Neutral		(*)	
LV Neutral earthing		LV Neutral shall be brought out through a 1.1 kV rated bushing, both inside the cable box for forming the 3 Ph, 4-wire system and outside the cable box for direct connections to earth by means of Copper Earthing conductor (*)	
One-minute power frequency			3.0
One-minute power frequency			3.0
withstand voltage (dry and wet)	kV (r.m.s)		
1.2/50 micro second full wave impulse withstand voltage	kV (peak)		-
Insulation of bushings		H.V.	L.V. (Line and Neutral)
Rated Voltage of bushing	kV	7.2	1.1
One-minute power frequency withstand voltage	kV (r.m.s)	70	3.0

1.2/50 microsecond full wave impulse withstand voltage	kV (peak)	60	-

Description	Unit	Technical Particulars	
Minimum creepage distance	Mm	25mm/kV on 7.2kV	25mm/kV on 1.1 kV
Vacuum withstand transformer main Tank with bushings, radiations, fitting And accessories.		250mm of mercury	250mm of mercury

NEUTRAL EARTHING RESISTOR

Applicable Standards

Neutral earthing resistor shall conform to latest applicable standards specified below. In case of conflict between Standards and this specification, this specification shall govern.

Neutral Earthing Resistors : IEEE32

Degree of Protection for enclosures : IS 13947 (Part I) / IEC 947-1 / BSEN 60529

Design Features

Resistor Element

The element material shall possess a balanced combination of properties, uniformity of resistance and mechanical stability over the intended temperature range, without any injurious effects on the elements and its associated insulation.

The resistor assembly shall be designed for a maximum temperature rise as per IEEE 32, Table 6, Column 7. The maximum operating temperature shall not be higher than 80% of the maximum design temperature.

Degree of Protection

The minimum degree of protection for the resistor element shall be IP 34.

Construction

The construction of the resistor assembly shall be such that the minimum required insulation resistance is maintained under all atmospheric conditions, without a space heater.

The front and back covers shall be removable for access to internal resistor connection and for removal of resistor banks.

The resistor shall be housed in a free standing and self-supporting metal enclosure suitable for installation in outdoor, humid atmospheric condition with IP-55 protection. For outdoor installation, the top of the enclosure shall be protected against direct sun radiation.

The enclosure shall be suitable for installation on a concrete foundation.

Terminations

The connection box and terminals shall be suitable for the cable specified and adequate space shall be provided for termination of cable.

All conductor terminations shall be bolted welded or brazed. Low melting alloys used to join connectors, which would be adversely affected by the resistor operating temperatures, shall not be used. All conductor terminations must be mechanically secured to provide continuous electrical continuity and shall be rated for the full system voltage.

Terminal box protection shall be minimum IP 55 for outdoor installation.

Cable gland plate shall be made of non-magnetic metal.

Specific Technical Particulars of 6.6kV Neutral Earthing Resistor shall be as follows:

Description	Unit	Technical Particulars
GENERAL		
Application/Designation		Transformer Neutral Earthing
Quantity	Nos.	2
Type Material A) Wire Wound (Stainless Steel) B) Strip Type Element	Nos.	Stainless Steel
Installation		Outdoor
Enclosure A) Sheet Steel Thickness B) Tank Type Weather Proof		Totally Enclosed Dust and Vermin Proof. 2 Mm

Description	Unit	Technical Particulars
With Aluminium Covers C) Tank Type with Galvanised Screen Covers		IP 55 Epoxy paint

D) Safety Screened Enclosure for Personnel Protection E) Degree of Protection F) Colour Shade		
Cooling		Naturally Air Cooled
Site Conditions A) Area Classification B) Gas Group C) Temperature Class		
RATINGS		
Rating	kW	(*)
Ohmic Value	Ohms	(*)
Taps	%	As per Specification
Rated Current	A	(*)
Duration of Rating Continuous / 60 Secs.		10 Sec.
Line to Neutral Voltage	kV	3.15
Insulation Class	kV	6.6
Voltage Class of Stand Insulators	kV	6.6
CURRENT TRANSFORMER a) Required and Part of Supply b) Ct Details		2 Core (*)/(*)

Description	Unit	Technical Particulars
C) Ratio D) Rating E) Class	A VA	(*) 5P20 – Both Cores Have Same Accuracy Class
TERMINAL CONNECTIONS		
Incoming to Terminal Box A) Cable Type B) Size	MM2 MM	 6.6kV (UE), 1C, XLPE, Al, Armoured cable

C) Overall Diameter D) Gland or Entry Type & Size		(*) (*)
Outgoing from Resistor		All Taps of Resistors Shall Be Brought to Terminal Box
Outgoing from Terminal Box A) Cable Type B) Size C)Overall Diameter D) Gland or Entry Type & Size	 MM2 MM	 6.6kV (UE), 1C, XLPE, Al, Armoured (*) (*)
Resistor Earthing Bushing Suitable for Conductor Of A) Material B) Size		
APPLICABLE STANDARDS Neutral Grounding Resistor Current Transformer Degree Of Protection Provided by Enclosures		 IEEE 32 IEC 185 IS 2147

TECHNICAL SPECIFICATION FOR COMPACT SUBSTATION (33/0.415KV)

1. Scope

This specification covers the design, Engineer-in-Charge manufacture, Shop testing packing, transportation to site, site storage, installation, testing and commissioning of a SCADA operated, prefabricated, factory assembled and fitted. 8 nos of required capacity in WDC areas and 1 no required capacity at WTP plant are to be installed at respective locations.

Compact Sub Station [CSS] consisting of following main components.

- 36kV, non-extendable, metal clad SF6 insulated switchgear, sealed for life, Ring Main Unit (RMU)
- Dry type 33/0.433kV distribution transformer
- LV switch board.
- Prefabricated weather proof enclosure.
- SCADA connection for remote control and monitoring.

All termination and connections to high voltage and low voltage side of distribution transformer, earthing and any other work to complete the works in all respects whether specifically mentioned or not in this specification.

Portable Fire extinguishers for electrical fires

Complete Documentation

Training to Owners personnel

The CSS is to be totally free from any external deposit (dust, condensation etc.) and suitable to operate in highly humid, hot environment without any preventive maintenance, cleaning etc. It shall be of "fit and forget" type. All nut bolts, frames etc. shall be rust proof, typically of stainless steel or materials not prone to rusting, in site environmental conditions.

CSS can be placed indoor or outdoor as per detail design and requirement. Scope shall also include design, Engineer-in-Charge of all the civil and all other related site works so as to complete the works in all respects.

The prefabricated substation unit is required for fast installation, to be maintenance free and with life expectancy of thirty years under site conditions.

Climate and Isocerunic Conditions

For AURIC BIA Project, the electrical equipment selected shall be such so as to give trouble free operation during the life of the equipment, under the most stringent atmospheric conditions prevailing at site.

Basic Design Criteria

The CSS shall be designed with the following design criteria:

- For design purpose maximum, ambient temperature of 50° C shall be considered.
- It shall be factory built and tested and preferably transported as such so that it is ready for site installation. Only external connections need to be done at site.
- Design to comply with latest version of IEC 62271-202.
- Maintenance free Ring Main Unit [RMU] with SF6 insulation sealed for life as per IEC standard.
- Dry type, epoxy insulated transformer with HV side metering.
- LV Switchboard with Capacitor bank for automatic power factor correction [APFC].
- Enclosure to have independent compartments for RMU, transformer and LV Board with suitable entry doors.

The electrical equipment including the enclosure, its supporting structure etc. is to be rust and corrosion proof throughout its life. In case there is no alternative to items such as mild steel sheet, and other structural items, the same shall be hot dip galvanized [minimum 610 gm zinc /m2] and epoxy painted. Nut, bolts, washers and other similar items shall be of rust proof material such as stainless steel.

Cables shall be mostly in trenches of concrete, as per site conditions.

The Enclosure consisting of High Voltage switchgear, Low Voltage switchgear & Transformer of the Unitized substation shall be designed to be used under Indoor or outdoor service condition.

Quality of Material:

All material used shall be new and of best quality and of class most suitable for working under the conditions specified herein without distortion or deterioration.

Galvanization of steel shall only be done by hot dip process after the parts are ready for the purpose of assembly. Alternatively stainless steel of the quality suitable for site shall be used.

Design and Standardization

The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to withstand sudden load variations due to short circuits and other fault conditions.

The design shall incorporate every reasonable precaution and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the switchgear.

All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All Connections and contacts shall be of ample section and surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position.

Standard sizes of bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum. Cast iron shall not be used for any part of the equipment which may be subjected to mechanical stresses. All apparatus shall be so designed and constructed as to obviate the risk of short circuits of the live parts by reptiles, rodents etc. Metal cubicles, housings and covers shall be 100% weather / vermin proof.

All parts shall be manufactured in accordance with relevant standard specifications. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.
All apparatus, connections and cabling [FRLS type] shall be designed and arranged to minimize the risk of fire and any damage, which might be caused in the event of fire.
Design shall take into consideration that equipment is to be operated under rainy, hot and humid atmospheric conditions, and surroundings with reptiles and rodents. Certification offering evidence for the satisfactory operation under such environmental conditions shall be provided.

- Technical Data for CSS

S. No.	Description	Technical Data
1	Applicable Standard	IEC 62271-202
2	Design Ambient Temperature	50□ C
3	Type of Ventilation for Normal Condition Hot Condition	 Natural Natural
4	Compartmentalized	Yes
5	Rated temperature enclosure class	10
6	Degree of protection for external enclosure for Transformer compartment	IP34
	Degree of protection for external enclosure for HV compartment	IP54
	Degree of protection for external enclosure for LV compartment	IP54
7	Location	Indoor / Outdoor
8	Rated HV	36kV, RMU, with metering
9	Transformer	100,160,250,1000 KVA, Dry Type
10	Nominal rated voltage rating on LV	415V
11	LV Board	Incomer ACB + Outgoing MCCB
12	Enclosure material	Resistant to rusting
13	Thickness of sheet (minimum)	2mm for enclosure.
14	Base	4mm hot-dip galvanized
14	Enclosure Paint	Epoxy, RAL 7032
15	SCADA system / Remote Control	Yes

Painting

Since the local environment is harsh, even galvanized steel will rust after a few years. Therefore, paint of suitable quality to protect the equipment is of utmost importance.

All sheet steel work shall be phosphated in accordance with IS: 6005 'Code of practice for phosphating iron and steel, through seven tank processes. Oil, grease, dirt shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed with the application of two coats of ready mixed zinc chromate primer. The first coat may be air dried while the second coat shall be stove dried. Panels shall be painted with epoxy paint of superior quality. ALTERNATIVELY, the panels shall be painted with electrostatic epoxy powder coating process to have paint of hard coating. Necessary details shall be provided to Engineer-in-Charge in this regard for prior approval.

- Paint Thickness

The final finished thickness of paint film on sheet shall be approximately 60 to 80 micron. The finished painted surface of panels shall present aesthetically pleasing appearance free form dents and uneven surfaces. Paints shall not scale off or wrinkle or be removed by abrasion due to normal handling. The colour for finishing paint shall be Siemens grey as per RAL 7032. Unless otherwise desired the same shall be got confirmed from the Engineer-in-Charge before taking up painting. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting.

- Spare Paint

A small quantity (one litre per board) of finishing paint shall be supplied for minor touching up required at site after installation of the panel.

Drawings and Manuals

The Agency shall furnish all drawings & manuals as called for and given below and also those which are not specifically included but are necessary for proper operation and maintenance.

- Complete assembly drawing of the Packaged & Ring Main Unit showing plan, elevations, side & typical sectional views giving complete dimensions.
- Assembly drawings & weight of main component parts.

- Foundation drawings showing the load on the foundations.
- Schematic control & wiring diagram in accordance with BIS / IEC practice.
- Bushing drawings & their specification.
- Cable termination details & drawings along with terminal connection drawings.
- General arrangement drawing of the complete panels showing CTs, PTs together with dimensions.
- Maintenance Manual.
- Graph indicating short circuit Vs number of tripping for Vacuum Circuit Breaker.
- Permitted mechanical opening and closing operations.
- Besides above drawings, the Agency shall submit type test certificates, leaflets & instruction manuals.
- Within 60 days after contract award, the Agency shall furnish to the Engineer-in-Charge three sets of following drawings for approval. No manufacture of equipment shall commence untill the drawings are approved:
- General arrangement drawing of complete assembly of packaged & individual RMU including giving dimensions & their salient features.
- Schematic wiring diagram.
- Foundation drawings.
- Locations of cables slots, cable terminations, CTs, PTs & terminal connections.
- Any other necessary detail.
- Instruction manuals for erection/construction, maintenance and operation.
- Height of centre line of HV and LV connectors of transformers from the rail top level as well as from the roof of enclosure.

Quality Control

All material shall be new and of best quality and of class, most suitable for working under the environmental conditions specified herein without distortion or deterioration of equipment during the lifetime of not less than twenty-five years.

1. Quality Assurance

Manufacturer shall submit its quality assurance plan for the approval of Engineer-in-Charge prior to fabrication.

2. 36kV RING MAIN UNIT

Specifications same as mentioned in Section 3 “Technical Specifications for Ring Main Unit”

3. DRY TYPE TRANSFORMER

- **General**

The distribution transformer in CSS shall be indoor Dry Type Transformer, complete with all accessories / fittings and spare parts as specified herein.

Three-phase transformers shall be with cast resin type, class F insulation system with natural (AN) cooling for indoor installation, for use in three-phase HV/LV distribution systems.

- Specific Technical Requirements (Standard Value)

Rated KVA	:	up to 1600KVA	
Number of phases	:	Three	
Type of installation	:	Indoor	
Frequency	:	50 Hz	
Cooling medium	:	AN	
Rated Voltage			
High voltage winding	:	33 kV (DELTA)	
Low voltage	:	0.433 kV (STAR) with Neutral	
Highest Continuous System Voltage:			
High Voltage	:	36kV	
Low Voltage	:	0.450 kV	
Method of System Earthing	:		
High Voltage	:	Unearthed	
Low Voltage	:	Solidly grounded	
Type of tap changer	:	OFF CIRCUIT GANG OPERATED	
Range of tapping	:	+5% to -5% with 5 steps of 2.5% on 33 kv side	
Impedance at rated KVA at 75oC	:	As per relevant IS	
Insulation and level	:	HV	LV
Type of insulation	:	Uniform	Uniform
One-minute power frequency withstands	:	28	3

test voltage (kV)			
Impulse withstand test voltage (kVp)	:	75	8
Winding			
Connection	:	Delta (HV)	Star (LV)
Material	:	Aluminium	
Vector group	:	Dyn-11	
Terminal details			
HV Termination	:	Suitable for tee-off Breaker of RMU	
LV Termination	:	Suitable for phase and neutral connection between transformer and LT board through an insulated copper bus bar or a sand witched copper bus bar enclosed in a non-segregated bus duct. The size of the neutral bus shall be same as phase bus.	
LT Neutral earthing	:	A separate Neutral point to be provided for earthing.	
Minimum Clearance in Air:		33 kV	0.433 kV
Phase to phase (mm)	:	As per IEC	
Phase to earth (mm)	:	As per IEC	
Design Ambient temperature:		50 degrees C Maximum Temperature Rise of winding over an ambient of 50°C and 1000m altitude, not to exceed 90°C.	
Maximum Temp of insulation:		150°C	
Over load capacity	:	As per IEC	
Noise level at rated voltage & frequency:		As per NEMA Pub. Tr-1	

- Transformer Losses

The guaranteed losses of the transformer shall not exceed as given in the Energy Conservation Building Code [ECBC], as per latest guidelines of the Bureau of Energy Efficiency [BEE] for the required rating of distribution transformer or as per the Bureau of Indian Standards [BIS] for transformers having energy efficiency level-3. Transformers not complying with BEE / BIS loss guidelines shall not be accepted. The guaranteed values of no load losses and load losses shall be stated in the bid and these shall be firm.

- Performance

Transformer shall be capable of withstanding for two seconds the short circuit at its terminals as per requirements of IS-1180 without any damage. Source short circuit power on the primary of the 33 or 11/0.433 kV transformer shall be assumed as 500 MVA for the short circuit capability of the transformer. The thermal ability withstand due to short circuit shall be demonstrated by calculation.

The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.9 Tesla.

Transformer shall, under exceptional circumstances, due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds. The transformer may be operated continuously without danger on any particular tapping at the rated KVA ±10% of the voltage corresponding to the tapping.

- Miscellaneous

Complete hardware for fixing the transformer as a part of packaged RMU substation shall be provided whether specifically mentioned or not.

- Delivery

The equipment shall be delivered, erected and commissioned at site as a part of the packaged RMU substation.

- Conflict in Clause

In case of any conflict between the Specific Technical Requirements and General Technical Requirements, the requirements indicated as Specific Technical Requirement shall prevail over the General Technical Requirements.

Environment: Climatic, Environmental and fire-resistant Requirements

As the equipment is to be installed in humid atmosphere the equipment and material provided must resist the corrosion likely to occur in any case.

Further the transformer must comply to the following class requirements of clause 13 of IS 1180/ IEC 60076- 11.

Class C1: Operation, transportation and storage at ambient temperature as low as -5ºC

Class E2: Frequent condensation combined with high pollution.

Fire Class F1: Limited flammability, Self-extinguishing of the fire and to be free from halogens, emission of toxic gases, and minimum of thick smoke.

The above classes will be indicated on the rating plate.

Note: The manufacturer must produce a test report, complying to above clauses as per test procedure of IEC-60076-11. Test report shall be from an accredited laboratory acceptable to Engineer-in-Charge, for a transformer of the same design.

Name Plate

Transformer rating plate in English and Hindi language shall contain the information as given in Clause 15 of IS: 1180 / IEC 60076-11. The details on rating plate shall be finalised during the detailed Engineer-in-Charge.

General Technical Requirements

Dry type transformer will be manufactured in accordance with a quality system in conformity with ISO 9001 and complying to latest version of IEC 60076-11

Environmental management system is to be in conformity with ISO 14001, which shall be certified by an independent recognized organization acceptable to Engineer-in-Charge.

Codes & Standards

The design, material, fabrication, inspection, testing before dispatch, erection/construction, testing, commissioning and performance of distribution transformers shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the Agency of this responsibility.

Transformers shall conform to the latest applicable standards and codes of practice as given below.

S.No.	Standard Number	Description
1	IS: 5	Colour for ready mixed paints and enamels.
2	IS: 104	Ready mixed paint, brushing, zinc chrome Priming
3	IS: 1180	Transformers
4	IS: 1271	Thermal evaluation and classification of Electrical Insulation
5	IS: 1363	Hexagon head bolts, screws and nuts of Product grade C
6	IEC: 60076-11	Dry Type Transformers

S.No.	Standard Number	Description
7	IS: 2016	Plain washers
8	IS: 2071	Method of high voltage test techniques
9	IS: 2074	Ready mixed paint, air drying, red oxide-zinc chrome, primary
10	IS: 2099	High voltage bushing for alternating voltage above 1000 V.
11	IS: 2633	Methods for testing uniformity of coating of zinc coated articles
12	IS: 2932	Enamel, synthetic, exterior (a) undercoating (b) finishing
13	IS: 3043	Code of practice for earthing
14	IS: 3347	Dimensions for transformer Bushings
15	IS: 3639	Fittings and accessories for power transformers
16	IS: 4257	Dimension for clamping arrangements for porcelain transformer bushings
17	IS: 5216	Guide for safety procedures and practices in electrical work
18	IS: 5561	Electric power connectors
19	IS: 7421	bushing for alternating voltage upto & including 1000 V
20	IS: 10028	Code of practice for selection, installation and maintenance of transformers.
21	IS: 12360	Voltage bands for electrical installation including preferred voltages and frequency.
22	C.B.I.P. Publication	Manual on Transformers

The equipment complying with other internationally accepted standard may also be considered if they ensure performance superior to the Indian Standards.

Drawings

The Agency shall furnish, within fifteen days after issuing of Letter of Intent, the following drawings / documents incorporating name of project and transformer rating for approval.

Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground etc.

- Foundation plan showing loading on each wheel and lifting lugs.
- GA drawings / details of bushing and terminal connectors.
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- Interconnection diagrams both on HV & LV sides.
- Over fluxing withstand time characteristic of transformer.
- Technical leaflets of major components and fittings.
- As built drawings of schematics, wiring diagram etc.
- Setting of winding temperature indicator.
- Completed technical data sheets.
- Details including write-up of tap changing gear.
- H.V. bushing.
- Bushing Assembly.
- B-metallic connector for connection to specified conductor / bus-bar /in bus-duct.
- Assembly.
- Two earthing terminals & core earthing
- Thermometer pockets
- Inspection cover

All drawings / documents, technical data sheets and test certificates / results / calculations shall be furnished.

Any approval given to the detailed drawings by the Engineer-in-Charge shall not relieve the Agency of the responsibility for correctness of the drawing and in the manufacture of the equipment for the packaged substation.

General Constructional Features

All material used shall be of best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.

Similar parts, particularly removable ones, shall be interchangeable.

Screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Bolts and nuts exposed to atmosphere shall be of stainless steel.

Exposed parts shall not have pockets where water can collect due to moisture or otherwise.

Labels, indelibly marked, shall be provided for all identifiable accessories. All label plates shall be of in-corrodible material.

All internal connections and fastenings shall be capable of operating under overloads allowed as per specified standards without injury.

Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.

No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.

The galvanizing if required shall be of minimum 610 gm zinc per square meter and it shall be hot dip galvanized.

Painting [as applicable]

The structural steel work shall be cleaned of all scale and rust by shot-blasting. Steel surfaces exposed to the weather shall be thoroughly cleaning and have a priming coat of zinc chromate applied. The second coat shall be of a glossy oil and weather resisting non- fading, paint of shade No. 631 as per IS: 5.

Metal parts not accessible for painting shall be made of corrosion resistant material.

All paints shall be carefully selected to withstand heat, rain, hot humid atmosphere and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

In case finish paint chips off or crinkle during transit or installation, the Agency shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the Agency.

Under Carriage

The transformer shall be supported on non- corrosive steel structure with forged steel flanged wheels suitable for moving the transformer completely. Wheels shall be provided with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication.

Magnetic Core

The magnetic circuit shall be constructed from prime quality high grade cold rolled, non-ageing, grain oriented silicon steel lamination. The manufacture shall submit the following documents to prove only Prime Quality Core are used:

Invoice of the supplier

Mill's test Certificate

Packing list

Bill of loading

Bill of entry certificate to custom

The manufacturers shall indicate whether they have in-house core cutting facilities or not, if not, they shall indicate place of cutting.

To reduce the noise produced by the magnetic core, it is to be equipped with noise-damping devices.

To reduce the no-load losses, the magnetic core is to be stacked using overlapping-inter-locking technology.

The laminations shall be free of all burns and sharp projections. Each sheet shall have an insulating coating.

The insulation structure for the core to bolts and core to clamp plate shall be such as to withstand a voltage of 2000 V for one minute.

The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.

All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.

The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

The core clamping structure shall be designed to minimise eddy current loss.

The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.

The core shall be provided with lugs suitable for lifting the complete core and coil assembly

The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination which may cause local heating. The construction is to be of 'core' type.

Internal Earthing

All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.

The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out. A dis-connecting link shall be provided on transformer to facilitate disconnections from ground for IR measurement purpose.

Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

Winding

LV windings

The LV winding shall be of Aluminium foils in order to cancel out axial stress during short circuit. This foil will be insulated between each layer using a heat-reactivated class F pre-impregnated epoxy resin film including the ends of the winding. The whole winding assembly is to be polymerized at suitable temperature to ensure high level of resistance environment and to have excellent dielectric strength.

HV windings

HV winding shall be separated from the LV winding to give an air gap between the MV and LV circuits for easy maintenance.

HV winding shall have linear potential gradient from top to bottom to have low stress between adjacent conductors, with high dielectric strength and low partial discharge.

HV winding shall be of Aluminium wire with class F insulation cast in vacuum with fire proof / flame retardant epoxy resin.

The interior and exterior of the windings will be reinforced with a combination of glass fibre or similar material to provide thermal shock withstand.

HV winding support spacers

Winding support spacers are meant to provide sufficient support in transport, operation, short circuit and earthquake conditions.

These spacers will be circular in shape for easy cleaning. They will give an extended tracking line to give better dielectric withstand under humid or high dust conditions.

These spacers will include an Elastomer cushion that will allow it to absorb expansion as peer load conditions. This Elastomer cushion will be incorporated in the spacer to prevent it being deteriorated by air or UV.

HV Connections

The connections shall be of copper and made from the top to give a safe and neat connection. A terminal plate shall be provided.

The HV connections will be made from the top connection bars. Each bar will be drilled with a hole for connection of cable lugs on terminal plates.

The HV connection bars will be in rigid copper bars protected by heat shrinkable tubing.

HV connections in cables are not allowed, in order to avoid all risk of contact, due to cables flapping.

Depending upon the design of the manufacturer the arrangement shall be approved by the Engineer-in-Charge.

LV Connections

The LV connections with copper bars will be made from top of coils on the opposite side to the HV connections.

Connection of the LV neutral will be directly made to the LV terminals between the LV phase bars. There shall be a separate earth point connected to neutral.

Depending upon the design of the manufacturer the arrangement shall be approved by the Engineer-in-Charge.

Transformer Thermal and Overload Protection

PTC type sensors [minimum 6] shall be placed in the winding to measure the winding temperature.

The transformer shall be equipped with an overload and thermal protection device with sensors to continuously monitor the LV and HV winding temperature for each phase.

Digital monitoring thermometers shall be installed locally in the CSS on LV Board, with a provision for monitoring the temperatures at remote SCADA. Necessary alarms and trip contacts along with warning LEDs shall be provided to protect the transformers from high temperature.

Sensors shall be so placed that it shall be possible to replace the same very easily. All sensors along with enclosures, digital thermometers, transducers, sensing relays, connecting leads, etc. complete in all respects shall be in the scope of supply. For this purpose, Security & Communication Agency shall lay a fibre optic cable from CSS to SCADA control Centre, termination of which to such devices shall be in the scope of Agency.

Provision shall be made that in case of fire the transformer circuit breaker shall be tripped.

Off Circuit Tap Changer

There shall not be a bolting arrangement for selecting the taps and shifting the copper bars. Instead the off circuit tap changer shall be operatable by means of an operating handle / ring brought out-side the tank operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The arrangement shall be such that an operator can change the tap while standing at ground level with complete ease. There shall be separate cover for tap changer.

Safety of Personnel

Transformer shall be properly fenced/protected in case the maintenance personnel are likely to come near the live parts while carrying out normal maintenance or monitoring activities near the transformer.

Fittings

The following fittings shall be provided on the transformers:

Separate LV neutral point, with two joined points for double earthing of neutral along with tinned copper strip compatible to transformer short circuit current rating for earthing.

One danger Plate

Temperature indicating device, sensors etc. complete in all respects with contacts for re-mote / local indication.

Lifting eyes or lugs for the top cover, core and coils and for the complete transformer.

Platform lugs / haulage lugs on under carriage.

Marshalling box.

Rating and connection diagram plate.

Two numbers earthing terminals on opposite sides, associated nuts, bolts and tinned copper earth strip of suitable section for connections to purchaser’s grounding strip.

4 bidirectional rollers.

Thermal and overload protection devices and equipment, along with necessary transducers, sensors etc. for local and remote SCADA indication, Alarm / trip contacts, LED indicators complete in all respects

Note: The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

Radio Interference and Noise Level

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimise interference with communication circuits. Transformer noise level, when energised at normal voltage and frequency shall be as per NEMA stipulations.

Mandatory Spare Parts

The mandatory spare parts shall be included in the bid along with costs. These shall be considered in evaluation.

Recommended Spare Parts

Agency shall provide a list of recommended spare parts for 5 years operations. The cost of these spare parts shall not form part of Agency proposal.

Tests

The Transformers shall be completely factory tested before dispatch in accordance with the standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification.

- Routine Tests

Transformer routine tests shall include tests stated in latest issue of IS: 1180 / IEC 60076-11. These tests shall also include but shall not be limited to the following:

Measurement of winding resistance.

- Voltage ratio on each tapping and check of voltage vector relationship.
- Impedance voltage at all tapping.
- Magnetic circuit test
- (After routine tests, each core shall be tested for 1 minute at 2 kV between all bolts, side plates and structural steel work. Immediately prior to the dispatch of the transformer, the magnetic circuit shall be pressure tested for 1 minute at 2 kV A.C. between the core and the earth).
- Load losses.
- No load losses and no load current.
- Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt/R1 mt).
- Separate source voltage withstand test (applied potential).

- Induced voltage test.
- Measurement of partial discharges.

Partial discharges less than or equal to 10 pC at 1.30 Un, or

Partial discharges less than or equal to 5 pC at 1.30 Un (Special test)

- Measurement of acoustic noise level.
- Measurement of Zero sequence impedance.

All routine and type tests shall be done free of cost. If it is to be done on the cost basis, the same may be indicated in the schedule of price and delivery and this will be taken into account for evaluation of prices.

When transformers are equipped with a protection enclosure, these shall be tested in their enclosure.

Moreover, in addition to the routine tests, the transformer shall be subjected to the following type tests:

- Lightning Impulse Test

This test shall be carried in accordance with clause 12 of the latest issue of IS: 1180. The Agency shall quote separate price for lighting impulse test on HV and LV windings. (one limb only).

- Temperature Rise Test

The temperature rise test shall be carried out in accordance with IS: 1180 /IEC-60076. The Temperature rise shall not exceed the values as in the IS: 1180 / IEC 60076-11

- Noise Level Test:

It shall be carried out as per IEC-60076-10

- Environmental and Firefighting tests

Certificates for tests carried out for Compliance to Class C1, E2 and F1 as per IEC 60076-11.

- Short Circuit Test

It shall be carried out as per IEC 60076-5. Alternatively, Authority at its discretion can ask for calculations instead of actual test.

- Test Waiver, Procedures and Costs

Certified test report and oscillograms shall be furnished to the Engineer-in-Charge for evaluation as per the schedule of distribution of documents. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.

The Agency shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the Agency shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing.

- Witnessing of Tests

The Clients' Engineer-in-Charge reserves the right to witness any or all tests. If required, visits can be made to the works of manufacturer to ensure that the approved quality ensuring programme is being followed. In this regard all the necessary facilities shall be arranged by manufacturer at his end and cost borne by the Agency.

- Site Tests

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

- ✓ Visual checks for connections etc.
- ✓ Dry out test
- ✓ PI / Resistance measurement of windings
- ✓ Ratio test
- ✓ Tap changer test
- ✓ Temperature Indicators & alarms
- ✓ Magnetizing current
- ✓ Earth connections are made.

- Rejection

The Engineer-in-Charge can reject any transformer if during tests or service any of the following conditions arise:

- ✓ No load loss exceeds the guaranteed value.
- ✓ Load loss exceeds the guaranteed value.
- ✓ Impedance value exceeds the guaranteed value by 10% or more.
- ✓ The difference in impedance values of any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.
- ✓ Winding temperature rise exceeds the specified value.
- ✓ Transformer fails on impulse test.
- ✓ Transformer fails on power frequency voltage withstand test.

- ✓ Transformer is proved to have been manufactured not in accordance with the agreed specification.

Instructions Manual

Six sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection/construction, testing, operation and maintenance of the transformer. The manuals shall include amongst others, the following particulars:

Marked erection/construction prints identifying the components, parts of the transformer as dispatched with assembly drawings.

Detailed dimensions, assembly and description of all auxiliaries.

Detailed views of the core and winding assembly, winding, connections and tapping's, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.

Salient technical particulars of the transformer.

Copies of all final approved drawings.

Detailed O&M instructions with periodical check lists etc.

Completeness of Equipment

All fittings and accessories, which may not be specifically mentioned in the specification but are necessary for the satisfactory operation of the equipment, shall be deemed to be included in the specification. These shall be furnished by the Agency without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not.

All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it shall be presumed that all the provisions of the specifications are accepted by the Agency.

Tools & Tackles

All the necessary tools and tackles required for the normal operation shall be supplied by the bidder.

LV Switchboard for Compact Sub-Stations

General

The LV switchboard for CSS shall be indoor 3-Phase, 4-wire, 440 V, 50 HZ, neutral solidly grounded, complete in all respects including base channels, foundation bolts and other hardware for various packaged RMU distribution sub-stations.

Standards

The equipment covered in these specifications shall conform to the latest revisions / replacements of the following Indian Standard Specifications.

The equipment complying with other internationally accepted standards shall also be considered, if they ensure performance equivalent to or superior to Indian Standards.

S. No.	Standard Number	Description
1	IS: 5	Colours for ready mixed paints & enamels
2	IS: 722	AC Electricity Meters
3	IS: 1554	PVC insulated (heavy duty) electric cables
4	IS: 2147	Degrees of protection provided by enclosures for Low-voltage switchgear and control gear
5	IS: 2419	Dimensions for panel mounted electrical indicating & recording electrical instrument
6	IS: 2551	Danger notice plates
7	IS: 2633	Methods for testing uniformity of coating of Zinc coated articles
8	IS: 2705	Current Transformers
9	IS: 3156	Voltage Transformers
10	IS: 3231	Specification for electrical relays for power system protection
11	IS: 4237	General requirements for Switchgear & Control gear for voltage not exceeding1000 volts.
12	IS: 4794	Push buttons
13	IS: 5082	Wrought aluminium and aluminium alloy bars rods, tubes, sections plates, sheets for electrical application
14	IS: 5578	Guide for making of insulated conductors
15	IS: 6005	Code of practice for phosphate coatings of iron and steel (First Revision)
16	IS: 6875	Control switches (switching devices for control and auxiliary circuit including Agency relays) for voltages up to and including 1000 V AC and 1200 V DC
17	IS: 8623	Low voltage Switchgear and Control gear assemblies
18	IS: 8828	Electrical accessories circuit breakers for over current protection for home load and similar installations.
19	IS: 9000	Basic environmental testing procedures for electronic and electrical items
20	IS: 10580	Service conditions for electrical equipment

S. No.	Standard Number	Description
21	IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
22	IS: 13703	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC
23	IS: 13942	Low voltage switchgear and control gear
24	SP: 39	Guide for insulation coordination within low voltage system
25	IEC -60364 IEC: 60664	Low Voltage Electrical Installations [All applicable series of IEC-60364] Insulation coordination within low voltage system including clearance and creepage distance for equipment.

System Details

The L.V. Distribution Board shall be a part of a packaged RMU substation having transformer rating as in the single line diagram for that location and technical data as given under Specific Technical Requirements. Only the standard size of transformer shall be selected. Broadly the LV distribution board shall have the following configuration:

- Connection to LV side of Transformer

Connection to LV side of distribution transformer shall be through insulated, three phase, four wire tinned Copper bars. Alternatively tinned Copper bars may be considered with a non-segregated three phase four wire bus duct, or with sand-witched bus bars, conforming to relevant IS Standard as per current requirements.

- Incomer and Board Bus bar

Incomer shall be Air Circuit Breaker, draw out type, electrically operated, equipped with microprocessor based electronic trip units, complete with CTs & metering. It shall be possible to operate this breaker from remote through SCADA also. Transformer incomer rating shall be same as that of bus rating. LV Bus bars shall be three phase, 4wire, and of tinned copper. Size of neutral conductor shall be same as of phase bars. The LV Board shall be designed for fault level as given in the Specific Technical Requirements.

- Outgoing Feeders

No HRC fuses are envisaged. All the outgoing feeders shall be equipped with Moulded Case Circuit Breakers of appropriate rating.

- External Cabling

The external, three phase, four core, LV cables of required size shall be terminated to the outgoing terminals of LV switch board. Necessary cable supports shall be provided in the cable alley of the board

Design and Standardization

General

The equipment shall be designed to ensure satisfactory operation of the system in which continuity and quality of service is the first consideration. It shall also be designed to withstand sudden load variations due to short circuits and fault conditions or for any other reason.

All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and have sufficient surface area for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless steel bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.

Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.

All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards, vermin's etc. Metal cubicles, housing and covers shall be 100% weather / vermin proof and shall be able to provide the degree of protection IP-54 in accordance with latest version of IS-2147.

All parts shall be manufactured in accordance with relevant standard specifications of IEC / I.S. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.

All apparatus, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage which might be caused in the event of such an eventuality.

Specific Technical Particulars

The standard technical particulars (which must be modified considering the climatic conditions as given in relevant standards) for the LV Switchboard, are given below:

AC System	:	3 phase, 4 wire, solidly earthed
Transformer secondary Voltage	:	433V
System Nominal Voltage	:	415 volts □6%
Frequency	:	50 Hz □ 5%

Combined variation in	:	10% absolute sum of Voltage & frequency
		Bus bar Electrolytic Copper, tinned, Continuous rating [as per transformer rating]
150KVA	:	400 A
250 Circuit Performance	:	P2
Short Circuit Capability	:	50 kA (rms) for 1 Sec.
Making capacity	:	62.5 kAp
Operating Mechanism	:	Manual, trip free
Temperature rise	:	As per IS: 2516
Mechanical	:	As per IS: 2516
Auxiliary contacts	:	4 No., 4 NC
Current Rating	:	As per Single Line Drawing
Multi-function Meters		
Accuracy class	:	1
One Minute Power	:	2 kV (rms)
Frequency Withstand Voltage		
Current Transformers		
Type	:	Cast resin, Bar primary
Secondary circuit	:	1 Amp.
Voltage class and Frequency	:	1100 v, 50 Hz
Class of insulation	:	E or better
Accuracy	:	
Accuracy class &VA	:	Class 1, 10 VA
of metering CT		
Accuracy class of VA	:	5 P 15, 10 VA
of protection CT		
Short time current rating	:	50 kA (rms) for 1 sec.
Dynamic rating	:	120 kA (peak)
One Minute Power	:	2.5 kV (rms)
Frequency Withstand Voltage		
Voltage Transformers		
Type	:	Cast resin

Rated voltage	:	
Primary	:	415 V / √3
Secondary	:	110 V / √3
Accuracy class and VA burden		
Metering	:	1.0, 25 VA
Protection	:	3 P, 25 VA
Method of connection		
Primary	:	Star
Secondary	:	Star
Rated voltage factor	:	1.1 continuous, 1.5 for 3 sec.
Class of insulation	:	E or better
One-minute power	:	2.5 kV (rms)
Frequency withstand voltage		
Relay		
One Minute Power	:	2.0 kV (rms)
Frequency withstand Voltage		
Cubicle Colour Finish		
Interior	:	Glossy White
Exterior	:	Grey shade No. 631 of IS: 5
Accessories		
Plug point with MCB.		
Space heater PTC type.		
Name plate on front & rear		
Danger plates.		
Cubicle		
Minimum thickness of CRCA sheet steel:		2 mm
Base Frame channel	:	100mmx50mmx6mm
Degree of protection	:	IP-54
Rubber mat between Panel & base:		15mm

Clearance and Creepage Distances

The clearances and creepage distances shall be in accordance with Indian Standard for condensing humidity and highly polluted environment.

Labels and Marking of Connections

All equipment, control gear and the apparatus mounted thereon shall be clearly labelled indicating, their purpose and the 'ON' 'OFF' and "EARTH' positions. The labels shall be clearly lettered on enameled surface or other approved materials. Brass shall not be used for labels. Each phase of alternating current and connections shall be coloured to distinguish phase, neutral and earth. The colouring shall be respectively for red, yellow, blue for phases black for neutral and green for earth.

Each phase of alternating current and connections shall be coloured heat shrinkable sleeve. The LT switchboards shall be labelled as per designation shown in the single lien diagram. The labelling shall be finalised after the arrangement for the same, is got approved by the successful Agency during detailed Engineer-in-Charge.

Drawings and Literature

Four sets of tentative G.A., Schematic drawings and detailed literature of equipment shall be submitted with the tender clearly giving the scope of supply and bill of material to enable the Engineer-in-Charge to scrutinize all aspects of design including arrangement and support of cable accessibility for maintenance work and future additions, cable connections, general appearance etc. In addition, the Agency shall submit drawings & literature are to be furnished by successful tenderer / bidder within 2 weeks after the award of contract, which shall include the following:

Complete assembly drawings of the boards, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.

Foundation plan, embedment channel frame with associated holes and suitable size of bolts for fixing to channel frame.

Wiring diagrams including terminal wiring design and cable schedule.

Schematic control diagram, details of relays, instruments, space heaters, cubicle illumination and receptacle etc.

Bill of material of each LV board.

Layout plan of each LV board.

Bought out Items

All bought out items such as switches, MCCBs, MCB's meters, terminal blocks, cables etc. shall be of reputed make. Engineer-in-Charge reserves the right to accept only materials of

proven make at its sole discretion. The list of recommended make for major items is given in the specification volume.

Details of L.V. Switchboard

- Constructional **Details**

The Switchboard shall be made of cold rolled sheet steel of 2 mm thick having different compartments for bus-bars, cable alley and instrumentation. The board shall be floor mounted, self-supporting.

The bus-bars shall be rectangular, of tinned electrolytic copper and of approved size for current rating for phases as well as for neutral. The bus bars shall be suitably supported on non-hygroscopic insulators to withstand forces arising from short circuits in the system. These shall be suitable for harsh environmental conditions.

The switch boards shall be of compact design. All doors and covers shall be fully gasketed. Individual feeder compartments shall be provided with stainless steel hinged doors, bolted type doors shall not be acceptable. Indicating instruments shall be of 96x96 mm.

The interconnections between bus-bars and MCCBs unit shall be solid insulated, tinned copper strip permanently bolted with the bus-bars and MCCBs. The bus-bar joints shall be given a thin coating of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact area and the contact pressure is maintained permanently. The bus-bars / tee off shall be insulated with heat shrinkable sleeve tapes with red, yellow, blue colours for 3 phases and black for neutral. All the bus-bar tapping & markings shall be in accordance with relevant IS.

The gland plate shall be of Aluminium minimum thickness of 3 mm and detachable type. A strong supporting channel of 100 x 50 x 6 mm shall be provided beneath the switchboard shell besides anti-vibration rubber gasket of 15 mm thickness.

The connection from 11/0.433 kV transformers to the LV switchboard shall be through a LV non-segregated bus duct [alternatively sandwiched bus duct] or through insulated copper bus bars as per requirement.

The bus-bars shall have non-hygroscopic support insulators. The bus bar shall be insulated with heat shrinkable insulating kits.

The short circuits withstand capacity of all the bus-bars and tap-connection shall be 50 KA for one second.

- **Details of Circuits**

Each switchboard shall have the following circuit arrangement.

- Incoming

1 no. 3 phase, 4 wire incomer four pole air circuit breaker, electrically operated with microprocessor based trip circuit release. The breaker shall conform to IEC 61439.

It shall be withdrawal type. The control supply can be provided from a line connected PT from the LV connection from the transformer or any other arrangement given by Agency can also be considered during detailed Engineer-in-Charge.

3 Nos. – Metering CTs of required ratio, 10 VA Class 1, with ISF less than 5.

3 Nos. – Protection CTs

The incomer breaker shall have numerical relay having three over currents of setting 50% to 100% of 1A rating with IDMTL; current Vs time characteristics. Short circuit instantaneous trip shall be included. Alternatively, the built in microprocessor based trip units having Overload protection [IDMTL, IEC characteristics], short circuit trip [time delayed], Instantaneous short circuit protection, Ground Fault Protection can also be considered.

1 no. 96 x 96 mm flush mounted multi-function meter. Meter shall measure unbalanced neutral current also along with three phase currents simultaneously.

1 no. digital bus voltmeter scale 0-500 V with three-line reading.

If required, 1 no. Automatic Power factor controller [APFC], connected to y-phase metering CT, with SCADA communication, and five steps to switch on capacitor banks for power factor improvement to 0.95.

Note: Number of steps is tentative and shall be finalised during detailed Engineer-in-Charge.

LED type lamps to indicate breaker closed, open, auto trip, protection operation, spring charged etc. indications.

- **Outgoing feeders**

3 phase, 4 wire, outgoing cable circuits are envisaged from the switchboard and each circuit shall have the following items, indicating instruments, terminal connectors etc.

4 pole withdrawable type Moulded Case Circuit Breakers of appropriate, rating as indicated in the single line diagrams.

- **Earth leakage relay**

3 nos. metering current transformers of secondary rating 1A & 1.0 accuracy class having primary current as per SLD.

1 no. 96x96mm flush mounted multifunction meter as per CT rating.

Termination points for 4C XLPE, Al. Armoured cables with lugs.

The LV board must have sufficient space of not less than 100 mm between two termination points for external cables.

Cable alley along with necessary clamping arrangement for the outgoing feeder cables.

Indicating LED lights – red, yellow and blue for the supply.

Capacitor Bank & Automatic Power Factor Controller [APFC] (If Required)

Considering the transformer capacity and load power factor as 0.8, a suitable size of switched capacitor bank shall be mounted inside the LT compartment to improve the power factor to 0.95. Necessary calculations, number of steps and switching details shall be provided for approval.

Capacitor units shall be fuse-less, with loss not exceeding 0.5W / kVAR, with metallised polypropylene film, double casing insulation, self-healing feature, non-flammable and with nontoxic material. Reactors shall be non- resonance, dry type resin embedded. Capacitor unit shall with automatic operation steps as required, built in discharge resistor and mounted on stainless steel frame. APFC shall also be supplied by the same manufacturer. APFC shall have LCD display, programmable, with monitoring of all parameters locally as well as at remote SCADA on mod bus via fibre optic cable. It shall be with built in cabinet placed in the cubicle of LV board with easy access doors.

Earthing

The LV switchboard shall be provided with two separate earthing terminals at the ends. With minimum rated for 50kA for 3 sec running in the board. All metal parts, enclosure, transformer and neutral have to be interconnected and ready for connection to the external earthing arrangement.

The earthing terminals shall be identified by means of proper embossed sign marks adjacent to the terminals.

In the cable gland area provision shall be made at cable gland for armour earthing and then connecting it to main earth bar in a proper way. There shall be a continuous tinned copper earth bus bar in the board. The size of the earth bus bar shall be suitable to carry 50 kA for 3 second. The bus bar shall not be visible or removable from outside the switchboard. The

earth bus bar shall have necessary holes, nuts & bolts including washers for making earth connection of cable glands / armouring of the cables.

Switchboard Lighting & Heating

A lamp holder with a 11 W LED lamp and operated by an internal SP-MCB shall be fitted for internal illumination. In addition, a 3 pin 6A/25A socket shall also be provided with a separate SP-MCB. Space heater of suitable rating of PTC type, and with SP MCB shall also be provided to avoid any moisture condensation inside the switchboard.

Danger Notice Plates

An enameled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the middle upper front of the switchboard.

Tests

All tests as required in relevant Indian standard shall be carried out on the LV switchgear. Engineer-in-Charge shall witness the tests at the works of the manufacturer.

- **Type Tests**

The purchaser may ask the manufacturer to conduct the following type tests on one of the AC Boards.

Verification of temperature rise limits test

Verification of rain test to determine the degree of protection against rain.

Verification of dielectric properties.

Necessary type tests as per IS on all the individual items such as ACB's, MCB's, MCCB's, instruments, links etc.

- **Short circuit test.**

The Engineer-in-Charge, at its option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / approved testing laboratory are furnished by the manufacturer.

- **Routine Tests**

The switchboard shall be subjected to all the routine tests as per Indian Standard [IS] and witnessed by the Engineer-in-Charge. For power frequency voltage the test voltage to be applied shall be for a period of one minute. Insulation tests with 500 volts megger before and after the high voltage test shall be carried out on the switchboard.

Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's, MCBs, meters etc.

- **Verification of wiring & earth continuity**

Voltage test on auxiliary circuits.

Tests for mechanical operation, control & interlocks.

- **Commissioning Site Tests**

Necessary site tests at site shall be carried out to ensure its satisfactory operation after installation at site.

Terminations of Incoming and Outgoing Circuits

The cable termination arrangements shall be located at the lowest point above the cable clamps, for ease of termination.

Cable support shall be provided by a suitable clamp at the bottom of the panel. These cable supports shall be adequate to support the outgoing cable in normal service and when subjected to the short circuit current specified. The distance between these cable supports and the gland plate shall be at least 200 mm.

The outgoing cables to be terminated in the switchboard shall be XLPE insulated PVC sheathed armoured and with aluminium conductors. The cables shall have bottom entry to the switchboard.

Air Circuit Breaker (ACB)

415 V four pole air circuit breakers shall be withdrawal type with manually / electrically operated mechanism. It shall be supplied for controlling the LV side of the 33/0.433kV, distribution transformer. Air circuit breakers shall have symmetrical short circuit rating of 50 kA for 1 sec. The circuit breaker shall be fitted with direct acting microprocessor based electronic release. It shall be provided with instantaneous and adjustable short circuit trip. The adjustment of the setting shall be possible without disrupting the supply. The releases shall be ambient temperature compensated type. The release shall have IEC IDMTL characteristics. The breaker mechanism shall be robust, quick making quick breaking and trip free. It shall be possible to close and trip the breaker without opening the compartment & door. It shall have auxiliary contacts for indications along with spare contacts.

The detailed specifications of Air Circuit Breaker shall be as under:

No. of poles	Four
Service voltage	415 Volts
Normal current	As per design calculation
Frequency	50 Hz

Rated Symmetrical Breaking Capacity at 415 V AC/50 Hz	50 kA for 1 Sec.
Making current	120 kA
Rated insulation voltage	1000 V
Max Breaking time	30 ms
Max Making time	80 ms

- **ACB Connection to Transformer**

The air circuit breakers shall be suitably earthed with the main earth bus. The air circuit breakers of the LV board shall be connected to the LV side of the distribution transformer as specified. In case bus duct is provided the connections at both the ends shall be through proper clamps preferably bimetallic. Suitable arrangement shall be provided in the bus duct to take care of the expansion.

- **LV Moulded Case Circuit Breaker**

All the LV outgoing underground feeders from the sub-station shall be controlled by 4 pole draw out type moulded case circuit breakers, provided in the LV switchboard.

The moulded case circuit breakers shall be of robust construction and shall comprise of switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact moulded case and cover. The insulating case and cover shall be made of high strength, heat-resistance and flame-retardant thermo-setting insulating material.

The switching mechanism shall be quick-make / quick break type, and shall be trip-free.

The arc extinguishing device shall comprise of a series of grid plates mounted in parallel between supports of insulating material. The arc shall be drawn from the moving contact into the divide chamber and extinguished.

The moulded case circuit breakers shall have a thermo-magnetic type tripping mechanism, where the heating effect and the electromagnetic effect of current are made use of to provide protection against overload and short-circuit conditions respectively. The heated-bimetal strip in each phase of the MCCB shall actuate the tripping system following on inverse-time-current characteristics depending upon the severity of the overload current. During short-circuits, the system shall trip instantaneously. The tripping element provided on each pole of the MCCB shall operate on a common trip bar, thereby preventing single phasing in the event of fault occurring on any of the phases. The tripping device shall be ambient temperature compensated type.

The MCCB shall have a minimum Ics rupturing capacity of 50 kA. Positive indication about the position of the MCCB i.e. whether 'ON' 'OFF' or TRIPPED shall be provided.

The short circuit breaking capacity and operation mechanism of the MCCB shall be supported by test certificates.

All the MCCBs used in LV switchboards for controlling the outgoing feeders shall have a Thermal current setting of 50 to 100% of its rated current and magnetic setting of 500% to 1000%

The rated currents given are provisional and shall be finalised during detailed Engineer-in-Charge.

The detailed specifications of the MCCBs shall be as under:

No. of poles	4 pole
Service voltage	415 Volts
Normal current [In]	As per SLD
Frequency	50 Hz
Service [Ics] Breaking capacity at 415V AC, 50 Hz	50 kA
Making current	120 kA

MCCB shall be provided with rotary handle for manual operation.

- **Internal Wiring**

The LV AC distribution boards shall be supplied with complete internal wiring. The central wiring shall be of 1100 V grade, FRLS, PVC insulated. Stranded tinned (not less than 48 strands) copper conductor cables of 1.5 mm2 size shall be used for control circuits and 2.5 mm2 for CT circuits. Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded and suitable for 500 V and of recommended make. Terminals shall be adequately rated for the short circuit current. Typically, terminals of 'Phoenix' make shall be provided which shall be approved by Engineer-in-Charge during detailed Engineer-in-Charge.

For CT circuits, shorting type terminals shall be provided. It shall be possible to measure the CT current through clip-on-ammeters.

Pre-fabricated Enclosure for Packaged RMU Substations

General

The enclosure for the compact substation also includes the base frame/ channels and all the necessary fixing hardware accessories required at site. The enclosure shall be compartmentalized and house RMU, dry distribution transformer, LV distribution board with capacitor bank and their interconnections both external and internal. Engineer-in-Charge at its sole discretion may also consider the alternate designs given by the Agency, if the same are found to be better or equivalent to the ones given hereunder.

Standards

The equipment shall conform (but shall not be limited) to IEC 6227-202 standard. The requirements of standards for necessary clearances, ventilation etc. shall also be complied with.

Specific Technical Requirements

Typical size	:	2 x 2.5 m (5 m2) with 2 m height [Agency may quote its own size, if different
Construction	:	Self- standing on concrete base
Steel base frame	:	4mm thick base [hot dip electro-galvanized steel, with epoxy paint]- suitable for local e
Lifting eyes	:	4 Nos from the bottom.
Housing enclosure	:	2 mm corrosion resistant Zinc/Aluminium alloy coated sheet steels
Degree of Protection	:	HV Compartment: IP-54 Transformer Compartment: IP-23 LV Compartment: IP-54
All hinges, supports Nuts, washers etc.	:	Stainless steel
Paint	:	Epoxy
Roof Design Load [min]	:	250 Kg/m2
Roof Design	:	Slanting on the sides
Top of Roof	:	Removable
Ventilation	:	With louvers (no exhaust fans shall be used)
Sound Level	:	60 dB
Standard Applicable	:	IEC 62271-202
Number of earths	:	Two (at opposite ends)
Compartments	:	Three with independent doors

Construction

General

The enclosure shall be self-standing on a concrete base. Necessary civil requirements to be satisfied for the concrete base shall be provided by the Agency. The levelling of ground and

construction of the concrete base and associated civil works shall also be in the scope of the Agency.

The compact substation is completely self-contained, mounted upon a 4 mm thick galvanised steel base frame, epoxy painted, factory assembled in a totally enclosed, aesthetically acceptable metal cladding, vandal-proof and weatherproof housing ready for placing into position upon a concrete base.

The lifting arrangement shall be with four lifting eyes from the bottom of the enclosure & not from the top.

The structure of the substation shall be capable of supporting the gross weight of all the equipment & the roof of the substation compartment shall be designed to support adequate loads. In case of relocation of the Package Substation, the entire substation shall be capable of getting lifted and placed as a Single Unit without dismantling of any of the major equipment inside the enclosure. The complete housing assembly with four lifting eyes shall be easy to lift and position the whole unit at the site by the use of crane. The substation can be lifted without damage or distortion. The transformer is located in the middle of the substation while the HV and LV compartments are located at both ends of the substation adjacent to the corresponding bushings of the transformer. The arrangement is subject to the approval of the Client or site Engineer-in-Charge.

There shall be adequate ventilation inside the enclosure so that hot air inside enclosure is directed out by help of duct. Louvers apertures shall be provided so that there is circulation of natural air inside the enclosure. The Package Substation shall be designed & Engineer-in-Charge to have natural cooling & ventilation only. No forced cooling / ventilation is acceptable.

The enclosure must be weather proof installation with proper measures against rusting.

The enclosure must also be vermin proof to prevent the entry of rodents, reptiles, & flying insects, which are prevalent in the area.

The enclosure shall be pre-fabricated such that fire from one compartment MUST NOT spread to other compartments.

It shall have easy access to all the equipment inside the enclosure, viz RMU, transformer, LV switchboard, capacitor bank, connections, and terminations of HV & LV cables.

The metal base and all supporting channels shall be hot dip galvanized. These shall ensure rigidity, ease in transportation to sites and installation.

The outdoor panel envelope may be made of electro-galvanised mild steel with nominal thickness of not less than 3 mm. The housing of the enclosure shall be made of 2 mm corrosion resistant Zinc / Aluminium alloy coated steel sheets.

All hardware such as hinges, supports, screws, nuts, bolts, washers etc. shall be made of stainless steel. All locking bolts shall be accessible from inside to prevent the unauthorised dismantling.

All the enclosures shall be or of similar type & design.

The colour of the enclosure shall be decided by Engineer-in-Charge during detailed Engineer-in-Charge, if different from the one given. The last finish coat shall be of epoxy paint.

The roof of the substation enclosure shall be designed to support loads up to 250 kg/m2. The roof shall be sloped on the sides so that the rain water cannot stay on roof during rainy days.

The pre-fabricated roof of the enclosure shall be removable whenever required. The locking nuts, bolts to allow the removal of roof shall be only accessible from inside the enclosure.

- **Covers & Doors:**

Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors in normal operation have been opened. The doors shall open outward at an angle of at least 90degrees & be equipped with a device able to maintain them in an open position. Proper padlocking facility shall be provided for doors of each compartment. Transformer compartment doors must be open from both the sides.

Door closing shall be by means of a three-point linkage arrangement (i.e. Centre, top and bottom) and controlled by a centrally located stainless steel operating handle. Pad locking facilities along with Master pad locks shall be provided. Master pad locks shall be operated by a master key for all the substations.

The outer doors of the enclosure shall be wide and provided with heavy duty hinges to prevent distortion and misalignment. A robust door restraint shall be provided to hold each door in the 950 open positions. The restraint shall be of a captive design so that it cannot be easily removed and shall be self-strong when the door is closed such that it cannot rattle. With the door in this position, operation of LV and HV switchgear shall be possible without endangering operator’s hands, etc.

When doors are closed, they are firmly locked; as such entry of dust, vermin and rainwater is completely prevented. Neoprene gaskets are to be used.

The HV doors are provided with a drawing pocket to keep drawing inside.

A weatherproof nameplate shall be provided on the door.

The edges of the doors are bended at both sides to assure they fit properly so that the door jams and misalignment is prevented.

The transformer, low voltage and HV compartments are completely separated by steel sheet. The barrier between the HV switchgear and the transformer is provided with pressure relief flaps.

All compartments are individually accessible by their own doors from outside.

Labyrinthine louvers form the sidings of the transformer room to assure free entry and exhaust of air, as such the inside temperature is kept within limits. Openings located at the lower and upper sides of the slanted roof shall allow air circulation as part of the ventilation design.

No exhaust fans shall be used. Ventilation louvers shall be required to provide sufficient ventilation.

All compartments are equipped with internal lighting consisting of 25 watts LED lamps controlled by their respective door micro switches. MCB shall be provided to control the supply.

Space heaters shall be provided to control condensing type humidity.

Labels for warning, manufacturer's operating instructions etc. & those according to local standards & regulations shall be pasted / provided inside and shall be durable & clearly legible.

The substation forms a complete metallic structure bolted together and each compartment is to be provided with tinned copper, grounding bus-bar. Bonding and interconnection of the grounding buses shall be made of 70 mm2 bare stranded copper tinned conductors. The ring main unit shall have 25x8 mm grounding bus while the low voltage switchgear shall have 30 x 10 mm tinned copper grounding buses to which connection to the grounding system at site can be made. At least two grounding points for bolting to ground conductor shall be provided on opposite ends.

All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by

way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include :

The enclosure of Unitized / prefabricated substation.

The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose.

The metal screen & the low - high voltage cable earth conductor.

The transformer tank or metal frame of transformer.

The frame &/or enclosure of low voltage switchgear.

- **Dimensions**

The overall typical dimensions of the enclosure may be around 2.5 m x 2.0 m (or 5m2) having height of about 2 m. To achieve necessary clearances, Agency may propose alternate size of the enclosure depending upon the dimensions of the equipment supplied.

- **Enclosure Requirements**

The enclosure must be totally safe to the personnel in the populated areas as the packaged substation shall be established in the residential townships.

The equipment in the enclosure must be accommodated with necessary clearances, easy access to the RMU, and transformer, LT switchgear and capacitor bank for testing, maintenance, removal and normal operation (including operation with normal switchgear handles).

There shall be unhindered access to the transformer, operation of OFF load tap changer and other normal operating requirements. Similarly, termination & removal of cables, withdrawals of ACB from LV board shall be easy & comfortable.

It shall be the sole responsibility of the contrator to satisfy all the statutory clearances and to provide safety measures against all possible hazards to the equipment in the enclosures, such as internal arcing faults in the enclosure considering environmental conditions existing at site.

Failure within the unitized substation due either to a defect, or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the unit shall be tested for Internal Arc fault test to the tune of at least 20KA for 1 second as per latest IEC 62271-202 standard. The enclosure must be so designed that internal arc faults are directed away from places where personnel or public may be present.

Test certificates from a recognised national / international test house [acceptable to Engineer-in-Charge] shall be supplied for internal arc.

Testing of incoming & outgoing cables and use of testing equipment for the same shall not entail the dismantling the sides or the roof of the enclosure.

There shall be sufficient space for termination & removal of cables from Load Break Switches & also from the LV board.

Sufficient clearance must be kept between the top of any equipment installed in the pre-fabricated substation and the roof of the substation for ventilation and operational purposes.

- **Interconnection**

The equipment inside the enclosure shall be interconnected as follows:

The RMU shall be directly coupled by VCB feeder to distribution transformer through insulated copper bars or cables as per manufacturer standard.

The LV side (three phases plus one neutral conductor) of distribution transformer shall be connected to LV incomer Air Circuit Breaker via flexible insulated copper bars or through a four-conductor sand-witched insulated bars or with bus duct enclosure.

The HV termination to Load Break Switches shall be from 33kv, Al. armoured XLPE cables, fitted with termination kits, for the ring system.

The earthing of pre-fabrication station shall be provided at two opposite ends for connection to the outside earth rods. It shall be a bolted connection.

- **Drawings**

The following drawings shall be submitted with the tender.

- ✓ The detailed sketch of the enclosure indicating general view, position of louvers etc.
- ✓ The drawing showing the layout of HV, transformer & LV switchgear along with interconnections.
- ✓ Size & position of doors in the enclosure.
- ✓ Fixing details of the enclosure including civil foundations (if any).

- **Safety Measures**

The enclosure shall have the following safety measures:

- ✓ Electric shock treatment chart duly framed shall be fixed in a conspicuous position inside the enclosure.
- ✓ Danger notice in English/ Hindi/ Telugu language conforming to IS: 2551 shall be fixed on all the four sides of the enclosure.

- ✓ Electric insulated rubber mat (non-skid type) with flouted top and plain border end, 12 mm thick to withstand 12kV di-electric strength shall be provided in front of HV/LV boards where people have to work.
- ✓ Two number portable fire extinguisher typically 2 litre, suitable for transformer / cable and other electrical equipment fires shall be placed & fixed in a suitable location in the enclosure, away from the place where fire is expected.
- ✓ Tests
- ✓ The following tests shall be carried out on the enclosure as per IEC standard at the works of the manufacture:
- ✓ The complete prefabricated substation unit will be tested at full load for temperature rise. The maximum temperature rise on any part of the equipment placed inside the enclosure shall not exceed the value as specified in IEC 62271-202.
- ✓ Test to verify the sound level of the pre-fabricated substation, which shall be less than 60 db.
- ✓ Test to verify the degree of protection of enclosure for various compartments.
- ✓ For the internal arc fault test on the enclosure the following need to be observed and tested as below:
- ✓ Internal Arc Fault tested to 20 kA 1 sec.
- ✓ Test to accessibility of Type “B” that is with unrestricted accessibility including that of the general public (Annex. AA.2 IEC). Although test to accessibility of Type “A” is not required, tenderers shall also provide adequate measures to have any hot gases directed away from the operator during switching with the door open.
- ✓ Arc initiation is made inside the SF6 gas compartment of the RMU (Annex. AA.3 IEC).
- ✓ Assessment of the internal arc fault test is based on the fulfilment of all 6 criteria as stated in Annex. AA.6 of IEC.
- ✓ Other Checks
- ✓ Inspection of conformity with the specification & approved drawings.
- ✓ Inspection of devices locking out and interlocks.
- ✓ Inspection and checking electrical continuity of metallic frame and earthing system.
- ✓ Dielectric tests of M.V. and L.V. bus bar.
- ✓ Provision of two earths as per Indian Electricity Rules.
- ✓ Tests as per IEC standard.

TECHNICAL SPECIFICATION FOR 33kV & 6.6kV METAL ENCLOSED SWITCHGEAR

Applicable standards

The switchgear and its components shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Circuit Breakers	IS: 13118 / BS : 5311 / IEC : 56,694
Metal Enclosed switchgear	IS: 3427 / BSEN:60298 / IEC:298
Current Transformers	IS: 2705 / BS: 7626
Voltage Transformers	IS: 3156 / BS: 7625 / IEC: 186
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS: 5578, 11353
Busbar Support insulators	IS: 2544 / BS: 3297 / IEC: 273
Degree of Protection	IS: 13947 (Part 1) / IEC: 947-1 / BSEN: 60529
Electrical Relays for Power system protection	IS: 3231, 3842 / BS: 142 / IEC: 255
Electrical Indicating Instruments	IS: 1248 / BS: 89 / IEC: 51
High Voltage Fuses	IS: 9385 / BS: 2692 / IEC: 282
AC Static Electricity Meters of accuracy Class 0.5S/0.2S	IEC: 687 / IEC : 620053-22
Specification for copper rods and bars for electrical purposes	IS: 613
Code of practice for phosphating iron and Steel	IS : 6005 / BS : 3189
Alternating current Switches for voltages above 1000 V	IS : 9920 / IEC : 129, 265 & 298
Low voltage fuses	IS : 13703 / BS 1362 / IEC 269
Toggle switches	IS : 3452 / BS : 3676
Code of practice for selection, installation	IS : 10118 and maintenance of switchgear & control gear
Control switches	IS:6875 / BSEN 60947 / IEC : 947

Circuit Breaker

Circuit breakers shall be Vacuum/SF6 type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

There shall be 'Service', 'Test' & 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected.

Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers.

Electrical tripping shall be performed by shunt trip coils. "Local / Remote" selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions.

Breaker "Service" and "Test" positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of "Service" and "Test" positions are not available on the cubicle door.

Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

Operating mechanism control

Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit. Operating mechanism shall normally be operated from the breaker cubicle itself.

The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor.

All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The

charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.

Circuit breaker control shall be 110V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 50 -110 % the rated control voltage.

Safety interlocks and features

Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.

Operation of a circuit breaker shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.

Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / switch disconnector carriage to cover the stationary isolated contacts when the breaker / switch disconnector is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

The circuit breaker carriage shall be earthed before the circuit breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.

Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

Constructional Features of Switchboard

Switchboard design shall comprise metal enclosed, fully compartmental execution having separate sections for each circuit. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits. Switchboard cubicle shall be provided with hinged door on the front with facility for locking door handle. Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X. All removable covers shall be gasketted all around with neoprene or superior gaskets.

Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields. Separate signal earth shall be provided for such devices, if necessary.

Each switchboard cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

Sheet steel used for fabrication of switchboards, control cabinets, marshalling boxes, etc shall be cold rolled. All panels, cabinets, kiosks and boards shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not less than 2.5 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary. All doors, removable covers, gland plates, etc. shall be of at least 2 mm thickness and shall be gasketted all-round the perimeter. All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All floor mounted panels / boards shall be provided with a channel base frame. It shall be possible to extend the switchboard on both sides.

The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

Earthing

Aluminum earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green colored, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

Circuit / Busbar Earthing Facility

It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker. The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Authority's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

Annunciators

Annunciators shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted. Each annunciation window shall be provided with two lamps to provide redundancy against lamp failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All facia annunciator points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15millisecond.

For static annunciator schemes, special precaution shall be taken by the Agency to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels / desks.

A "Lamp Test" push button shall be provided for each individual panel's group of annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible alarm circuits of annunciators is desirable. The Agency shall give the details of the offered scheme.

Annunciators shall have following features:

Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.

During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.

Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.

"Alarm Supply Failure” Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply.

Instruments

All electrical instruments and meters shall comply with IEC 60051, 61010 and IS 722, 1248. All indicating and recording instruments shall be flush mounted in dust proof cases complying with IEC 60068 and dimensions to IEC 61554. All digital instruments shall have interface facilities to communicate data to SCADA system.

Indicating Instruments

Electrical indicating instruments shall be 144mm x 144mm square with 2400 scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

Instrument dials shall be white with black numbers and lettering. A red line shall be drawn on each scale to represent rated conditions.

Normal maximum meter reading shall be of the order of 60 % normal full scale deflection.

Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.

Instruments shall have accuracy class of 0.2. The design of the scales shall be such that it can read to a resolution corresponding to 50% of the accuracy class index.

Ammeters and current coils of Watt meters and Voltmeters shall continuously withstand 120% of rated current and 10 times the rated current for 0.5 sec., without loss of accuracy.

Voltmeters and potential coils of Watt meters and Varmeters shall withstand 120% of rated voltage continuously and twice the rated voltage for 0.5 sec. without loss of accuracy.

Alternatively, instruments can be electronic / digital type with LCD display. These instruments shall have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

Metering instruments

Watt-hour meters shall be of the static type and shall be provided with reverse running stops.

Watt-hour and Varhour meters shall be of the three phase two element type of accuracy class 0.2, suitable for measurement of unbalanced loads in three phase three wire circuits.

Watt-hour and Varhour meters shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.

All the meters shall be electronic / digital type with LCD display. These instruments shall have high performance ratio and can be equipped with digital output (for alarms).

Control and Selector Switches

Control and instrument switches shall be rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

The control switches shall be 3 position, spring return to neutral type. They shall be provided with contacts to close in 'normal after close' and 'normal after trip' position. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch.

Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.

Instrument selector switches shall be of the maintained (stay-put) type. Ammeter selector switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch.

Lockable type switches, which can be locked in a particular position, shall be provided, if required.

Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

Indicating Lamps / Pilot Lights

Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.

Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colors, red, green, blue, white and amber, in accordance with IEC 60073. Bulbs and lenses shall be interchangeable and easily

replaceable from the front of the panel. Tools, if any, which are required for replacing the bulbs and lenses, shall also be included in the scope of supply.

Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

The basis of colors shall be as follows:

Red	:	Flow of energy.
Green	:	No flow of energy.
White	:	Supervision of power available, relay coil healthy, etc.
Amber	:	Disagreement with original condition, 'abnormal' condition or 'Sequence–on' condition.

Push Buttons

Push buttons shall be of momentary contact type with rear terminal connections. The color of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 230 V, 1 ph, 50 Hz, AC supply. A 230 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

Power and Control Cable Terminations

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.

Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

Wiring for Control and Protective Circuits

All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one restripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.

Wiring shall only be jointed or teed at terminals. Terminals of the clamp type shall not have more than two wires connected.

Terminations and Ferrules

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.

All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

Control Wiring Terminal Blocks

Terminal blocks shall be of 1000 V grade and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved 'black on-white' labels shall be provided on the terminal blocks describing the function of the circuit.

Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled. Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility for earthing the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

Busbars

The phase and neutral busbars shall be of rating indicated in the corresponding one-line diagram. Busbars shall be of Copper type and shall be provided with minimum clearances as specified.

All busbars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature

range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

The HV switchboards are being procured under the present scope of works with following protections systems:

Over current / Earth Fault Protection

This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the over current elements and another for the earth fault element.

Phase current range shall cover at least 50-300% of 'In' in steps of not more than 10% while the earth current range shall cover at least 5-100% of 'In' in steps of not more than 5%.

The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.

The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.

Over current and earth fault relays shall have separate timers and operation indicators.

The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25 ms and possible to be selected on "blocked" position. Reset time shall be not more than 50 ms for both elements.

The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.

Under voltage relays

Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating

type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.

Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection

Following Minimum protections to be provided for incomer & outgoing which are listed below

Incomer & Outgoing

IDMTL over current (51) for phase fault

Definite time O/C relay (50 N) for earth fault.

Auxiliary Relays and Timers

Following auxiliary relays shall be provided on each breaker cubicle:

Trip circuit supervision relay

Anti- pumping relay

Hand reset type lockout (tripping) relays and timers shall be provided as required in addition to the protection relays given in the single line diagram.

Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.

Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation, high oil temperature, high winding temperature, pressure relief device (PRD) operation etc. shall be provided. Each relay shall have four (4) pairs of self-reset contacts except for

Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.

Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self-reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100ms. The relays shall have hand reset operation indicator.

Component Identification

A component reference number shall be marked adjacent to each component. Where this is impossible, components shall be identifiable from the layout drawings provided.

The following shall be marked in all instances:

Fuses: The rating and the circuit identification of each fuse shall be marked adjacent to the fuse base.

Control, Protection and Indication Devices: The function of each control, protection and indication device shall be marked. The caption and its arrangement shall be subject to the approval of the Authority's Representative.

Preset Controls: The circuit reference and if possible, the function shall be marked adjacent to each preset control in a position where it will be clearly visible while the adjustment is being made.

Connectors: The diagram reference number shall be marked on or adjacent to each connector.

Test points shall be individually marked with the diagram reference number.

The polarity of any polarized devices (e.g. diodes) shall be marked.

Test Terminal Blocks

Test terminal blocks, if any, shall be provided for secondary injection and testing of relays. A suitable metering block shall be provided for the connection of a portable precision instrument to be operated when required for specific plant testing purposes.

Tests

The following routine tests shall be carried out on the assembled switchboard / panel during inspection at the manufacturer's works in addition to other tests as per applicable standards.

Primary injection tests to ensure correct ratios and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.

Balance earth fault stability test by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.

Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.

Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.

Carry out functionality tests, check interfacing status contacts and instrumentation.

Checking of Differential protection relay.

One-minute power-frequency voltage dry withstand tests on the main circuits

One-minute power-frequency voltage dry withstand tests on auxiliary circuits

Insulation resistance tests

Following minimum type tests shall be performed on a typical section of the bus assembly, unless otherwise mentioned.

Impulse Test & PF withstand test

Temperature rise Test

Short circuit Test

Internal Arc Test for 25kA 1 sec

Short circuit test duties

Mechanical Endurance test

The offered switchgear panel shall be one which is successfully type tested for Inclination and Vibration and Seismic conditions.

All circuit breakers shall be subject to the following tests:

Routine tests including HV pressure test, milli-volt drop tests and mechanical tests.

To ensure the operation of the dc closing coil and satisfactory closing of the circuit breaker with the voltage of the coil down to 80% of its rated voltage, and that mal-operation does not occur with a voltage on the coil of 120% of its rated voltage.

Inter changeability of withdrawable identically equipped circuit breakers, and checking of all mechanical and electrical interlocks.

Type test figures for heat test runs performed on identical panel types shall be made available.

Specific technical particulars of the 33kV Metal Enclosed Switchgear shall be as shown in the technical data sheet below:

Description	Unit	Particulars
General		
Type		Metal enclosed, compartmentalized draw-out type
Rated voltage, no. of phases and rated frequency	kV / - / Hz	36 kV, 3 Phase, 50Hz
System neutral earthing		33kV system earthed
Rated Insulation Levels		
Rated short duration power frequency withstand voltage	kV (rms)	70

Rated lightning impulse withstand voltage	kV (peak)	170
Rated normal current of bus bars under design ambient temperature of 450C and material of busbar	A	Aluminium - suitable for 100% load
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Dynamic rating	kA (peak)	62.5
Constructional Requirements		
Minimum thickness of sheet steel in mm Cold rolled (Frame/Enclosure/Covers)	mm	Frame – 2.5 Doors/Covers – 2.0
Degree of protection of enclosure		IP-4X

Description	**Unit**	**Particulars**
Color finish shade		
- Interior		Glossy White
- Exterior		Light Grey Semi Glossy
- Cable connection		Bottom entry and exit
Circuit Breakers		
Type		Vacuum/SF6
Rated current inside the cubicle under design ambient temperature at 45°C	A	(*)
Rated operating sequence		O–3 Min–CO-3 Min-CO
Rated short time breaking current	kA (rms)	25
Rated short time making current	kA (peak)	62.5
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Rated peak withstand current	kA (peak)	62.5
Min. no. of auxiliary contacts		6 NO + 6 NC after internal use by manufacturer
Type of operating mechanism		
- Normal		Spring charging for closing and tripping
- Emergency		Manual and spring charged for closing and tripping
Auxiliary control voltage		
(i) For closing / tripping coil	V	110 DC

- Spring charging motor	V	110 DC
- Space heater and lighting	V	230 AC
Earthing switch		Required
Current Transformers		
Type		Cast resin
Class of insulation		Class E or better
Rated current ratio and burden (i) Incomer	A & VA	(*)
(ii) Outgoing feeders	A & VA	(*)
Accuracy class (i) Metering		0.2
(ii) Protection		5P20
Short time 1 sec current rating	kA (rms)	25
Dynamic rating	kA (peak)	62.5
Voltage Transformers		
Type		Cast resin
Rated Voltage (i) Primary (ii) (ii) Secondary – S1	 V V	 33000/√3 110/√3
Method of connection (i) Primary – P (ii) Secondary – S1		 Star, earthed Star, earthed
Application – S1		Metering and Protection
Rated burden	VA	(*)
Accuracy class		Metering 0.2 Protection 3.0
Rated voltage factor (i) Continuous		1.1
(ii) Short time		1.5
Insulation class		Class E or better
Meters		
Make		As per Preferred Makes/ Manufacturers
Accuracy Class		
(i) Indicating Meters		Class 0.2
(ii) Energy Meter		Class 0.2
Details of ratio, taps, burden, accuracy		(*)
Protective Relays		

Type		Numerical Type
Auxiliary supply	V	110 DC

Specific technical particulars of the 6.6kV Metal Enclosed Switchgear shall be as shown in the technical data sheet below:

Description	**Unit**	**Particulars**
General		
Type		Metal enclosed, compartmental-ized, draw-out type
Rated voltage, no. of phases and rated frequency	kV / - / Hz	7.2 kV, 3 Phase, 50Hz
System neutral earthing		7.2 kV Earthed
Rated Insulation Levels		
- Rated short duration power fre-quency withstand voltage	kV (rms)	28
- Rated lightning impulse withstand voltage	kV (peak)	75
Rated normal current of bus bars un-der design ambient temperature under design ambient temperature of 450C and material of busbar	A	Aluminium - suitable for 100% load
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Dynamic rating	kA (peak)	62.5
Constructional Requirements		
Minimum thickness of sheet steel in		Frame – 2.5
Minimum thickness of sheet steel in mm Cold (Frame/Enclosure/Covers)	Mm	Doors/Covers – 2.0
Degree of protection of enclosure		IP- 4X
Color finish shade		
- Interior		Glossy White
- Exterior		Light Grey Semi Glossy
- Cable connection		Bottom entry and exit
Circuit Breakers		
Type		Vacuum

Rated current inside the cubicle under design ambient temperature at 45°C	A	(*)
Rated operating sequence		O–3 Min–CO-3 Min-CO
Rated short time breaking current	kA (rms)	25
Rated short time making current	kA (peak)	62.5
Rated short-time withstand current and time	kA (rms) / sec	25 kA for 1 sec
Rated peak withstand current	kA (peak)	62.5
Min. no. of auxiliary contacts		6 NO + 6 NC after internal use by manufacturer
Type of operating mechanism		
Type of operating mechanism - Normal		Spring charging for closing and tripping
- Emergency		Manual and Spring charged for closing and tripping
Auxiliary control voltage		
(i) For closing / tripping coil	V	110 DC
- Spring charging motor	V	110 DC
- Space heater and lighting	V	230 AC
Earthing switch		Required
Current Transformers		
Type		Cast resin
Class of insulation		Class E or better
Rated current ratio and burden (i) Incomer	A & VA	(*)
(ii) Outgoing feeders	A & VA	(*)
Accuracy class (i)Metering		0.2
(ii) Protection		5P20
Short time 1 sec current rating	kA (rms)	25

Description	**Unit**	**Particulars**
Dynamic rating	kA (peak)	62.5
Voltage Transformers		
Type		Cast resin
Rated Voltage	V	6600/√3

(i) Primary		
(ii) Secondary – S1	V	110/√3
Method of connection (i) Primary – P		Star, earthed
(ii) Secondary – S1		Star, earthed
Application – S1		Metering and Protection
Rated burden	VA	(*)
Accuracy class		Metering 0.2
		Protection 3.0
Rated voltage factor (i) Continuous		1.1
(ii) Short time		1.5
Insulation class		Class E or better
Meters		
Make		As per preferred Makes/manu-facturers
Accuracy Class		
(i) Indicating Meters		Class 0.2
(ii) Energy Meter		Class 0.2
Details of ratio, taps, burden, accuracy		(*)

Description	**Unit**	**Particulars**
Protective Relays		
Type		Numerical Type
Auxiliary supply	V	110 DC

TECHNICAL SPECIFICATION FOR 415V METAL ENCLOSED SWITCHGEAR PMCC /MCC /SWITCHBOARDS /LIGHTING PANELS

Applicable Standard

The switchgear and components shall conform to the latest applicable standards specified below:

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages upto and including 1000V AC & 1200V DC	IS:8623/BS:5486/IEC:60439

Air Break Switches	IS:13947-P3/BSEN60947/ IEC:60947-3
Moulded Case Circuit Breaker	IS 2516/IEC 60947-2/BS EN 60947-2
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947-4/ IEC:60292-1TO 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626
Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722,8530/BS:5685/ IEC 60145,60 211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and Control gear	IS:10118
Code of practice for phosphating iron and Steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and Control gear voltage not exceeding 1000V AC	IS:12021

Features of Construction

(a) General Constructional Requirements

Lighting/UPS Distribution Boards/Panels

Lighting Distribution board shall be wall mounted, IP42 with Metallic Double door with incomer & outgoing as per indicated in single line diagram.

Panels shall be Epoxy Powder coated with paint shed RAL 7032. Din rails shall be provided for mounting of MCB/MCCB as applicable.

Panels shall have copper Bus bars which shall be sized considering design ambient temperature of 50 Deg C.

Panels shall have separate terminal strip for circuit neutrals and earth connection.

For termination of incomer and outgoing cables / wires adequate space shall be provided including proper clamping and dressing arrangements for cores. The busbar Links shall be fork type, tin plated copper and shall have end caps. For 50sq.mm and above size cable terminations entry terminals shall be used.

In case of Aluminum cables being terminated on tinned copper Busbars, the tinning shall withstand the temperature rise and aberration so as to avoid bi-metallic corrosion.

External Earthing stud shall be provided on both sides of panels.

Panels shall be wall mounted on metallic bracket, which shall be painted with anti-corrosive epoxy paint.

The MCBs shall be IP20 with current ratings and kA ratings as indicated. For lighting circuits MCBs with Characteristic 'C" shall be used. For Power circuits MCBs with Characteristics "D" shall be used.

MCB shall have Label Holder, Combined head screws, two positions Dolley.

All MCCBs shall have extended Rotary Handle & Extension Links/Spreaders.

Current density for busbars shall be 0.7A/mm2

All identical equipment and corresponding parts shall be fully interchangeable without any modifications.

Busbar material shall be copper upto & including 100A and above 100A, it shall be Aluminium

The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus shall have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

Main LT PMCC Panel/MCC Panels

The following clauses shall be deemed to apply for this Panel.

Sheet steel used for fabrication of switchboards, control cabinets, marshalling boxes, etc shall be cold rolled.

All panels, cabinets, kiosks and boards shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not

less than 2 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary.

All doors, removable covers, gland plates, etc. shall be of at least 1.6 mm thickness and shall be gasketed all-round the perimeter.

All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts.

All floor mounted panels/boards shall be provided with a channel base frame. Total height of all floor mounted cubicles/panels shall not be greater than 2300 mm. Where steel pedestals for mounting of boards/panels are specified, the total height including that of the pedestal shall exceed 2300 mm.

Switchboard/control cabinet/panel shall be dust and vermin proof. Degree of protection of the enclosure shall be IP 54 for indoor installations and IP 55 for outdoor installations.

Separate, segregated metal clad compartments shall be provided for main and auxiliary bus bars, each feeder and cable alleys. Metal clad cubicles/modules shall be provided with hinged doors in the front, with facility for padlocking door handles. More than one module may be arranged in the same vertical section. Circuits not controlled by air circuit breaker (ACB) shall be of the fixed type. The switchboard enclosure shall conform to “Form – 4” as per IS-8623. It shall be possible to extend the switchboard on both sides.

ACB, if any, shall be fully draw-out type. The breaker carriage shall be fitted with positive guides to ensure proper alignment. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers. External cable connections shall be through separate cable compartments for power and control cables.

The fixed type module shall have all the circuit components mounted in the compartment, with bolted type power and control connections. It shall be possible to remove all circuit components after removing the connections and the component fixing bolts.

Instruments, relays and control devices shall be mounted flush on hinged door of the cubicles. Switchboard shall be complete with inter-panel wiring.

Each switchboard shall also be fitted with a label indicating its title. Each cubicle shall be fitted with a label on the front and rear of the cubicle. Each relay, instrument, switch, fuse, contactor and MCCB/MCB shall be provided with a separate label.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping sections shall have metal sheets at both ends.

After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the busbars and adjacent circuits alive.

The current rating of outgoing feeders of any switchboard shall not be less than 10% of that of the incoming feeder. Deviation from this requirement shall be subject to the approval.

Busbars

The phase and neutral busbars shall be of rating indicated in the corresponding one-line diagram. Busbars shall be of aluminium and shall be provided with minimum clearances as specified.

All busbars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

Sequence of red, yellow and blue phases and neutral for four-pole equipment.

Air Circuit Breaker (ACB)

Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.

Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

The Breaker shall be provided with Microprocessor based releases for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases

The breaker service Short Circuit breaking capacity (ICS) shall be equal to ultimate Short Circuit capacity (ICU) and shall be equal to short time withstand current of Breaker (ICW)

Moulded Case Circuit Breaker (MCCB)

MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing. MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified-MCCBs shall have a service short circuit breaking capacity (ICS) equal to the ultimate short-circuit capacity (I_{CU}).

Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid-state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

The MCCBs shall be provided with the following features:

Common trip bar for simultaneous tripping of all poles

Shrouded terminals

Time for clearing short circuit current of 20 msec.

2 NO + 2 NC auxiliary contacts

Miniature Circuit Breaker (MCB)

MCB shall be hand operated, air break, quick make, quick break type.

Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where

this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

Contactors

The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

Motor starters shall be complete with auxiliary relays, timers and necessary indications.

Current Transformers

Current Transformers shall be Cast Resin type.

Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block

Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification.

CT core laminations shall be of high grade silicon steel.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

Voltage Transformers

Voltage Transformers shall be Cast Resin type.

Secondary and tertiary windings of voltage transformers shall be rated for a three-phase line to line voltage of 110 V.

It shall be possible to replace voltage transformer fuses easily without having to de-energise the main bus-bars.

Indicating Instruments & Meters

Electrical indicating instruments shall be 110 mm square with 240º scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers. Instrument dials shall be white with black numbers and lettering. Normal maximum meter reading shall be of the order of 60 % normal full-scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current. Watt hour meters shall be of the static type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0.

Indicating Lamps

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labeled to facilitate testing.

Earthing of Switchboards / Panels

Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

Internal Wiring

The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper or equivalent size aluminium conductor. Control circuits shall be wired with copper conductor of at least 1.5 Sq.mm.

The specific technical particulars of Main LT PMCC Panel / MCC Panel / Chiller PCC / UPS & Lighting Distribution Board shall be as given below:

Description	**Particulars**
Rated voltage, Phases and Frequency	415 V, 3 Ph, 50 Hz
Type of Construction	For Main LT PMCC/MCC/Chiller PCC Panel - Single front, fixed type with IP54 Enclosure For UPS/Lighting DB- Wall Mounted with Degree of protection IP 42
Maximum system voltage	476 V
One-minute Power Frequency withstand voltage	
Power circuit	3000 V (rms)
Control Circuit	2000 V (rms)
Auxiliary circuit connection to secondary of CTs	2000 V (rms)
Current rating of busbars over design ambient temperature of 50 Degree C	As per …….
Short circuit withstand for main and auxiliary busbars (1 sec.)	As per …….
Maximum temperature of main and auxiliary busbars at continuous rated current rating under site design ambient temperature of 50 Degree C	85
Colour finish shade as per IS:5	
Interior	Glossy white
Exterior	Light grey, semi-glossy, shade 631 of IS 5

Earthing bus material and size	Copper, 25 x 6 mm
Clearances in air of live parts	25.4 mm
Type of Mounting	Floor / Wall Mounted
Cable Entry	To be decided based on Layout
Type of Starter for MCC Panel	VFD : For all pumping Motors

415V CAPACITOR BANKS WITH APFCR PANEL

Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern

Shunt capacitors for power systems IS: 13340

Internal fuses and internal overpressure disconnectors: IS:12672 for shunt capacitors

Metal enclosed switchgear IS: 3427 / BSEN 60298/ IEC: 60298

Code of practice for phosphating iron and steel IS: 6005/BS: 3189

Specification for copper rods and bars for electrical purpose IS: 613

2.5.2 Design Features

The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.

The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free-standing type.

All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphated and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stoved shall be applied.

The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers may be provided in the cubicle to ensure proper ventilation.

Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one-minute in accordance with the provisions of the latest edition of IS: 2834.

Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnant shall be non-PCB (poly chlorinated biphenyl) oil.

Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage upto a maximum of 10% above the rated voltage, excluding transients.

Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

Power Capacitor and Control Panel

Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.

The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of:

- ✓ Busbars shall be of copper conductor of hard drawn (HD) and high conductivity
- ✓ Isolating switch
- ✓ Contactor with overload element
- ✓ Relays responsive to current/voltage/KVAR/PF as specified for automatic switching
- ✓ Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- ✓ Auto-manual selector switches

- ✓ Push button for opening and closing the power circuit.
- ✓ Red and green lamps for capacitors ON/OFF indication
- ✓ Protective relays to protect the healthy capacitor units when one unit fails in a series connection
- ✓ Space heater and cubicle lighting as per the requirements.

The specific technical particulars for 415V Capacitor Banks with APFCR Panel shall be as given below:

Description		Unit	Technical Particulars
General			
Make			As per Preferred Makes/Manufacturers.
Rated Capacity		KVAR	(*)
Rated voltage		V	415
Rated frequency and phases			50 Hz, 3 Phase
Ambient temperature		o C	v
Cable gland required			Yes
Type of cable			1.1 kV, XLPE, Al. Conductor
Size of cable			(*)
Cable entry			Bottom
Constructional Requirement			
Thickness of sheet steel i) Frame, Frame enclosures, doors covers and partition		Mm	Cold rolled 2.0
Degree of protection			IP 54
Colour finish shade			Interior: Glossy white Exterior: Light Grey Semi Glossy Shade 631 of IS 5
Earthing bus	Material		Copper
	Size	mm x mm	
Earthing conductor	Material		GI Flat
	Size	mm x mm	(*)
Design Requirement			
Insulation level		kV (rms)	3.0
Capacitor bank connection			Delta

Short circuit withstands for busbars i) Short time (1 sec)	kA (rms)	10
(ii)Dynamic	kA (peak)	25
Type of switching		Automatic switching responsive to power factor through power factor sensing relay
Switching steps		Minimum 8 steps
Rating of contactor		To suit KVAR unit
Incomer switch current rating		To suit rated capacity of KVAR
Busbars		Copper

7.0 TECHNICAL SPECIFICATION FOR BACKUP SYSTEM:

UNINTERRUPTED POWER SUPPLY (UPS):

The UPS system shall be true on-line static type and the components of UPS shall isolate power line transients, frequency and voltage variations. The UPS shall provide no-break power supply to the critical loads under normal conditions, during outages in the input power and during failure / maloperation of the main components of the UPS by switching the alternate supply.

Static UPS systems shall be of the type described below:

Non-Redundant UPS with static bypass to regulated supply

The non-redundant UPS shall comprise a solid-state rectifier/ battery charger, battery, a solid-state inverter, static switches and stand-by regulated AC supply as mentioned in Data sheet at the end of this section. The three phase AC mains input is fed to the controlled rectifier via a matching 2 winding Delta-star connected Isolation transformer. The down-stream inverter converts the DC into a regulated AC. In the event of power sag or failure, the battery which is connected to the DC link circuit, is called up automatically, without any interruption, to supply to critical loads. On mains recovery, the rectifier resumes its function of supplying the inverter and charging the battery. When a fault develops in the inverter or an overload occurs, the static switch automatically transfers the critical load to the stand-by AC supply, until manually reset.

The List of Applicable standards is given below:

Basic climatic & mechanical durability tests for components for electronic and electrical equipment	IS 9000
Environmental tests for electronic & electrical equipment	IS 9000

Transformer and inductors (Power, Audio, Pulse & switching) for electronic equipment	IS 6297
Printed wiring boards	IS 7405
Environmental requirements for semiconductor devices and integrated circuits	IS 6553
Terminals for electronic equipment	IS 4007
HRC Cartridge fuses	IS 9224
Indicating Instruments	IS 1248
Degree of protection	IS 13947
Semiconductor rectifier equipment code	IS 6619
Thyristor converters	IS 5082
Emergency std by power systems	IEEE -446
Surge withstand capability test in accordance with	IEC 60255-5
Harmonic levels	IEEE -519

Design Requirements

UPS shall be designed in such a way that it shall be compatible to take DC power from DC distribution board to which battery banks were connected. The total load capacity of the DC DB shall be designed in such a manner to withstand both loads of DC and UPS. Dedicated feeder to be provided for UPS.

UPS components, i.e., inverter, static switch, by-pass switch, isolation transformer, associated controls shall be mounted in floor mounted, sheet steel panel. The panels shall be designed for continuous operation for the ambient conditions defined in Technical data sheet. The battery shall be separately installed in a battery room, alternatively if Sealed maintenance free batteries has been specified and offered, then the same may be integrated with the UPS panels suitably. In case fans are required for cooling, 100% stand-by shall be provided to ensure rated output of the UPS.

Rectifier

The rectifier shall essentially be a three phase 6 pulse design with input isolation transformer. The rectifier shall be provided with soft start feature. The rectifier shall have features for temperature compensation charging of the batteries

The rectifier shall be capable of supplying the inverter full load, in addition to charging the fully discharged batteries in 8 hours or as recommended by battery manufacturer and then maintain the battery on trickle charge mode. The rectifiers shall automatically share the load during parallel operation in case of common battery, as specified in Technical Data Sheet.

Inverters

The inverter shall be of PWM (Pulse Width Modulation) type. The inverter system shall be complete with necessary filters to limit the harmonic distortions to the load. The system shall have features to prevent deep discharge of battery.

Static Switch

The static switch shall comprise thyristors connected in anti-parallel configuration, enabling loads on each branch circuit to be connected to the inverter of the other branch circuit or to the stand-by regulated AC supply.

The current rating of the static switch shall be not less than the continuous full load rating of the branch circuit and short time rating of 750% for 1.0 sec.

Automatic initiation of the transfer from a faulty branch circuit to either a healthy branch circuit or the stand-by regulated source shall be accomplished during following conditions:

- Inverter failure.
- Loss of inverter AC output.
- Load over current (in case of non-redundant UPS with static by pass to regulated supply).

Regulated Stand-by AC Supply

Regulated stand-by AC supply shall be derived from stand-by source through a 3 ph servo controlled voltage stabiliser (SCVS) and a 3 ph Delta-Vie connected adequately rated isolation transformer.

The voltage regulation and transient response shall be as specified in Technical Data Sheet.

Circuit Protection

The following devices shall be provided to protect the UPS system:

- AC input circuit breaker to Rectifier unit.

- AC input circuit breaker to supply stand-by transformer / voltage stabiliser.
- DC circuit breaker for battery output.
- Fast acting semiconductor fuses.

Indications & Annunciation

The UPS system shall be provided with necessary meters, mimic diagram, local indication / alarm conditions.

Meters

Meters shall be suitable for semi flush mounting with flanges projecting in vertical panels. Meters shall have circular 2400C scale, 110 mm square, moving coil (taut band) type, conforming to IS: 1248 with accuracy class 0.2 or better.

DC ammeters shall be provided with external shunts. The following meters shall be provided:

- Voltmeter with selector switch to measure input voltage / stand-by AC supply.
- Ammeter with selector switch to measure input current.

DC Volt meter for rectifier .

- DC Ammeter for rectifier
- Volt meter for inverter output.
- Ammeter for AC output and regulated stand-by AC.

Control & Monitoring

Discrete LED indicators integrated in mimic diagram or multi line alpha numeric text display unit shall be provided for continuous monitoring of the UPS operation. The UPS control system shall be fully compatible for remote operation via communication link Vendor to indicate the type of communication protocol supported by the system along with the details of links provided in the system. The control system shall operate on Windows or equivalent Platform. The following operating conditions shall be annunciated.

Alarm Indication

- System fault
- Rectifier charger failure
- Inverter failure
- Battery under voltage
- Thyristor over temperature
- Fuse failure

- Over load
- Static transfer to stand-by
- Transfer inhibited
- Over load shutdown
- Emergency shutdown
- Battery circuit breaker / switch open
- AC Main failure
- AC stand-by source mains failure
- Manual bypass ON
- Fan failure
- Asynchronous condition
- Control power failure
- DC ground fault.
- Status Indication on Mimic
- Mains on
- Rectifier on
- Battery on load
- Inverter on
- AC Stand-by source on
- Inverter on –load
- Manual by-pass on
- Load on static by pass.
- Invertor faulty

Harmonics

Necessary input and output filters shall be provided or the Rectifier and Inverter design shall be such that the harmonics injected back to the source and to the load shall be within limits specified in IEEE-519 at the point of coupling of the UPS to the system. The fault level of the system at the point of common coupling shall be as specified in Technical Data Sheet.

System Earthing

The VENDOR shall clearly bring out the earthing philosophy to be adopted for the UPS electronics, protective earthing (PE) and neutral earthing. The requirement of separate clean earth independent of the plant electrical system earth shall be clearly brought out.

Tests On UPS

- Type and routine tests certificates for all components made use in the UPS system shall be furnished. Tests for components shall be as per relevant standard specifications indicated.
- Vendor shall furnish his quality assurance plan for the equipment offered. The quality assurance plan shall include bought out components and assemblies used in the UPS system.
- Routine tests on the complete UPS system shall be carried out as per relevant standards for each major sub-system in the UPS, viz., Rectifier, Inverters, batteries, stand-by supply etc.
- System tests shall be performed on the completely assembled UPS system. System tests shall include frequency regulations. Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such synchronisation with range of adjustments, transfer of static switches for conditions of loss of square wave, overload and under voltage conditions
- Type, routine and optional tests covered under clause 7.3 of IEC-60146-4 shall be conducted on the UPS system in addition to the system tests.
- Endurance test on static switches shall be performed for not less than 10 transfer / retransfer cycles at full load.
- The complete assembled UPS system shall be operated at rated load under relevant ambient conditions for not less than 96 hours continuously prior to release for shipment.

Spares

Vendor shall include list of spares with quantities as recommended by him for three years trouble free operation. The offer shall include list and quantity of Start-Up spares required for commissioning of the equipment and Essential Spares for one year.

The items and quantities of the above shall include all but not limited to those indicated in Technical Data Sheet below:

Sr.No.	Description	Unit	Particulars
1.1	Application		UPS

1.2	Power rating at load PF 0.8 lagging	kVA	(*)
1.3	Quantity	Nos.	As per Requirement
1.4	Method of energy storage		Nickel Cadmium Battery – 30 Min.
1.5	Type		Non-Redundant with static by pass to regulated supply
1.6	Installation		Indoor, Natural ventilated
1.7	Ambient Temperature	(0C)	45
1.8	Relative Humidity	%	Upto 95 Non-condensing
2.0	ENCLOSURE		
2.1	Sheet steel thickness		2mm, CRCA for doors and 1.6mm CRCA for side covers
2.2	Degree of protection as per IS-13947		IP-31
2.3	Painting		
	- Exterior		RAL 7032
	- Interior		Glossy white
2.4	Cable Entry		Top
2.5	Acoustic Noise level	dBA	60 – 65 upto 40 kVA 60 – 70 above 40 kVA Measured at a distance of 1m
2.6	Space heater, 240V, 1 Ph		Required
3.0	UPS SYSTEM		
3.1	Input		
3.1.1	Supply voltage	V	415
	No. of Phases	Nos.	3
	Frequency	Hz	50
3.1.2	Allowable Variation		
	Voltage	%	+ 10
	Frequency	%	+ 5
	Combined voltage + frequency	%	10
3.2	Output		
3.2.1	Output voltage	V	240
	No. of Phases	Nos.	1

3.2.2	AC voltage accuracy (steady state) Over entire load, load PF & DC voltage range.		+ 2% for balanced load + 3% for 20% unbalanced load (RYB 100%, 80%, 0% or 100%, 100%, 80%
3.2.3	Transient voltage regulation	%	+ 8 at 100% load step
3.2.4	Transient recovery		Return to steady state condition within 50 ms after disturbance.
3.2.5	Voltage wave from		Sinusoidal
3.2.6	Range of adjustment of AC output voltage	%	+ 5 at rated load
3.2.7	AC Harmonic content (THD-Voltage)	%	5 Total, 3 for any single harmonic
3.2.8	Phase displacement for three phase output		1200 + 10 for balance load 1200 + 30 for 20% unbalanced load.
3.2.9	Nominal frequency	Hz	50
3.2.10	Frequency regulation (Without Static by-pass source)	Hz	+ 0.1
3.2.11	Frequency regulation (With static by-pass source)	Hz	± 2
3.3	AC standby supply		
3.3.1	Servo controlled voltage stabi-lizer (SCVS) Rating Overload capac-ity Input voltage phase & fre-quency Percentage voltage regulation Spike busters/surge suppressors and in-put filters	%	Required To match UPS continuous rating 10 times rated current for 100mS 415V + 10% 3 ph 3 wire 50 HZ + 2 Required.
3.3.2	Isolation transformer Rating In-put voltage & frequency No. Of phase requency	V Nos Hz	To be decided by Vendor 415V 3 50
3.4	Maintenance by pass switch		Required.
4.0	RECTIFIER		
4.1	Rectifier unit		Three phases 6 pulse
4.2	Parallel Operation		Required

4.3	Recharge Time on battery boost charge		As per Battery manufacturers recommendation
5.0	INVERTER		
5.1	Overload Capacity	% % %	125 for 10 Min. 150 for 1Min 500 for 5 milli seconds
5.2	Synchronising		
	- Between inverters		Required
	- Between inverters And standby supply		Not required
5.3	Parallel Operation		Required
5.4	Synchronising Range		50 ± 2 Hz(adjustable)
6.0	STATIC SWITCH		
6.1	Maximum transfer time	ms	5 (1/4 cycle)
6.2	Short time current rating	%	750 for 1.0 secs.
7.0	CIRCUIT BREAKER & LOAD BREAK SWITCHES		
7.1	Type		MCCB / LOAD BREAK SWITCH

NICKEL – CADMIUM BATTERY

Design Features

- Battery offered shall be Nickel Cadmium (Ni-Cd) type. Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. Aqueous solution of Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically change during charging/ discharging.
- The containers shall be transparent and preferably be made of toughened glass or plastic and provided with acid level indicator. The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have maximum recharge time of 8 hours.
- Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be

lead covered. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte. Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

- Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:
  - ✓ Battery racks
  - ✓ Porcelain insulators, rubber pads, etc.
  - ✓ Set of inter-cell, inter-tier and inter-bank connectors as required for the complete installation.
  - ✓ Electrolyte for first filling + 10% extra.
  - ✓ 1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
ii.	One	-	Filler hole thermometer fitted with plug and cap and having specific gravity correction scale.
iii.	Three	-	Pocket thermometers
iv	Two	-	Cell lifting straps
v	One set Each of	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors Spare vent plugs Spare nuts and bolts Suitable set of spanners

Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

It shall be the responsibility of the Agency to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication annunciation, etc. and emergency lighting. For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell

at the end of the loading cycle. The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages. The Battery Voltage shall be 240V DC. The specific technical particulars of Nickel Cadmium Battery shall be as given below:

Description	Unit	Technical Particulars
Make		As per Preferred Makes / Manufacturers
Type of battery		Ni-Cd
Applicable Standards		As per Specification
Number of battery banks required		As per requirement (*)
Ambient conditions		Min. Temp. 25° C Max. Temp 45° C
D.C. system voltage	V	110
Ampere hour capacity of battery at 27 Deg. C at 5-hour rate to give final cell voltage of 1.16 volts/cell	Ah	As per the Requirement
Momentary load/duration	A	As per the Requirement
Emergency load/duration	A	To be furnished by the Agency
Continuous load/duration	A	
Cell voltage - initial/final	V	1.42/1.16 V
Number of cells required to give rated voltage	Nos	To be furnished by the Agency
Number of spare cells	Nos	To be furnished by the Agency
Overall dimensions		
Each Cell (L x W x H)		To be furnished by the Agency
Complete battery in the rack		To be furnished by the Agency
Mounting arrangement		Multi-tier
Charging method		Float cum boost charging

BATTERY CHARGER AND D.C. DISTRIBUTION BOARD

Applicable Standards

The battery charger and D.C. distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	: IS 9000
Environmental tests for electronic and electrical equipment	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic equipment	IS:6297
Printed wiring boards	IS:7405
Environmental requirements for semi-conductor devices and integrated circuits	IS 6553
Terminals for electronic equipment	IS:4007
Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	IS:8623/BS: 5486 / IEC:439
Air break switches	IS : 13947 (Part –3)BSEN 60947-3
Miniature circuit breakers	IS 8828/BSEN:60898
HRC cartridge fuses	IS:9224/BS:88
Contactors	IS:13947 (Part – 3) /BS:775/ IEC:158-1
Control switches/push buttons	IS:6875
Indicating instruments	IS:1248/BC:89/ EC:51
Degree of Protection	IS:13947- (Part 1) /IEC:947-1
Climate-proofing of electrical equipment	BSCP:1014
Code of practice for phosphating iron and steel	IS:6005/BS:3189
Semi-conductor converters	IEC:146
Semi-conductor rectifier equipment safety code	IS:6619
Specification for copper rods and bars for electrical purposes	IS : 613

Battery Charger

Battery charger shall be combined float-cum-boost type. The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit. The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The Agency shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

- The float charger shall be designed for supplying :
- The D.C. loads specified, i.e. continuous load and short-time overload.
- The trickle charging current of the battery.
- The boost charger shall be designed for supplying the boost charging current of the battery.

If the battery and charger are to be supplied by separate Agency, the charger Agency shall coordinate with the battery. Agency regarding the float/trickle and boost charging current and voltages required by the battery,

- Performance
- Float Charger

The D.C. output voltage during float charging shall be stabilised within ±1% of the set DC bus voltage. There shall be provision for manual control if auto mode fails.

Boost Charger

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.

In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. There shall be provision for manual control if auto-mode fails.

During boost charging, following emergency measures shall be provided:

- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

The specific technical particulars of Battery charger shall be as given below:

Description	Unit	Technical Particulars
General		
Make		As per Preferred Makes / Manufacturers
Applicable Standards		As per Specification
Number required		
(i) Battery charger	Nos	(*)
Rated Output voltage (DC)	V	110
Rated Output	kW	(*)
DC System Earthing		Unearthed
Voltage regulation from no load to rated load	%	± 1
Ambient Design Temperature	Deg. C	45° C
Busbar material & size	-	Copper, size as per Requirement
Overall dimensions		To be furnished by the Agency
Battery Details		
Float/Trickle charging current of battery	A	(*)
Boost Charging Current of Battery (Maximum)	A	(*)
Boost Charging Voltage of Battery (maximum)	V	142
Maximum Time for Boost charging of Battery	hr	5
Battery capacity & no. of cells	Ah	(*)
	Nos.	(*)
AC System Data		
Supply Voltage Phase	V Nos.	415 3
(i) Variation in supply Voltage	%	± 10
(ii) Variation in supply frequency	%	± 5
Short Circuit level	kA	40
Type of Earthing		Solidly Earthed
Performance		

DC voltage setting adjustment for float charger		±10% of nominal voltage
Voltage stabilisation for constant voltage regulator		±1% of set D.C. voltage, with AC input variation and DC load variation from 0 to 100%
Maximum permissible variation in DC voltage (no load to full load)		± 1%
D.C. voltage setting adjustment for boost charging		70% to 100% of max. boost charging voltage
D.C. current adjustment for boost		30% to 100% of max. boost charging
Charging		current
Current stabilisation for constant current regulator for boost charger		± 2%
Minimum permissible power factor to rated continuous load		0.8
Permissible ripple content at rated continuous load		3% (maximum)
Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)		Yes
Constructional Features		
Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition	mm	Cold rolled 2.0
Degree of protection		IP 42
Colour finish shade		Interior : Glossy white Exterior : Light Grey Semi Glossy Shade 631 of IS 5
Earthing bus Material Size Earthing conductor Material Size	 mm x mm mm x mm	 Copper (*) GS (*)
Cable entry		Bottom
Cable Sizes		

(i) Battery	sq.mm	As per the Requirement
(ii) DC output	sq.mm	As per the Requirement
(iii) AC input	sq.mm	As per the Requirement

Charger Panel and D.C. Distribution Board

- Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.
- Indications, controls and output voltage setting adjustments shall be on front panel. The Agency shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.
- The components shall be liberally rated and housed in a well ventilated sheet metal cu-bicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP- 42.
- Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints
- All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.
- All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
- All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.
- All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm2 and for power wiring shall be 2.5 mm2.
- Ground terminals with isolating links shall be provided.
- Cable glands shall be provided to suit the incoming and outgoing cables.

Components/Accessories

- The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Agency scope. Instead of incoming ON/OFF switches, stricker fuses and contactors, the Agency may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.
- One (1) set - Three phase full wave half controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.
- One (1) Double wound, dry type, three phase suitably rated mains transformer.
- One (1) set of suitably rated control transformers for electronic controller.
- One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.
- The electronic controller shall be provided with following features.
- Boost current stabilisation of ±2% with AC input variation of voltage and frequency variation of ±10% and ±5% respectively.
- Boost charge current limiter with potentiometer to adjust the setting.
- Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
- One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
- One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.
- One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
- One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.
- One (1) TP AC ON/OFF switch for float charger incoming.

- One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.
- One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.
- One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.
- One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
- One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.
- One (1) Double pole DC ON/OFF rotary switch for float charger output.
- One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.

Power Electronic Components

- Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
- If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care shall be taken to select matched pairs of rectifier heat sink units.
- Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
- Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
- The diodes or thyristor banks shall be natural air cooled.
- The diodes or thyristors shall be protected against overvotage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

The specific technical particulars of Charger Panel & DC Distribution Board shall be as given below:

Description	Unit	Technical Particulars
General		
Make		As per Preferred Makes / Manufacturers
Applicable standards		As per specification
DC System voltage	V	110
DC Bus Load		
Total continuous DC load	A	(*)
Short time loads (Additional to continuous loads)		
(i) DC lights/Facia lamps	A	(*)
(ii)Starting current and duration of Largest Connected DC Motor	A Secs	(*) (*)
Bus bar material and rating		Copper , size as per Requirement
Constructional Features		
Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition	mm	Cold rolled 2.0
Degree of protection		IP 54
Colour finish shade		Interior : Glossy white Exterior : Light Grey Semi Glossy Shade 631 of IS 5
Earthing bus Material Size	mm x mm	Copper (*)
Earthing conductor Material		GS
Size	mm x mm	(*)
Cable entry		Bottom
Cable Sizes		
(i) Battery	sq.mm	(*)
(ii)DC output	sq.mm	(*)
(iii) AC input	sq.mm	(*)

TECHNICAL SPECIFICATIONS FOR HT & LT INDUCTION MOTORS

Motors Rated 175kW & below shall be suitable for 415V, 3 Phase, 4 Wire, 50Hz, Solidly Earthed System and remaining motors are to be designed for 6.6KV system.

The Motors Shall be of Reputed and Reliable make and the same shall be subject to approval of PURCHASER.

Performance and Characteristics

- HT & LT induction motors shall conform to IS: 325/IS:9283. The motor shall be three phase squirrel cage induction type with non-overloading characteristics, energy efficient motors.
- Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
  - ✓ Variation of supply voltage ±50%
  - ✓ Variation of supply frequency ±50%
  - ✓ Combined voltage and frequency variation ±50%
- The starting current of motor shall not exceed 130% of rated full load current for VFD starting under any circumstances.
- Motors shall be suitable to operate with Variable Frequency Drives.
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.
- Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- The motor vibrations shall be within the limits specified in the relevant standard.
- Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.
- The enclosure for motor shall be IP-68.
- Minimum three number thermistors in series are to be provided to sense the stator winding temperature.
- Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.
- The power rating of the motor shall be larger of the following:
  - ✓ 115% of the power input to the pump at duty point.
  - ✓ 105% of the power input to the pump at 75% head.

Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966.

For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

Insulation

The stator winding shall be made from high conductivity annealed copper conductor; winding insulation shall be of class-F insulation, conforming to IS: 325. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 (Part-VII): 1970 for induction type motors.

Constructional Features

- The motor shall be suitable for continuous duty as well as intermittent duty with or without full submergence of the motor.
- Aluminium die cast rotor to be provided for better starting torque characteristics.
- The electric motor shall be suitable for 10 starts & stops per hour.
- Single phasing and overload protection system shall be provided.
- The motor degree of protection shall be IP68.
- Each motor shall be provided with minimum 25 m length of power & control cables and 15 m length of lifting chain.
- Junction box (i.e.) for terminating power & control cables for each motor.

Induction *Motor Characteristics*

All motors shall comply with IEC 60034, 60072 and IS-325, 4029, 4722 including standards referred to therein.

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	As per BOQ
Rated voltage	kV	6.6KV & 0.415
Synchronous speed	Rpm	As per BOQ
Quantity	Nos.	As per BOQ
Type of mounting		Horizontal/ Vertical (depending on application and process requirement)
Duty type		Continuous (S1)

Description	Unit	Particulars
Method of starting		Variable Frequency Drives
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	°C	50
Location		Indoor
Degree of Protection		IP55
Cooling designation		IC416
Terminal box		LHS – looking from NDE end
External cable details		As per BOQ. Aluminum, XLPE, armoured

- Motors shall be energy efficient (Category –2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55. They shall be capable of starting and accelerating the load for the method of starting, as per SLD without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage. Main conductor and insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.
- Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
  - ✓ Variation in supply voltage ±50%
  - ✓ Variation in supply frequency ±50%
  - ✓ Combined voltage and frequency variation ±50%
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage. Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
  - ✓ The Power rating of the motor shall be the larger of the following:
  - ✓ 115% of the power input to the pump at duty point.
  - ✓ 105% of the power input to the pump between 110% to 75% head.

- Motors shall withstand the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150% of the rated voltage, during fast changeover of buses. The duration of this condition is envisaged for a period of one second.
- The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by atleast two seconds or 15% of the accelerating time, whichever is greater.
- The motors shall be provided with class F insulation with temperature limited to that of class B insulation.
- Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

Constructional Features

- Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.
- The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.
- All bearings shall be fitted with oil or grease lubricators. Motor bearings shall not be subjected to any external thrust load. Unless otherwise specified, motor bearings shall have an estimated life of at least 40,000 hrs. It shall be possible to lubricate the bearings without dismantling any part of the motor. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.
- The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

Terminal Box

- Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degree in steps of 90 degree.
- The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied.
- Separate terminal boxes shall be provided for each of the following:
  - ✓ Stator Leads
  - ✓ Space Heaters

Accessories

Drain Plugs

Motors shall be provided with drain plugs, so located to drain water, resulting from condensation or due to other causes, from all pockets in the motor casing.

Heating during Idle Period

- For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.
- Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

Rating Plate

- The following details, in addition to those specified in applicable standards shall be included on the rating plate.

- Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.
- Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard, in the presence of the Engineer-in-Charge. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Authority's approval. The Agency shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

***Air* Compressors (Rotary Screw Compressor)**

The operation of all valves and instruments will be done electrically. However, if a Compressor system is required for some reason, it shall comprise compressors, after-coolers and air/dryers, duty/standby air receivers together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators as required.

Electrically driven screw air compressor sets shall operate up to minimum10 bar working pressure.

Compressor sets with at least 1 standby shall be provided complete with the following:

- Common base frame for Compressor & Motor
- Single stage air-cooled unit
- Isolating valves
- Air filter and silencer
- Pressure relief valve or excess pressure safety device
- pressure reducing valves
- Pressure gauges
- Pressure tank
- Off loading piston
- Automatic changeover (failure of duty unit)
- drain pipes
- Isolating valve
- Stoppers
- Air-receivers

- Others necessary appurtenances

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

1 Duty & 1 Standby after coolers shall be provided. Water- cooled or air blast types will be considered. Air receivers shall be designed and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges and relief and check valves.

Supply of all necessary electrical components, devices, equipment, control panels, etc. together with cabling, earthing provisions, etc. shall be the responsibility of the Agency.

Interconnecting pipe work shall be arranged to avoid low points, which may trap water. Unavoidable low points shall be provided with drain cocks piped to waste.

Electric actuators

- The actuators shall be suitable for use on a nominal _volt _ phase Hz power supply and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self contained, sealed enclosure.
- In order to maintain the integrity of the enclosure, setting of the torque levels, position limits and configuration of the indication contacts etc shall be carried out without the removal of any actuator covers over an Infra red interface. Sufficient commissioning tools shall be provided with the actuators and must meet the enclosure protection and certification levels of the actuators. Commissioning tools shall not form an integral part of the actuator and must be removable for secure storage/authorised release. In addition, provision shall be made for the protection of configured actuator settings by a means independent of access to the commissioning tool.
- The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction of valve travel irrespective of the connection sequence of the power supply.
- Actuators shall be suitable for indoor and outdoor use. The actuator shall be capable of functioning in an ambient temperature ranging from 15 to 45 degree C, up to 100% relative humidity.

- Actuators for hazardous area applications shall meet the area classification, gas group and surface temperature requirements specified in data sheet.

Actuator sizing

The actuator shall be sized to guarantee valve closure at the specified differential pressure and temperature. The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10% below nominal. For linear operating valves, the operating speed shall be such as to give valve closing and opening at approximately 10-12 inches per minute unless otherwise stated. For 90□ valve types the operating time shall be specified.

Enclosure

Actuators shall be 0-ring sealed, watertight to /IP68 7m for 72hrs, NEMA 4, 6. The motor and all other internal electrical elements of the actuator shall be protected from ingress of moisture and dust when the terminal cover is removed for site for cabling, the terminal compartment having the same ingress protection rating as the actuator with the terminal cover removed.

Enclosure must allow for temporary site storage without the need for electrical supply connection.

All external fasteners shall be zinc plated stainless steel. The use of unplated stainless steel or steel fasteners is not permitted.

Motor

The motor shall an integral part of the actuator, designed specifically for valve actuator applications. It shall be a low inertia high torque design, class F insulated with a class B temperature rise giving a time rating of 15 minutes at 40°C(104°F) at an average load of at least 33% of maximum valve torque. Temperature shall be limited by thermostats embedded in the motor end windings and integrated into its control. Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearcase.

Motor protection

Protection shall be provided for the motor as follows:

- Stall - the motor shall be de-energized within 8 seconds in the event of a stall when attempting to unseat a jammed valve.
- Over temperature - thermostat will cause tripping of the motor. Auto-reset on cooling

- Single phasing - lost phase protection.
- Direction – phase rotation correction.

Gearing

The actuator gearing shall be totally enclosed in a oil-filled gearcase suitable for operation at any angle. Grease lubrication is not permissible. All drive gearing and components must be of metal construction and incorporate a lost-motion hammerblow feature. For rising spindle valves the output shaft shall be hollow to accept a rising stem, and incorporate thrust bearings of the ball or roller type at the base of the actuator. The design shall be such as to permit the opening of the gearcase for inspection or disassembled without releasing the stem thrust or taking the valve out of service. For 90□ operating type of valves drive gearing shall be self locking to prevent the valve backdriving the actuator.

Hand operation

A handwheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/auto selection lever to be locked in both hand and auto positions. It shall be possible to select hand operation while the actuator is running or start the actuator motor while the hand/auto selection lever is locked in hand without damage to the drive train.

Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise stated in the data sheet. For linear valve types the actuator handwheel drive must be mechanically independent of the motor drive and shall be such as to permit valve operation in a reasonable time with a manual force not exceeding 400N through stroke and 800N for seating/unseating of the valve.

Drive bushing

The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox. input shaft. Normally the drive bush shall be positioned in a detachable base of the actuator. Thrust bearings, when housed in a separate thrust base shall be of the sealed for life type.

Torque and turns limitation

Torque and turns limitation to be adjustable as follows:

- Position setting range – multi-turn: 2.5 to 100,000 turns, with resolution to 15 deg. of actuator output.
- Position setting range – direct drive part turn actuators: 90□ +/-10□, with resolution to 0.1 deg. of actuator output.
- Torque setting: 40% to 100% rated torque.
- Measurement of torque shall be from direct measurement of force at the output of the actuator. Methods of determining torque-using data derived from the motor such as motor speed, current, flux etc are not acceptable A means for automatic "torque switch bypass" to inhibit torque off during valve unseating and "latching" to prevent torque switch hammer under maintained or repeated control signals shall be provided.

The electrical circuit diagram of the actuator shall not vary with valve type remaining identical regardless of whether the valve is to open or close on torque or position limit.

Remote valve position/actuator status indication.

- Four contacts shall be provided which can be selected to indicate any position of the valve, Provision shall be made for the selection of a normally closed or open contact form. Contacts shall maintain and update position indication during handwheel operation when all external power to the actuator is isolated.
- The contacts shall be rated at 5A, 250V AC, 30V DC.
- As an alternative to providing valve position any of the four above contacts shall be selectable to signal one of the following:
  - ✓ Valve opening, closing or moving
  - ✓ Thermostat tripped, lost phase
  - ✓ Motor tripped on torque in mid travel, motor stalled
  - ✓ Remote selected
- Actuator being operated by handwheel
- Provision shall be made in the design for an additional 4 contacts having the same functionality. Provision shall be made in the design for the addition of a contactless transmitter to give a 4-20mA analogue signal corresponding to valve travel for remote indication when required. The transmitter will auto range to the set limits

Local position indication

- The actuator display shall include a dedicated numeric/symbol digital position indicator displaying valve position from fully open to fully closed in 1% increments. Valve closed

and open positions shall be indicated by symbols showing valve position in relation to the pipework to ensure that valve status is clearly interpreted. With main power on the display shall be backlit to enhance contrast at low light levels and shall be legible from a distance of at least 6 feet (2m).

- Red, green, and yellow lights corresponding to open, closed, and intermediate valve positions shall be included on the actuator display when power is switched on. The digital display shall be maintained and updated during handwheel operation when all power to the actuator is isolated.
- In addition, the actuator display shall include a separate text display element with a minimum of 32 characters to display operational, alarm and configuration status.. The text display shall be selectable between English and one of the following languages: Hindi or Marthi. Provision shall be made to upload a different language without removal of any covers or using specialized tools not provided as standard with the actuator. Provision shall be made to orientate the actuator display through increments of 90degres.

Local torque Indication:

The digital display shall be capable of indicating real time torque and valve position simultaneously, both being displayed in 1% increments of valve position and actuator rated torque. In addition, torque shall also be displayed in horizontal bar graph form.

Integral starter and transformer

The reversing starter, control transformer and local controls shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The controls supply transformer shall be fed from two of the incoming three phases and incorporate overload protection. It shall have the necessary tappings and be adequately rated to provide power for the following functions:

- Energization of the contactor coils.
- 24V DC output for remote controls.
- Supply for all the internal electrical circuits.

Local controls

- The actuator shall incorporate local controls for Open, Close and Stop and a Local/Stop/Remote mode selector switch lockable in any one of the following three positions: local control only, stop (no electrical operation), remote control plus local stop only. It shall be possible to select maintained or non-maintained local control.
- The local controls shall be arranged so that the direction of valve travel can be reversed without the necessity of stopping the actuator.
- Provision shall be made to orientate the local controls through increments of 90 degree.

Control facilities

- The necessary control, wiring and terminals shall be provided in the actuator for the following functions:
- Open and close external interlocks to inhibit local and remote valve opening and/or closing control. It shall be possible to configure the interlocks to be active in remote control only.
- Remote controls fed from an internal 24V DC supply and/or from an external supply between 20V and 120V AC or 20V and 60 V DC, to be suitable for any one or more of the following methods of control:
  1) Open, Close and Stop control.
  2) Open and Close maintained or "push to run" (inching) control.
  3) Overriding Emergency Shut-down to Close (or Open) valve from a normally closed or open contact.
  4) Two-wire control, energise to close (or open), de-energise to open (or close).
- It shall be possible to reverse valve travel without the necessity of stopping the actuator. The motor starter shall be protected from excessive current surges during rapid travel reversal.
- The internal circuits associated with the remote control and monitoring functions are to be designed to withstand simulated lightning impulses of up to 2kV.
- Provision shall be made for operation by distributed control system utilising the following network systems.
  1) Modbus
  2) Profibus
  3) Foundation Fieldbus
  4) DeviceNet

5) Pakscan

Monitoring facilities

Facilities shall be provided for monitoring actuator operation and availability as follows:

Monitor (availability) relay, having one change-over contact, the relay being energized from the control transformer will de-energise under any one or more the following conditions:

- Loss of main or customer 24V DC power supply
- Actuator control selected to local or stop
- Motor thermostat tripped
- Actuator internal fault

Where specified, provision shall be made for contacts to provide discreet indication of one or more of the following:

- Remote selected
- Thermostat trip
- Actuator fault

Actuator text display indication of the following status/alarms:

- Closed Limit, open limit, moving open, moving closed, stopped
- Torque trip closing, torque trip opening, stalled
- ESD active, interlock active
- Thermostat trip, phase lost, 24V supply lost, Local control failure
- Configuration error, Position sensor failure, Torque sensor failure
- Battery low, power loss inhibit

Integral datalogger to record and store the following operational data:

- Opening last /average torque against position
- Closing last /average torque against position
- Opening motor starts against position
- Closing motor starts against position
- Total open/closed operations
- Maximum recorded opening and closing torque values
- Event recorder logging operational conditions (valve, control and actuator)

The datalogger shall record relevant time and date information for stored data.

Datalogger data is to be accessed via non-intrusive IrDA communication. Sufficient standard intrinsically safe tools shall be provided for downloading datalogger and actuator configuration files from the actuators and subsequent uploading to a PC. The actuator manufacturer shall supply PC software to enable datalogger files to be viewed and analysed.

Wiring and terminals

Internal wiring shall be tropical grade PVC insulated stranded cable of appropriate size for the control and 3- phase power. Each wire shall be clearly identified at each end.

The terminals shall be embedded in a terminal block of high tracking resistance compound.

The terminal compartment shall be separated from the inner electrical components of the actuator by means of a watertight seal and shall be provided with a minimum of 2 threaded cable entries with provision for a maximum of 4.

All wiring supplied as part of the actuator to be contained within the main enclosure for physical and environmental protection. External conduit connections between components are not acceptable.

A durable terminal identification card showing plan of terminals shall be provided attached to the inside of the terminal box cover indicating:

The code card shall be suitable for the Agency to inscribe cable core identification alongside terminal numbers.

TECHNICAL SPECIFICATIONS FOR VARIABLE FREQUENCY DRIVES

The rating of motors in the pumping stations will be on higher side. To limit the starting current of the motors and minimize mechanical jerk on motor and pump shaft, it is proposed to install VFD for the motor starting purpose. VFDs are proposed in this installation considering the reliability and advantages in operation post consideration of losses in the VFD drive. The smooth and trouble free starting is envisaged.

APPLICABLE STANDARDS:

The specified VFD shall be designed and materials shall be furnished in accordance with the latest revisions of applicable sections of the following Codes and Standards.

International / European Standards for Design and Construction

IEC/EN 60071-1: Insulation coordination - Part 1: Definitions, principles and rules

IEC / EN 60146: Semiconductor Converters

IEC / EN 60664-1	Insulation coordination for equipment within low-voltage systems - Part 1: Principles, requirements and tests
IEC / EN 61800-4	Adjustable speed electrical power drive systems-Part 4: General requirements – Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV
IEC / EN 61800-5-1	Safety requirements electrical thermal and energy
IEC 62103	Electronic equipment for use in power installations (EN 50178)
IEC 62271-200	High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

International / European Standards for Transformers

IEC 60146-1-3	Semiconductor Converters – General requirements and line commutated converters – Part 1-3: Transformers and reactors
IEC 61378-1	Converter transformers – Part 1: Transformers for industrial applications

EMC Standards

CISPR 22 Cl A	Information technology equipment - Radio disturbance characteristics; Limits and methods of measurement
IEC / EN 61000-2-4	Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances
IEC / EN 61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods

Environmental Standards

IEC / EN 60721-3-1	Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 1: Storage
IEC / EN 60721-3-2	Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 2: Transport

IEC / EN 60721-3-3 Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Section 3: Stationary use at weather protected locations

American Standards

IEEE 519	Guide for Harmonic Control and Reactive Compensation of Static Power Converters
IEEE 958	Guide for Application of AC Adjustable Speed Drives on 2400-13800 V auxiliary systems in electric power generating stations
IEEE 1566	Standard for Performance of Adjustable Speed AC Drives Rated 375 kW and Larger
IEEE C57.12.00	General Requirements for Liquid-Immersed Distribution Power and Regulating Transformers
IEEE C57.12.01	General Requirements for Dry-Type Distribution and Power Transformers
IEEE C57.18.10	Practices and Requirements for Semiconductor Power Rectifier Transformers
ICS7.1	NEMA Safety standard for construction and guide to selection, installation and operation of Adjustable Frequency Drive Systems

Configuration
Frequency drives shall have one of the two configurations given below:
a) Current source inverter.
b) Voltage source inverter.

Smoothing Reactors for Current and Voltage Source Inverter

a) The smoothing reactor shall be sized to avoid conditions of discontinuous current

Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.

The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.

The smoothing reactor shall be made from electrolytic grade copper/aluminium and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.

Inverter

The inverter system suitable for three phase output shall consist of the following subsystems:

- The basic inverter circuit consisting of the switching device say Thyristors/Transistors/IGBT/MOSFET, connected so as to supply three phase power.
- The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.
- Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.
- The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude.
- The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.
- The output frequency of inverter shall be controlled to within the limits.

Inverter for AC drive

CURRENT SOURCE INVERTER

a) Constant Torque Operation

The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

b) Constant Horsepower Operation

In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

VOLTAGE SOURCE INVERTER

a) Constant Torque Operation

The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value. The DC voltage input shall be maintained within + 1% of the required value. Shall this fall for any reason, necessary action for tripping the frequency converter, and initiation of annunciation/alarm and fault diagnostic shall be provided.

b) Constant Horsepower Operation

In this type of operation, the voltage at the terminals of the motor shall be maintained within +1% of the rated value while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

Output Overcurrent Limit

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated and an alarm contact initiated for annunciation.

Control Modules

- All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug in module mounted on a standard nineteen inch rack which shall be accessible from the front. Each card shall have LED indication on its front plate to indicate normal condition of the card. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.
- The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.
- Adjustments susceptible to change by accidental contact shall be lockable.

Control and performance Requirements

VFD operational range shall be 25Hz to 50Hz to control the motor speed.

Short time voltage dips upto 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

- The VFD shall run with a sensorless torque control algorithm with static speed error of less than 0.2% and torque step rise time of less than 10 milliseconds.
- Unless specified, the VFD shall not require the use of a speed encoder.
- Drive shall have minimum 24 pulse configuration.
- To use auto-restart and / or Flying start instead of power loss ride-through function is not allowed.
- The VFD shall be able to catch and take control of a spinning load if started while rotating equipment is already spinning. Appropriate safeguards shall be included in this operation to prevent damaging torque excitations, voltages or currents from impacting any of the equipment. The user shall have the option of employing this feature or disabling it.
- The VFD shall be able to control the motor current from 0 Hz to maximum motor frequency and provide a "soft start" torque profile for the motor-load combination.
- The VFD shall provide current and torque limit adjustments to limit the maximum VFD output current and the maximum torque produced by the motor.
- The VFD shall accept a start/stop command and speed reference from a local VFD panel, or from a remote panel.
- Each VFD shall be equipped with a front mounted operator control panel consisting of a back lighted alphanumeric display and a keypad with the functions:
  - Run/Stop command
  - Local/Remote command
  - Speed Increase/Decrease command
  - Menu navigation and parameter selection
- All parameter names, fault messages, warnings and other information shall be displayed.

- During normal operation, the speed reference, run/stop, forward/reverse and local/remote status shall be displayed. At least 3 additional user selectable analog values shall be available for display including the following values as a minimum:
  - Motor speed, current and power
  - Output frequency, voltage and torque
  - DC bus voltage
  - Values of analog input and output signals
  - Status of discrete inputs and outputs.
- Password protection shall be available for prevention of unauthorized parameter access.
- If specified, hardware inputs and outputs shall be provided to interface with external operator and supervisory control and monitoring equipment. The following galvanically isolated I/O points shall be included:
- Discrete (binary) inputs shall be designed for 24 VDC. Discrete input functions shall include 'Run/Stop', 'Disable Local' (to prevent unauthorized operation from the local panel) and 'Remote Reset' (minimum 4 channels).
- Analog outputs shall be 4 to 20 mA signals. Analog outputs shall be programmable to provide signals proportional to at least output motor speed, current, torque or power (minimum 3 channels).
- Relay contact outputs shall be rated to switch in minimum 3 A at 24 VDC or 230 VAC. Function selections shall include 'VFD ready', 'Running', 'Alarm' and 'Trip' indications.

If specified in Buyer's Datasheet, serial fieldbus communication interface modules shall be provided.

Microsoft Windows based software shall be provided for VFD commissioning, parameters setup, fault log viewing, diagnostic analysis, monitoring and control. The software shall provide real time graphical displays of VFD performance.

Protection

- **Protection of Power Semiconductor**

- Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I2t does not exceed the I2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

- All fuses shall have a trip indicator to operate a suitable microswitch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.
- A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

➢ **Protective Systems for AC Inverter Drive**

- Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.
- Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.
- Protection for all control cards, power supply stabilisers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.
- Polarising relay to prevent reversal of polarity on the input side of the inverter.
- Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.
- Current limit fuses at the output of the inverter.
- Commutation circuit undervoltage
- Inverter overfrequency
- Programmable overcurrent
- Phase sequence/loss of phase protection
- Earth fault protection
- DC link overvoltage protection
- Specific motor protection
- Incoming line surge protection
- Ventilation Loss
- Over temperature

Cooling of Power Converters

Power semiconductors shall be mounted on heatsink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available. Cooling of power semiconductors can either be natural air cooled or forced air cooled. The Agency shall recommend the type of cooling. However, for power converters which exceed capacities of 2kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably

be double side cooled.

Switching Devices

Switching devices such as circuit breakers, isolators, contactors, switch-fuse units etc. shall be considered in the scope of supply. The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper/aluminium strips. These connections shall be adequately braced and insulated.

Constructional Features

The controller shall have modular construction to facilitate maintenance.

- **Bus bars**

- Power connections shall be of the bolted type and mating surfaces shall be tinned.
- The bus bars running to various converters shall be suitably designed to ensure equal sharing between the parallel strings and prevent mechanical stress on the fuse.
- All bus bars shall be adequately insulated for full circuit voltage by insulating tapes and similar insulating material.
- In case aluminium bus bars are specified, care shall be taken to ensure that bimetallic connections are provided wherever necessary.
- All cubicles shall have copper earth buses of adequate size running the entire cubicle height along the sides.

- **Cubicle**

- Cubicles housing the power semiconductors and drive level control system shall conform to IP 42 degree of protection to enclosures.
- Panels shall be free standing, floor mounting type and shall comprise rigid welded structural frames enclosed completely with cold rolled sheet steel of thickness no less than 2.5 mm for front and rear portions and 2.0 mm for sides, top and bottom portions. There shall be sufficient re-inforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.
- All doors, removable covers and panels shall be gasketed all round with neoprene gaskets. Ventilating louvers shall have screens and filters. The screens shall be made of either brass or GI wire mesh.
- Design, material selection and workmanship shall be such as to result in a neat appearance inside and outside with no welds, rivets or belt heads apparent from outside, with all exterior surfaces true and smooth.

- **Painting**

- All sheet steel work shall be phosphated in accordance with the following procedure and in accordance with IS: 6005 "Code of Practice for Phosphating Iron and Steel".
- Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.
- Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
- After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and even drying.
- The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved.
- After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.
- The final finished thickness of paint film on steel shall not be less than 100 microns and shall not be more than 150 microns.
- Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.
- A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

- **Bins and Printed Circuit Cards**

- Individual bins shall be mounted on a swingable frame so that the connections at the rear are also accessible.
- Self retaining thumb head screws shall be needed for holding the bins in position.
- Adequate number of card/bin extenders for testing of PCBs shall be provided, each with flexible cables at least two metres long. These extenders shall be of a universal type suitable for use with any card / bin as the case may be.
- All adjustments which are to be made while changing a card shall be outside in a separate module preferably plugged into the regulator bin.
- Locking of individual cards in a bin shall preferably be through self retaining thumb-head screws.

- Control modules shall be in the form of plug in packages, plugged into a module bin. Each plug in unit shall consist of a strong frame on which a printed circuit board would be permanently screwed.
- The plug connections shall only be of the pin type.
- The printed circuit board (P.C.B.) shall be made of glass fibre filled with epoxy laminates. The plug in unit shall be screwed to the basic socket in the module bin with long through bolts and knurled heads.
- The front plates of the plug in unit shall have the switches, the potentiometers, miniature monitoring meters, test points etc. Each plug in unit shall have its own identification legend.
- All plug in units shall be polarised to prevent incorrect insertions into the module bin.
- The gap between two plug in units inside a bin shall be sufficient to permit adequate ventilation.
- The copper side of the printed circuit board shall be lacquered to prevent oxidation.
- Each side of the printed circuit board shall have a shield cover to prevent inter circuit and external interference.
- The P.C.B. shall be mounted on P.C.B. guides fixed on standard racks and the shield properly grounded.
- Control circuit test points shall be easily accessible for monitoring and maintenance.

➢ **Annunciation**

- The annunciator shall work on DC power supply.
- Each annunciator window shall have two lamps connected in parallel which operate at not more than 75% of their rated voltage.
- Window shall be arranged in a logical group.
- The annunciator shall have a module construction with glass epoxy plug in cards.
- Alarm bell/siren shall be continuously rated and shall have a series resistance.
- The annunciator shall have the following facilities.
  a) First in sequence, memory reset.
  b) Fleeting faults shall be memorised.
  c) Test Feature.
- There shall be a three-tier system of protection and annunciation:
  a) Alarm both audible and visual.

b) Warning with delayed shut down –time delay through a timer of range 0-60 sec.

c) Disturbance associated with failures of systems elsewhere.

- **Meters**

- Individual meters shall be provided for speed reference, speed feedback, current reference, current feedback, pulse output, and regulated power supply voltages.
- All meters shall be identical and fed through individual buffer I.C. amplifiers.
- All meters shall be the circular scale type having a full scale deflection of 2700.
- All meters shall conform to at accuracy class 0.2
- All meters with their individual buffer amplifier cards shall be housed in separate bin. It is recommended that the buffer amplifiers all be housed on a single/two card/s and this card/s be itself/themselves housed in the regulator bin.
- Sensitive signal leads in that case will not have to traverse from one bin to another, only noise insensitive buffer amplifier output leads will need to go to the meter bin.
- Selector switches if used with any meters shall have pistol grip handles.

- **Wiring**

- Stranded, flexible copper cable of 2.5 sq.mm shall be used for C.T. circuits and 1.5 sq.mm for other control circuits. However, for PCB terminals 0.75 sq.mm may be accepted.
- Ultra-flexible cables shall be used for all connections from a fixed part to a movable member. In addition, a hanging loop of sufficient length shall be provided to avoid any cable stressing.
- All terminal boards for outgoing connections shall be at a height of at least 250 mm from the cubicle floor, and preferably tilted at an angle of 450 to the horizontal for ease of connections. Similarly, connection of the incoming power cables to the bus bars shall be done at a height of at least 250 mm from the cubicle floor.
- Item designation and location marking shall be in line with IEC recommendations.
- Device labeling shall be on its fixed mounting and not on the device itself such that labeling remains even when the device is replaced. Metallic labels/paper labels or sticker shall be accepted.

- **The specific technical particulars of Variable Frequency Drive shall be as given below:**

Description	Unit	Technical Particulars
Make		As per Preferred Makes/Manufacturers
Type of Drive		Inverter Controlled A.C Drives
Rated voltage, frequency and Phases		433, V 50 Hz, 3 Phase
Variation in voltage		415 V + 10
Variation in frequency		50 Hz + 5
Type of Duty		100% continuous, 150 % overload for 2 minute once in period of 24 hours, 200 % overload for 10 seconds once in period of 24 hours
Design Ambient Temperature		45 C
Overall Harmonic Limitation		Less than 5% as per limits given in IEC 61800
Application		As per Requirement
Interfaces		Serial or Profit bus

TECHNICAL SPECIFICATIONS FOR HV & LV POWER CABLES AND CONTROL CABLES

Applicable Standards

The cables shall conform to the latest applicable standards specified below.

PVC insulated cables (for voltage upto 1100 V)	:	IS:694
HRPVC & PVC insulated cables heavy duty	:	IS:1554
Cross linked polyethylene insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with	:	IEC: 60189-1 &
PVC insulation and sheath		IEC-60189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS:6474
Conductors for insulated electric cables	:	IS:8130
Methods of test for cables	:	IS:10810
Specification for drums of electric cables	:	IS:10418

Specification for PVC insulated cables for electricity supply	:	BS:6346
Specification for PVC insulation and sheath of electric cables	:	BS:6746

Features of Construction

XLPE Insulated HV Power Cables:

The Cables shall be 33kV Earthed grade & 6.6kV Unearthed grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting Compound, insulation screening through Combination of semi conducting compound and non-magnetic tape (Copper tape), inner sheath over laid up cores, galvanised steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.XLPE Insulated LV Power & PVC Insulated Control Cables

LV Power Cables:

The Cable shall be 1.1 KV Grade, heavy duty, stranded aluminium/Copper Conductor, XLPE insulated, Extruded PVC inner sheathed, galvanised steel wire/strip armoured, Extruded black PVC Compound type ST2 outer sheathed.

LV Control Cables:

The Cables shall be 1.1 KV Grade, heavy duty, Stranded Copper Conductor, PVC Compound type A insulated, PVC Tape inner sheathed, galvanised steel wire/strip armoured, black PVC compound type ST1 outer sheathed.

Cable Rating

- The Agency shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.
- In assessing the rating of any cable or wire, the following factors shall be taken into account
- Supply voltage and frequency
- Maximum voltage drop permissible
- Type and magnitude of load
- Fault level and duration related to circuit protection relays and fuses
- Circuit Overcurrent protection

- Route length and disposition of cables
- Ambient temperature
- Method of installation
- All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 50^0C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.
- Under motor starting conditions, the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event, shall not exceed 10%. The Agency when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

Cable Colours

- All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.
- The colour coding shall be as follows:

3 phase	red, yellow and blue
single phase or dc	red and black
earth	green/yellow
control	blue (dc), red (ac)

Cable Conductors

Copper conductors shall be used for cables of sizes upto 4 Sq.mm. Aluminium conductors shall be used for cables of size 6 Sqmm and above. Cores of cross-sectional area greater than 1.5 mm^2 shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm^2. Power cables shall be of a minimum cross-section of 2.5 $mm^{2.}$ Internal wiring of control panels shall be of a minimum cross-section of 1.0 mm^2 flexible and stranded. Control cables shall be of a minimum cross-section 1.5 mm^2 for external use and 1.0 mm^2 for internal use.

2.10.6 Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit number.

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _

2.10.7 Cable Drums

- Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.
- The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. However before winding the cables on drums, Agency shall obtain Authority's approval for the drum lengths.
- Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size, number of cores, length, result and date of tests as required in the Authority's Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Agency shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

Cable Installation

General

- Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
- Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
- Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/Protection
HV Power	N/A	300	500
LV Power	300	N/A	300
C&I/Protection	500	300	N/A

- These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.
- In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
- Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.
- Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.
- Heavy duty galvanised iron cable tray and ladder racking shall be used for cable support systems. Plastic or GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support

systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

Cables Laid Direct in Ground

- Buried cable up to 650/1 100 V shall have a minimum cover of 500 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.
- Cables of greater than 650/1100 V shall be buried with a minimum cover of 1m.The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75mm of sieved sand shall be laid above the cable.
- Interlocking cable protective covers, minimum 1m long x 300mm wide, marked `Danger -Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50mm.
- Warning tape shall be laid a minimum of 200mm above the protective covers.
- Cables are to be installed without tees or through joints unless otherwise approved by the Engineer-in-Charge. Single core cables shall be run in trefoil formation.

Cables Laid in Underground Ducts

- Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 500 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1m deep and encased on all sides by 150mm of concrete.
- The Agency shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.
- Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer-in-Charge. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

Cables installed in Conduit

General

- Conduits shall be galvanised heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanised.
- A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.
- Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.
- Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.
- Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.
- Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Engineer-in-Charge. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.
- Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.

- Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150mm movement shall be allowed.

Surface Installation

- Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Engineer-in-Charge before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanised cable trunking. Conduits installed on structural steelwork shall be secured at spacings not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Engineer-in-Charge. Any drilling or access which is required through any structural member of the building shall be agreed with the Engineer-in-Charge before carrying out the work.
- Exposed threads and places where galvanising has been damaged shall then be painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

Concealed Installation

- Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.
- At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

- Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.
- The conduit installation shall be inspected by the Engineer-in-Charge before the building operation conceals the work.

Cable Installed in Flexible Conduit

- Flexible conduit shall be of the waterproof galvanised type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations. Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

Cable Installed in Cable Trunking – Metal

- Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanised. The Agency shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50mm x 50mm minimum size.
- Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

- Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.
- Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.
- Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically.
- Crossings over expansion joints shall be made in flexible conduit.
- Shall it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanising paint.
- Cable and conduit/trunking runs shall be determined by the Agency and agreed by the Engineer-in-Charge before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services.
- Conduit/trunking systems erected outside a building shall be weatherproof.

Cable Installed on Cable Tray

- Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm for trays from 150 mm to 300 mm width.
- Cable tray shall be hot dipped galvanised. Cable tray for use in areas where chlorine gas may be present shall constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.
- All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.
- Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.
- Cable tray supports supplied by a manufacturer or made up on Site shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at midspan.

- Wherever possible, cable trays shall be installed in full lengths without cutting. Shall it be necessary to cut or drill a length of tray, then for galvanised trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanised paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.
- All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer-in-Charge, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at midspan. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.
- Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray.
- The sizing of the cable tray shall provide a minimum of 25% spare capacity.
- The tray shall be run at least 150 mm clear of plumbing and mechanical services.

Cable Installed on Ladder Rack Systems

- Ladder racking either light or heavy weight shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed.
- Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed.
- The sizing of the cable rack system shall provide a minimum of 25% spare capacity.
- The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

Cable Clipped Direct

- All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed.
- Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

Cable Installed in Internal Floor Trench

In Shallow trenches (maximum depth 500 mm)

- In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner.
- Where the trench is shared by other services, cables shall be installed on the walls of the trench in an approved manner.

All other trenches including walk through service ducts

Cabling shall be installed to the walls of the trench in an approved manner. Where other services are present the cables shall be segregated from them and wherever possible kept above `cold' wet services. Cables shall not be run if at all possible above or in close proximity to `hot' services. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation.

Cable Terminations and Joints

Multi core or Control Cable Terminations

- A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.
- Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.
- Terminals which remain energised when the main equipment is isolated shall be suitably screened and labelled.
- Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

Cable Fixings

- Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.
- Large single cables shall be secured with cable clamps or cable cleats.

Cable Identification

- At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall

be indelibly marked to the approval of the Engineer-in-Charge. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

Cable Glands

- Glands shall generally be of the mechanical compression hexagon type. Earth continuity of brass glands shall be assured. This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment. Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.
- Glands for single core cables shall be constructed from non-magnetic materials.
- Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.
- Where holes for cable entries are not provided it shall be the responsibility of the Agency to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.
- For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.
- For dry indoor situations, standard industrial glands with shrouds are acceptable. For hazardous areas, glands used shall be used with double seal and shroud.
- Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the glanded device in order that a true earth loop value may be measured when carrying out tests on the installation.

Marking Locations of Underground Cables

- The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300mm above ground level and directly above the point where cables pass through the wall.

- In addition, concrete marker posts shall be installed at intervals of not more than 50m at all junctions and changes of direction along the cable route. Such marker posts shall be not less than 200mm high and of substantial construction. A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer-in-Charge.
- The markers shall be marked `electric cable' in English and the vernacular

The specific technical particulars of HV & LV Cables shall be as given below:

Description	Unit	Technical Particulars
33kV EARTHED GRADE XLPE INSULATED POWER CABLES		
Make		As per Preferred Makes/Manufacturers
Applicable Standards		
Continuous current rating with cable laid in air under specified ambient temperature	A	(*)
Overall diameter of the cable	mm	To be furnished by the Agency
Recommended minimum bending radius	mm	To be furnished by the Agency
Safe pulling force when pulled by using pulling eye		To be furnished by the Agency
Standard length of cable on each drum	mtr	As per requirement
6.6KV UNEARTHED GRADE XLPE INSULATED POWER CABLES		
Make		
Applicable Standards		
Continuous current rating with cable laid in air under specified ambient temperature	A	As per requirement
Overall diameter of the cable	mm	To be furnished by the Agency
Recommended Minimum bending radius	mm	To be furnished by the Agency
Standard length of cable on each drum	mtr	To be furnished by the Agency
1.1kV EARTHED GRADE XLPE INSULATED POWER CABLES		
Make		

Applicable Standards		
Continuous current rating with cable laid in air under specified ambient temperature	A	As per requirement
Overall diameter of the cable	mm	To be furnished by the Agency
Recommended minimum bending radius	mm	To be furnished by the Agency
Standard length of cable on each drum	mtr	To be furnished by the Agency
650/1100V Grade PVC Insulated Control Cables		
Make		As per Preferred Makes/Manufacturers
Applicable Standards		
Rated voltage	V	As per requirement
Overall diameter of the cable	mm	To be furnished by the bidder
Standard length of cable on each drum	mts	To be furnished by the bidder

CABLE CARRIER SYSTEM

General

Applicable Standards

Steel for general structural purposes	:	IS:2062
Dimensions for hot rolled steel beam, column channel and angle sections	:	IS:808
Code of practice for use of metal arc welding for general construction in mild steel	:	IS:816
Hot deep galvanising of iron & steel	:	IS:2629
Methods of testing uniformity of coating of zinc coated articles	:	IS:2633
Hot dip zinc coatings on structural steel and other allied products	:	IS:4759

Cable Racks and Trays

- Cable racks/trays shall be fabricated from standard structural steel members.
- All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanised.

Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

(a)	Fabricated Steel	
	Thickness less than 2 mm, but not less than 1.2 mm	340 gms/sq.m
	Thickness less than 5 mm, but not less than 2 mm	460 gms/sq.m
	Thickness 5 mm and over	610 gms/sq.m
(b)	Fasteners	
	Upto nominal size M10	270 gms/sq.m
	Over M10	300 gms/sq.m

Galvanising shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts shall be covered well by zinc rich primer and aluminium paint.

TECHNICAL SPECIFICATION FOR LIGHTING SYSTEM

General Requirements

- The Lighting system includes the following items.
- Indoor & outdoor Lighting fixtures complete with Lamps and accessories
- Lighting system equipment
- Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
- Lighting fixture supports, street lighting poles and flood light towers
- Main Lighting distribution board, lighting panels.
- Multi core cables for street, boundary and flood lighting.

Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

(a) Lighting Fixtures & Accessories		
Electrical lighting fittings general and safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665

Calculation of co-efficient of utilisation	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting outfits	:	IS: 5077
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaries for street lighting	:	IS: 10322 Part 5
Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holder	:	IS:1258/BSEN 61184IEC:60061
Edison screw lamp holders	:	IS: 10276/BSEN 60238
Cast acrylic sheets for use in Luminaires	:	IS:7569
Screwless terminal and electrical connections for light-ing fittings	:	IS:10322
Emergency lighting units	:	IS:9583
Ignition proof enclosures, dust-tight for elect. equipment	:	IS:11005
Luminaires	:	IS:10322 (Part I to V)
Dust proof electric lighting fittings	:	IS: 4012

(b) Lighting System Equipment		
Switches for domestic and similar purposes	:	IS:3854/BS:3676
Three pin plugs and socket outlets	:	IS:1293/BS:546
Boxes for enclosure of electrical accessories	:	IS:5133(1)
Rigid steel conduits for electrical wiring	:	IS:9537/BS:31
Accessories for rigid steel conduits for electrical wiring	:	IS:3837/BS-31
Flexible steel conduits for electrical wiring	:	IS:3480
Rigid non-metallic conduits for electrical installations	:	IS:9537/BS:4607(2)
Fittings for rigid non-metallic conduits	:	IS:3419/BS:4607(2)
PVC insulated cables for working voltages upto and including 1100 V	:	IS:694
Tubular steel poles	:	IS:2713
Specification for copper rods and bars for electrical purposes	:	IS:613
Code of practice for phosphating iron and steel	:	IS:6005/ BS:3189

Fittings for rigid steel conduits for electrical wiring	:	IS:2667

Lighting Fixtures (Luminaires)

- Luminaires shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.
- The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
- Connections between different components shall be made in such a way that they will not work loose by small vibration.
- For each type of Luminaires, the Agency shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
- All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.
- The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- Led type Luminaires shall be complete with accessories like lamps, drivers, etc. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.
- Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires upto 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes upto 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring shall be completed by means of standard copper wire of minimum 1 sq.mm size and terminated

on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

- Mounting facility and conduit knock-outs for the luminaries shall be provided.
- The fixtures provided shall be energy efficient and shall be consuming less power.

Earthing

Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire. All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

Painting/Finish

All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading. The luminaire housing shall be stove-enameled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel. The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection. External control gear box provided for housing accessories shall be painted or galvanised.

LED STREET LIGHT LUMINAIRE

- Supply of LED streetlight luminaries complete with pressure die cast/extruded aluminium housing and adhering to the following specifications and lighting design requirements will be as per actual applications-
- Efficiency of driver electronics shall be more than 95%.
- The LED shall be driven at the suitable current and within the permissible limits specified by the LED manufacturer.
- Power factor of the electronic driver shall be at least >0.95 with THD <10%.

- The LED luminaries shall produce constant lux level in the voltage range of 100V to 280V. Voltage variations/ fluctuations in the specified voltage range shall not impinge upon the lux level it produces.
- The life span of the LED source including its Driver shall be greater than 50000 hours.
- The luminaries shall conform to IEC 60598 or equivalent standard. The driver shall comply with IEC 61347-2-13, IEC 61547, CISPR-15; and 61000-3-2.
- The luminaire shall be suitable for 80W, LED and for mounting height up to 9mtrs from ground level.

ELECTRONIC COMPONENTS

The electronic components used shall be as follows

- IC (integrated circuit) used shall be of industrial grade.
- The resistors shall be preferably made of metal film of adequate rating.
- The conformal coating used on PCBs shall be cleared and transparent and shall not affect color code of electronic components.
- The heavy components shall be properly fixed. The solder connection shall be with good finish.

CONSTRUCTION

- The casing of the lighting luminaries shall be made of pressure die cast aluminium coated with epoxy polyester powder coat single, self-contained device not requiring any on-site assembly for installation onto an existing lighting luminaries integral with power supply unit. The driver unit must be accessible and if need be replaceable easily and with minimum use of tools.
- The casing made of non-corrosive aluminium having high conductivity shall have external surface designed in a manner so as to act as an efficient heat sink to extract heat generated at pn-junction of a LED. Efforts shall be made to keep the overall outer dimensions as minimum as possible without compromising on the performance of the LEDs or luminary.
- The assembly and manufacturing process for the LED source assembly in modules/ arrays shall be designed to assure all internal components are adequately supported to withstand sudden impacts and mechanical shock and vibration from high winds and other sources.
- No part shall be constructed of polycarbonate unless it is UV stabilized

- Material used for the lens of LED source shall be of toughened glass, heat resistant and shall not undergo discoloration during lifetime of the LED source. It shall conform to ASTM specifications for the materials. Any discoloration observed in the lens shall be considered a failure under warranty clause.
- All luminaires shall be provided with acrylic / polycarbonate / glass diffusers and/or aluminized reflectors and/or lenses to provide proper road lighting distribution.
- Toughened and/or tempered glass of sufficient strength may be provided under the LED chamber to protect the LEDs and luminaires.
- The LED lens shall be UV stabilized and shall be capable of withstanding ultraviolet (direct sunlight) exposure for a minimum period of 60 months without exhibiting evidence of deterioration.
- The luminaries shall be capable of operating normally in ambient temperatures from -20*C to 50*C maintaining junction temperature below 100*C and heat sink temperature below 60*C, ensuring efficient thermal management of the luminaire.
- The fixture shall be designed in such a manner that it is easy to handle and install, is not too large and unwieldy, is of robust construction, light weight and conforms to minimum IP65 class of protection for outdoor use against dust and moisture intrusion.
- The luminary shall be provided with a built-in external heat sink as well as an aluminum MCPCB printed circuit board, designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaries.

2.12.6 Flood Light Luminaire

General Purpose Flood Light Luminaire

- Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
- The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
- The Luminaires shall be suitable for LED upto 250 watts.

- The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.
- It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
- It shall be possible to replace the lamp from the canopy without opening the front glass.

2.12.10 Lighting System Equipment

Light Control Switches

Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.

Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanised. The enclosure box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

Receptacle Units

Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanised 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in “ON” position. Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in “ON” position. The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

Lighting Wires

The wires for wiring in lighting system shall be 250/440V, 1/C, PVC insulated, unarmoured with stranded copper conductors. The minimum area of conductors shall be 1.5sq.mm. for

light fittings and 5A Receptacles and 2.5 sq.mm for receptacles rated 15A and above. The wires shall be coded white for phase/positive of D.C. and black for neutral/negative of D.C.

Estimation for point wiring

Wiring of all lighting fixtures, fans and receptacles and earthing wiring shall be on point wiring basis. Insulated green coloured earthing wire shall also be run in conduits. Indian TNS type of distribution (as per IS 3043) shall be followed. Neutral of the circuits shall not be looped.

Point wiring for lighting and fans

Primary point (GI) shall consist of supply, installation and testing commissioning of lighting system / fan system including supply of 19/25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 1.5 sq. mm. copper PVC wires and their termination etc.

The point wiring for lighting and fans shall be classified into the following lengths:

i.	Short point	from 0 to 5m
ii.	Medium Point	5 to 10m
iii.	Long Point	10 to 20m
iv.	Extra long point	more than 20m

Point wiring for receptacles (5/15A)

Primary point (GI) shall consist of supply, installation and testing commissioning of 5A receptacle including supply of 19/ 25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 4 sq. mm. copper PVC wires and their termination etc.

The point wiring for 5A receptacles shall be classified into the following lengths:

i.	Short point	from 0 to 5m
ii.	Medium Point	5 to 10m
iii.	Long Point	10 to 20m
iv.	Extra long point	more than 20m

Conduits

Rigid steel/non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20mm for surface installation and 25mm for concealed installation. Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5m. Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

Junction Boxes

Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type. The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

Lighting Poles and Flood Light Pole Mounting

Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied. Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles, shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm. The supply of poles shall be complete

with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the attached drawings.

The specific type of Luminaire to be used at various areas shall be as given below:

Area/Structure	Type of Fixtures	Type of Luminaire.
Pump House	Industrial low bay for mounting heights > 5 to 6 M Industrial Medium bay for mounting heights > 6 to 9 M Industrial high bay for mounting heights > 9 M.	1 x 30 W LED 1 x 80/ 120 W LED 1 x 180 - 200 W LED
Switchgear / PMCC / MCC Room	Industrial type with vitreous enamel reflector	1 or 2 10-20 W LED
Office / Control Room/ Laboratory	(Mirror optics) (Decorative)	2 x 10-20 W LED
Periphery	Street lighting cut off type	1 x 30 W LED
Internal Road lighting	Street lighting cut off type	1 x 60-70 W LED
Chiller Room	Industrial Corrosion proof IP65	2 x 20W LED
Corridors / passage	Mirror optics, Surface type	1 x 20W LED

The specific technical particulars of Lighting Fixtures & Accessories shall be as given below:

Description	Unit	Technical Particulars
General		
Make		As per Preferred Makes/Manufacturers
Illumination levels at various premises		IS:3036 Part-I & given in General Design criteria
Normal supply voltage, phase and frequency	AC	240 V, 1 ph, 2 wire, 50 Hz
Variation in supply:		
(i) Voltage (AC & DC)	%	+ 10
(ii) Frequency	%	+ 5
(iii) Combined voltage & frequency	%	+ 10
Design ambient air temperature	0C	45° C

Luminaire terminal suitable for Indoor area		
(i) Conductor material		Copper
(ii) Cable size	Coresxmm2	(*)
Outdoor area		
(i) Conductor material		Aluminium
(ii) Cable size	Cores x mm2	(*)
Luminaire earthing terminal suitable for		
(i) Conductor material		G. I. wire
(ii) Conductor size	SWG	(*)

LOW VOLTAGE FEEDER PILLARS

This specification covers the design, Engineer-in-Charge, manufacture, testing at works, packing, supply, delivery and storage at site of low voltage outdoor type feeder and lighting pillars for lighting of streets, parking areas landscaped/developed area including all mounting bolts and other accessories required to make the pillars operable for 3 phase, 4-wire, 415 volts, 50 Hz. Neutral grounded distribution system. The pillars shall be complete with links, MCCBs, MCBs, Bus bars, Ammeter with CTs, Voltmeter / indicating lights & all such other accessories as required, even though specifically not mentioned.

Standard and System Conditions

Standard

The equipment covered in this specification shall conform to the following updated I.E.C. Publications / ISS:

S. No	Standard Number	Description
1	IS : 375	Marking and arrangement for switchgear bus-bars, main Connectors and auxiliary wiring.
2	IS : 589	Basic climatic & Mechanical durability test for components for electronic & electrical equipment.
3	IS : 1336	Push buttons
4	IS : 1554	PVC insulated (Heavy duty) electric cables
5	IS : 2147	Degree of protection provided by enclosure
6	IS : 3202	Climatic proofing of electric equipment

7	IS : 4064	Air break switches, air break dis-connectors, air break switch disconnectors and fuse combination units for voltages not exceeding 1000V.
8	IS : 5039 - 1991	Distribution pillars for voltage not exceeding 1000 Volts.
9	IS : 8623 (Part I-3)	Specification for switchgear & control assemblies.
10	IS : 8828	Specification for MCBs
11	IS :3947 (Part-II)	Low voltage switchgear and control gear
12	IEC 664 A-1980	Insulation co-ordination with in low voltage systems including clearance and creepage distance for equipment.
13	IS : 2551	Danger plate
14	IS : 0580	Service conditions for electrical equipment
15	SP : 39-987	Guide for insulation coordination within low voltage systems.

The equipment complying with other internationally accepted standards shall also be considered if they ensure performance equivalent to or superior to Indian Standards.

Quality of Material

All material used shall be new and of best quality and of class, most suitable for working under the conditions specified herein without distortion or deterioration.

Design and Standardization

General

- The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to with stand sudden load variations due to short circuits and fault conditions. The design shall incorporate every reasonable precaution and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the pillars.
- The mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and contact surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.
- Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.

- All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards etc. Metal cubical, housings and covers shall be 100% weather / vermin proof & shall be able to provide the degree of protection IP 45 in accordance with latest version of IS:2147.
- All parts shall be manufactured in accordance with relevant standard specifications of IEC/IS, corresponding parts of similar equipment and apparatus shall be mutually interchangeable.
- All apparatus, connection and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.
- The distribution feeder / service pillars shall be suitable for working outdoor in the conditions given herein. As the feeder / service pillar will be installed normally on footpaths adjoining to the roads, these shall be made robust and capable of withstanding the vibrations normally experienced due to vehicular traffic.

Clearance & Creepage Distances

The clearance & creepage distance shall be in accordance with IS: 13947 Part-I updated & corrected for operation under environmental conditions of site.

Labels and Marking of Connections / Feeder Pillars

All apparatus, control gear and the apparatus mounted there on shall be clearly labelled indicating, their purpose and the 'ON' 'OFF' and 'EARTH' positions, as applicable. The labels shall be clearly lettered on enamelled surface or other approved materials. Brass shall not be used for labels. Each phase of alternating current and connections shall be coloured by heat shrinkable sleeves to distinguish phase, neutral and earth. The colouring shall be red, yellow, blue for phases black for neutral and green for earth. Feeder pillar shall be labelled as per designation shown in the single line diagram. The labelling shall be finalised after the samples and arrangement for the same is approved by the Agency during detailed desing/Engineer-in-Charge phase.

Drawings & Literature

- Four sets of tentative G.A., schematic drawings and detailed literature of equipment shall be submitted within 120 days after contract award clearly giving the scope of supply and bill of material to enable the Engineer-in-Charge to scrutinise all aspects of

design including arrangement and support of cable accessibility for maintenance work and future additions, cable connections, general appearance etc.

- Further sets of drawings & literature are to be furnished by successful tenderer / bidder within 2 weeks after the award of contract by the Engineer-in-Charge, which shall include the following:
- Complete assembly drawings of the pillars, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.
- Foundation plan showing embedment channel frame in the floor with associated holes and suitable size of bolts for fixing to channel frame of feeder pillars.
- Wiring diagrams including terminal wiring design and cable schedule.
- Schematic control diagram for controls, relays, instruments, space heaters, cubicle illumination and receptacle etc.
- Detailed bill of material of each feeder pillar.
- Layout plan of feeder pillar.

Bought Out Items

All bought out items such as switches, MCCBs, MCB's meters, terminals, cables etc. shall be of reputed make. Engineer-in-Charge reserves the right to accept only materials of proven make at its sole discretion.

Specification of LT Feeder pillars

Constructional Details

- A totally enclosed cubicle shall be fabricated out of heavy gauge stainless steel sheets of thickness not less than 3.15 mm on all sides and mounted on angle iron frame or of coating of Aluminium / non rusting and non corrosive material on mild steel sheet. A set of double hinged doors shall be provided on front, to enable installation, maintenance and inspection of cable connection and other equipment inside the cubicle from the front side. Three heavy duty stainless steel hinges (not visible from outside) shall be provided per door in such a way so that interior gasketing of the doors shall be continuous. Good quality neoprene gaskets, weather resistant shall be used. The design shall permit the doors being completely removed when necessary. The doors shall be so fitted as to provide the interior with maximum protection from atmospheric

conditions. The doors shall get closed as in case of a steel almirah through a handle so as to have a tight fitted door.

- The door handles shall be of rectangular shape made out of 12 mm round or equivalent size of flats.
- A pad lock of suitable size, rust proof, operatable in outdoor humid conditions shall be welded to one of the doors. All the locks on the feeder pillars shall be opened and closed by a single master key.
- The ammeter, LT CTs, voltmeter, selector switches, MCCB shall be provided on the incoming side of the MCCB on an openable and separate inside the pillar and not on the main door leaves.
- The top of the pillar shall have a sloping canopy having necessary slope so that rain water does not accumulate there. The canopy shall project over the sides of the pillar shell which shall be lower than the top section.
- The pillar is to be mounted on brick and cement concrete plinth by the road side and the dimensions shall be such that it does not obstruct the normal traffic on the footpath.
- The lower part i.e. apron shall be covered with 3.15 mm sheet on all sides. The sheet covers shall be welded to the frame on three sides except on the front side where it shall be bolted so that it can be removed for fixing cables. Ingress of water or any other insects etc. does not take place from this portion as well.
- The stand shall be made of rust proof angle of 75x35x6mm and shall have adequate height to provide a strong supporting structure to the shell.
- Suitable ventilation louvers with wire mesh inside shall be provided at the side sections of the shell in a flat frame welded inside so that no object, lizard etc. can enter the pillar through the ventilation louvers.
- The gland plate shall be of thickness 3.15 mm thick Aluminium & detachable type. All the cable glands shall be chrome plated and double compression type and shall be supplied with the pillar box for the cable sizes given.
- The bus bars shall be rectangular and of electrolytic aluminium.
- Phase as well as neutral size shall be suitable for continuous current rating. The bus bars shall be insulated with heat shrinkable tapes with red, yellow and blue colours for the 3 phases and black for neutral. All bus bar tapping and markings shall be in accordance with relevant IEC/IS, 374-1963. The bus bar shall be mounted on insulators.

The inter-connections between bus bars and MCBs units shall be solid electrolytic Aluminium / strip/Aluminium conductor permanently riveted with the busbar. The connections between outgoing side of MCBs and outgoing cable shall be through an isolating link so as to ensure a physical isolation of outgoing circuit whenever needed. These shall be suitably taped with colours as that of bus bars. Thimbles, nuts & bolts etc., (which must be non-rusting) for the incoming and outgoing cables terminals shall be included & provided with the pillar. Only external cables shall be brought from outside for making connections to the pillars at site. The bus bar joints shall be given a thin coat of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact for the cable size used & shall be capable of receiving the size of cable. It will be ensured that necessary contact pressure is maintained permanently.

- The above arrangement shall be got approved by Agency by designer / client / site Engineer-in-Charge prior to fabrication.

Outgoing Feeders

Outgoing circuits fed by MCB's of suitable ratings for controlling the outgoing cable circuits from feeder pillar shall be provided. A 4-pole disconnecting link of the rating corresponding to the rating of MCB shall also be provided between the cable connection terminals and MCB. This link shall provide visible disconnection in the case of any maintenance work required to be carried out on the outgoing cable circuit.

Earthing

- The distribution feeder pillar shall be provided with two separate earthing terminals on its casing for copper earthing.
- The earthing terminals shall be easily accessible and so placed that the earthing connection of the distribution pillars is maintained when the cover or any other moveable part is replaced.
- The earthing terminals shall be identified by means of proper indelible green sign marks adjacent to the terminals.
- The feeder pillar shall also have an inside earth bus bar for connecting the cable gland earthing and the armouring to it. The size of the earth bus bar shall be suitable to carry 50 kA for one second. The bus bar shall not be visible or removable from outside the cubical. The earth bus bar shall have necessary holes, nuts & bolts including washers

for making earth connection of cable glands / armouring of the incoming / outgoing cables. Mild steel galvanised or otherwise is not acceptable due to harsh environment.

Feeder Pillar Lighting & Heating

A lamp holder with a 11 W CFL lamp and operated by an internal SP-MCB shall be fitted in the canopy of the feeder pillar for internal illumination. In addition, a 3 pin 5A socket shall also be provided with a separate SP-MCB onside of the pillar box. Space heater of suitable rating, with thermostat and SP-MCB shall also be provided inside the pillar near the bottom to avoid any moisture condensation inside the cubicle.

Danger Plate

An enamelled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the left upper front door of the pillar.

Painting

- All sheet steel work shall be phosphatised in accordance with the relevant IEC/IS: 6005 Code of Practice of phosphatizing iron and steel with seven tank process.
- After application of the primer, two coats of finishing synthetic enamel epoxy paint of reputed make shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The colour for the finishing paint shall be light grey as per shade no. 631 of IS:5 or other equivalent standard shade. Each coat of primer and finishing paint shall be with slightly different shade to enable inspection of the painting.
- The finishing painted surface of pillars shall present aesthetically pleasing appearance free form dents and uneven surface.
- A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the pillars.

Tests

➢ **Type Tests**

- The Engineer-in-Charge may ask the manufacture to conduct the following type tests on one of the feeder pillars out of any of the consignment, considering site conditions.
- Verification of temperature rise limits test
- Verification of rain test to determine the degree of protection against rain.
- Verification of dielectric properties.
- Necessary type tests as per IS on all the bought out items such as MCB's, MCCB's etc.

- The Engineer-in-Charge, at his option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / testing laboratory of repute in India are furnished by the manufacturer.

➢ **Routine Tests**

- The pillars shall be subjected to high voltage tests described in the relevant ISS. The test voltage to be applied shall be for a period of one minute.
- Meggar tests with meggar of 500 volts before and after the high voltage test shall be carried out on the feeder pillars and the recorded readings shall be furnished to the Engineer-in-Charge prior to the despatch of feeder pillar.
- Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's and MCBs etc.

➢ **Site Tests**

- Engineer-in-Charge at its sole discretion reserves to carryout the necessary tests at site to ensure that the equipment is not disturbed / damaged during transportation.

➢ **Cable Terminations**

- Incoming and outgoing cables to be terminated in the feeder pillar shall be Aluminium or copper XLPE insulated PVC sheathed armoured / unarmoured.
- Horizontal angle iron bars shall be provided with bolted holes so that the cables could be clamped by 'U' bolts of 12 mm diameter, so that no pull is exerted on the terminals due to the weight of the cable. U bolts of necessary size to clamp the cables shall be supplied fitted with nuts & washers, fitted on the bars.

➢ **Specification for LT Street lighting pillars**

The L.T. street lighting service pillars shall be manufactured suitable for outdoor installation and shall have all constructional details, earthing arrangement, danger plate, painting, other features and tests as specified under various paras above for L.T. feeder / service pillars. The final paint on the street lighting service pillars shall be red. The L.T., street lighting pillars shall have circuits as detailed below:

➢ **Incoming**

One No. 3 phase, 4 wire incoming circuit placed on the left hand side having 4-pole MCCB of suitable rating complying with IS: 13947-2 as updated with 50-100% adjustable thermal release and & breaking capacity of 50 kA suitable for incoming XLPE aluminium conductor cable..

- **Outgoing circuits**

3 Number Single phase 2 wire outgoing circuits with voltage rating of 240 volts & current rating of 25A having 2 pole, MCB of 16 A rating, suitable for outgoing aluminium cable of size provided.

- **SCADA Controlled Dimmer and Astronomical Switch**

The above shall be provided to automatically switch OFF and switch ON the supplies in line with sunrise and sunset with astronomical clock. Further there shall be automatic dimming arrangement with reference to time at night.

- **LT Moulded Case Circuit Breakers (MCCB'S)**

- The incoming underground cable to the feeder pillar from the LT AC Board in the substation shall be controlled by DRAW OUT, CURRENT LIMITING type moulded case circuit breaker.
- The moulded case circuit breakers shall be of a robust construction and shall comprise of a switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact moulded case and cover. The insulating case and cover shall be made of high strength, heat-resistant and flame-retardant thermo-setting insulating material.
- The switching mechanism shall be quick-make / quick break type, and shall be trip-free.
- The arc extinguishing device shall comprise of a series of grid plates mounted in parallel between supports of insulating material. The arc shall be drawn from the moving contact into the divide chamber and extinguished.
- The moulded case circuit breakers shall have a thermo-magnetic type tripping mechanism, where the heating effect and the electromagnetic effect of current are made use of to provide protection against overload and short-circuit conditions respectively. The heated-bimetal strip in each phase of the MCCB shall actuate the tripping system following on inverse-time-current characteristics depending upon the severity of the overload. During short-circuits, the system shall trip instantaneously. The tripping element provided on each pole of the MCCB shall operate on a common trip bar, thereby preventing single phasing in the event of fault on any of the phases. The tripping device shall be ambient temperature compensated type.

- The MCCB shall have a minimum rupturing capacity of 25.8 MVA. Positive indication about the position of the MCCB i.e. whether 'ON', 'OFF' or 'TRIPPED' shall be provided.
- The short circuit breaking capacity and operating of the MCCB shall be supported by test certificates.
- The detailed specifications of the MCCBs shall be as under:

  3-phase, 4 wire, neutral earthed

  system no. of pole : 4 Pole

  Service voltage : 415 volts

  Normal current : Rating shown in SLD

  Frequency : 50 Hz.

  Short circuit current rating [Ics] : 36 KA
- Crimp type cable lugs shall be used on the outgoing side of the MCCBs and the 4-pole links for each of the outgoing feeder.
- All the MCCBs, used in LT feeder / service / street lighting pillars for controlling the LT feeders shall have a current setting of 50 to 100% of its rated current.

➢ Miniature Circuit Breaker (MCB)

- The outgoing underground feeders / service lines from the LT feeder pillars shall be controlled by MCBs. It shall provide protection against over loads and short circuit.
- The MCBs shall be of robust construction with insulating case made of self extinguishing, thermoplastic material. The switching mechanism shall be quick make / quick break.
- The details specification of the MCBs shall be as under:

  No. of poles 4 and 2 poles as required

  Service voltage 415 / 240 volts

  Normal current Rating shown in SLD

  Frequency 50 Hz

  Breaking capacity 20 kA (as per clause no. 5.3.4.2 of IS: 8828-1996)

➢ Specific Technical Parameters

  Low Tension A.C. Feeder Pillar

  Feeder Pillar

  Rated Voltage : 3 Phase, 4 wire 415 volts □10%

Rated current at 50oC (A) : as per design

Frequency (Hz) : 50

Symmetrical short circuit withstand : 36 current for 1 sec at rated voltage (kA rms)

Degree of protection as per IS: 2147 for

Outdoor IP : 45

- Material of Cubical

Cubical sheet metal for panel : CRCA, Electrically Aluminium Coated or other non- rusting material except galvanised]

Thickness, structural frames and load bearing members for panel (mm) : 3.15

Thickness, front & rear (mm) : 3.15

Thickness sides & top (mm) : 3.15

Size of non rusting Angle Support frame : 75 mm x 35 mm x 6 mm Painting shade as per IS: 5

External surfaces : 631

Internal surfaces : White

Minimum clearance air (bus-bars)

Between phase : As per relevant Indian Standard

Between phase & earth : -do-

Bus-bar Details L.T. feeder pillar : Electrolytic Aluminium used for bus bar

- construction shall be preferably equivalent to E91 E of BS-2398 with mechanical strength properties approximating closely to that of copper.
- Protection against accidental Contact: Heat shrinkable sleeving with requisite dielectric properties leaving no voids or pin holes. Sleeving to be permanent & non removable by hand. Busbars joints and tee off, where possible to be provided with removable shrouds for complete isolation.
- Temperature rise over design ambient 50oC for continuous current rating deg. As per relevant BIS / IEC Temperature of

Indicating lamps 240 V

Space Heater rated voltage	240 V

- Components

- MCCB

No. of Pole	4 Pole
Rating (A)	As per design
Rupturing capacity (kA)-Ics	36
Thermal Tripping range	50 to 100%
Short circuit release	To be fixed for 36 kA

- MCB

No. of Pole	4 Pole
Rating (A)	As per design
Rupturing capacity (kA)	20 kA
Tripping	Thermal overload

EXTERNAL ILLUMINATION

- The specification covers the design, Engineer-in-Charge, material, fabrication testing, inspection, packing, forwarding supply, delivery and installation of Poles composite street light, LED lights fittings complete in all respects for the street lighting system by underground cables under the project. Exterior lighting shall be provided for streets, parking areas, open areas developed areas, as per following items of work.
- The components of street lighting shall be supplied and installed, complete in all respects. All the equipment and materials used for installation shall be brand new and of high quality in design and performance. Unless otherwise specified, all the items shall be tested and installed as per the latest Indian Standards Specification.

POWER SUPPLY

The voltage available for the street lighting and security lighting will be 415 volts three phase and neutral 50Hz AC from the main external lighting board located in outdoor area.

WIRING OF FIXTURES

The street light fixtures shall be wired from terminal block by means of flexible (3 * 2.5 sq mm) copper conductor, PVC insulated cable through a rewire-able MCB and neutral or suitable sized MCB.

CABLE

All cables shall be aluminum conductor (unless copper wire is specifically asked for), PVC insulated, PVC sheathed, armoured of 1100 V grade. The wire of different colours shall be used for quick identification of phase wire and neutral. The cable shall be of approved make as specified in the list of makes

GENERAL

- All light luminaires shall conform to the relevant Indian Standard Specification. The assembly of light luminaires shall be such that it is easy to handle, install, operate and maintain them. The equipment shall be reliable in operation.
- All the hardware used in the assembly of the luminaires, shall be either galvansied or painted with corrosive paint.
- The internal wiring of the luminaires, from the junction box shall be done with wires of adequate size. All the accessories of the fittings shall be clamped/supported suitably at the entry to the luminaires.
- All light luminaires and the associated control gear shall be rated for operation at 230 V, 50 Hz. A.C. supply unless otherwise specified in this specification.
- The supplier shall supply all the technical features, light distribution diagrams; zonal luminous flux diagram and isocandala diagram of the luminaries. A dimensional drawing giving the overall dimension of the luminaires shall also be supplied.
- The lighting circuits are generally of three phase and neutral 500 V distribution with Aluminum conductor PVC insulated armoured cables.
- Installation price of cables buried underground shall include excavation and back filling, supplying of sand, brick, protective cover, identification tags. Termination of lighting cables at both ends and all accessories are grouped together The installation price of lighting poles shall include all necessary foundation work including concreting, mounting of loop-in and loop-out box. Lighting luminaires fixing along with a PVC insulated copper conductor cable from the loopin and loop-out box to fittings is taken together in one item.
- The installation price of earthing electrode shall include burying of the electrode and the termination of the earthing conductor.
- For all the installation work necessary materials, accessories, hardware etc. as required to make the installation complete in all respects shall be included in the offer.

- While loading, transporting, unloading and erecting the poles, care shall be taken so that the poles do not get bent out of shape and where necessary, such defects shall be rectified before the poles are erected in position. The poles shall be erected in plumb line and correct level as indicated in drawing and to the satisfaction of the Engineer-in-Charge. They shall be kept in this position with the help of manila ropes until the foundations are constructed, (for a minimum period of 7 days) and the backfilling is complete.
- At road crossing, the cables shall be taken through RCC Hume pipe to be buried at a depth of 1 meter below the finished round level and shall cover and run below the drainages on both sides of the road. The trenches excavated for embedding the RCC Hume pipe shall be back filled with the excavated earth and compacted to same degree as that of the surrounding area.
- The protection of cement mortar for brick work to be used shall be CM: 1:4 for covering the hume pipe at the road crossing.

ROUTE MARKER

Cable route marker marked "CABLE" shall be provided along route of the cable and location of loops. The route markers shall be of tapered concrete slab of 60 * 60cm at bottom and 50 * 50cm at top having a thickness of 10cm having 1:2:4 mix. Cable marker shall be mounted parallel to and 50 cm away from the edge of the trench. The concrete marker shall be laid over the trench projecting over the surrounding surface.

STEEL TUBULAR POLES

The steel tubular poles shall be Galvanised octagonal types.

Galvanized Octagonal Poles

Design

The Octagonal poles shall be designed to withstand the maximum wind speed of 169 KM / Hr. as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BS : 5649 Part VI 1982.

Pole Shaft

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. The welding of pole shaft shall be done by submerged Arc Welding (SAW) process. All octagonal pole

shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

Door opening

The octagonal poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal resistance and shall be weather proof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.

The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

Material

Octagonal Poles	-	HT Steel Conforming to grade S355JO
Base Plate	-	Fe 410 conforming to IS 226 / IS 2062
Foundation Bolts	-	EN.8 grade

Welding

The welding shall be carried out confirming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

Pole sections

The Octagonal Poles shall be in single section (upto 11 mtr). There shall not be any circumferential weld joint.

Galvanization

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 70 micron. The galvanizing shall be done in single dipping.

Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for Installation of the luminaries.

Manufacturing

The pole manufacturing & galvanizing unit shall be ISO 9001 : 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

Service window

A service window of the size 150 mm x 100 mm shall be provided in the base of the pole to allow access to electrical connections and terminations. It shall be covered with MS plate and proper rubber gaskets shall be provided to prevent any ingress of water etc..

Electrical connections

Four way connectors shall be provided along with Slide lock and 1 no. 6 amps Sp MCB including 2.5 sqmm PVC insulated copper conductor wires from the terminal block to the fixture and 2 nos. 32 mm dia GI sleeves of suitable length shall be provided upto the service window. An earth boss is provided on the control plate along with connectors and interrupt-ers.

Galvanized Octagonal Poles Dimensions

Height	Top Dia (A/F)	Bottom Dia (A/F)	Sheet Thick -ness	Base Plate Dimensions (LXBXT)	FOUNDATION BOLT			
					Bolt Size (No. X Dia)	Pitch Circle Dia (PCD)	Bolt Length	Projected Bolt Length
(mtr)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
3	70	130	3	200 x 200 x 12	4 x 16	200	450	80
4	70	130	3	200 x 200 x 12	4 x 16	200	450	80
5	70	130	3	200 x 200 x 12	4 x 16	200	600	80
6	70	130	3	220 x 220 x 12	4 x 20	205	600	100
7	70	130	3	220 x 220 x 12	4 x 20	205	700	100
8	70	135	3	225 x 225 x 16	4 x 20	210	750	100
9	70	155	3	260 x 260 x 16	4 x 24	250	750	125
10	70	175	3	275 x 275 x 16	4 x 24	270	750	125
11	90	210	3	300 x 300 x 20	4 x 24	300	750	125
12	90	240	3	320 x 320 x 20	4 x 24	325	850	125

TESTS

The supplier, before handing over the installation to the Engineer-in-Charge, shall carry out tests on all fittings and cables as per IS Specifications. The test shall include:

Megger test

Continuity test.

Phase seq

CONSTRUCTION

- The casing of the lighting luminaries shall be made of pressure die cast aluminium coated with epoxy polyester powder coat single, self-contained device not requiring any on-site assembly for installation onto an existing lighting luminaries integral with power supply unit. The driver unit must be accessible and if need be replaceable easily and with minimum use of tools.
- The casing made of non-corrosive aluminium having high conductivity shall have external surface designed in a manner so as to act as an efficient heat sink to extract heat generated at pn-junction of a LED. Efforts shall be made to keep the overall outer dimensions as minimum as possible without compromising on the performance of the LEDs or luminary.
- The assembly and manufacturing process for the LED source assembly in modules/ arrays shall be designed to assure all internal components are adequately supported to withstand sudden impacts and mechanical shock and vibration from high winds and other sources.
- No part shall be constructed of polycarbonate unless it is UV stabilized
- Material used for the lens of LED source shall be of toughened glass, heat resistant and shall not undergo discoloration during lifetime of the LED source. It shall conform to ASTM specifications for the materials. Any discoloration observed in the lens shall be considered a failure under warranty clause.
- All luminaires shall be provided with acrylic / polycarbonate / glass diffusers and/or aluminized reflectors and/or lenses to provide proper road lighting distribution.
- Toughened and/or tempered glass of sufficient strength may be provided under the LED chamber to protect the LEDs and luminaires.
- The LED lens shall be UV stabilized and shall be capable of withstanding ultraviolet (direct sunlight) exposure for a minimum period of 60 months without exhibiting evidence of deterioration.
- The luminaries shall be capable of operating normally in ambient temperatures from -20*C to 50*C maintaining junction temperature below 100*C and heat sink temperature below 60*C, ensuring efficient thermal management of the luminaire.

- The fixture shall be designed in such a manner that it is easy to handle and install, is not too large and unwieldy, is of robust construction, light weight and conforms to minimum IP65 class of protection for outdoor use against dust and moisture intrusion. The luminary shall be provided with a built-in external heat sink as well as an aluminum MCPCB printed circuit board, designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaries.

TECHNICAL SPECIFICATION FOR EARTHING AND LIGHTNING PROTECTION SYSTEM

- This specification covers the technical and associated requirements for the entire earthing system substations, required to protect persons and equipment and to allow safe service and maintenance of the installations. The earthing system includes the underground grid, ground rods and connections. The earthing system shall be designed to minimise the dangers from step, touch and transferred potentials which can occur under maximum fault conditions. The Agency shall design, furnish and install the substation earthing system in accordance with the provision on latest IEEE Std. 80, Guide for Safety in Substation Earthing, IS: 3043, Code of Practice For Earthing and the provision of this specification. The Agency shall submit calculations in support of his design.
- In addition to the above codes and standards, the Agency shall comply with applicable national and local laws, codes, regulations, statutes and ordinances.
- The Agency shall bear full responsibility that the earthing system materials have been designed and fabricated in accordance with all codes and standards and that they perform under the conditions and to the standards specified herein.
- The Agency shall carry out earth resistivity measurement for the substation site. Based on the result of this measurement and the system parameter, the appropriate design and the calculation will be determined whether impermissible touch and step voltages occur at any place of the station (including outside area) which may be endangered. These calculations will decide on the provisions for earthing to be made with the relevant part of the civil works related to foundations. It shall be agreed between Engineer-in-Charge

and Agency, about special arrangements, if calculations prove that touch and step voltages are higher than permitted and the Agency proves that he modified the earthing grid to its optimum. Only calculations built up on computer generated design programmes shall be accepted. A special software for providing detailed analysis of the actual step and touch voltages likely to be generated has to be used.

- The HV and LV systems are solidly earthed at the neutral point of the power transformer. The size of earthing conductors to be connected with the earthing system shall be designed for an earth fault level of 40 kA (1 sec). The material for earthing in particular for jointing shall be selected to prevent corrosion at the connection points as well as at the earthing material itself, both underground and exposed to air. If necessary, cathodic protection of an approved design shall be applied. In order to minimise the effect of seasonal variations of earth resistance, the earthing system shall be designed for the worst conditions.

Description of Services

The Agency shall provide a complete earthing system consisting of:

- The main outdoor subsoil earthing system, with individual loops around each building, foundation, structure, etc., of the site.
- Sub-earthing systems for buildings, foundations, structures, tanks, etc., being connected to the subsoil earthing system as required
- All electrical equipment such as motors, transformers, substations, foundations, switchboards, control boards, relay and auxiliary relay boards, all other subsidiary electrical equipment as well as all metal parts of civil construction or the mechanical equipment such as transformer rails, pumps, pipes, steel structure, tanks, cable trays, etc. shall be connected to the earthing system.
- All materials and parts which are not specifically mentioned herein but are necessary for the safety of operating personnel and safe operation of the substation shall be furnished and determined by the Agency at no increase in cost to the Owner.

Design Requirements

General

- The ground grid shall be composed of a system of galvanized conductors buried approximately 500 mm below finished ground level, excluding crushed rock surfacing. The grid system shall cover the entire fenced substation area and shall be extended to

the outer of the substation fence. A perimeter conductor shall run around the substation in a distance of 0.5m to the fence and shall be connected to the inner earthing grid and to the fence in regular intervals. Where necessary to reduce the overall earth resistance, earth electrodes shall be provided and connected to the perimeter of the main earth grid. A minimum of four (4) of the specified ground rods must be installed (one at each corner of the ground grid). The Agency shall determine the spacing of ground grid conductors and the total number and location of ground rods and their lengths.

- Earthing conductors buried in the soil shall be of galvanized steel rounds, coated if and as necessary. Earthing conductors embedded in concrete shall be of galvanized steel. Adequate corrosion protection shall be provided when conductors leave the concrete, respectively the soil.
- The design of the earthing system and the materials to be used shall comply with the requirements for the specified cathodic corrosion protection.
- Earthing conductors laid on cable trays or similar shall be galvanized steel.
- All interconnections of the earthing grid to equipment and the connections be-tween the earthing grid and the earthing rods shall be made by the termite welding process. Only those connections located in earthing pits and occasion-ally intended to be opened for testing purposes shall be of the bolted type.
- When a substation is located adjacent to the existing earthing system, the ground systems of the existing or new facilities shall be connected together by at least three galvanized steel strips appropriately sized for mechanical strength and the specified fault current with minimum conductor size to be 125 mm2.
- Drawings and calculations shall be submitted for approval giving sufficient in-formation on the earthing, lightning protection, the earthing of structure mounted equipment, as well as on methods of measuring the earth resistance, respectively the earth voltage, the touch and the step voltage.
- If the actually measured resistance of the Agency-designed and installed ground grid is higher than one ohm or as specified, the Agency shall install, at no extra cost to the Owner, additional earthing rods, mats, earthing electrodes, etc., until the field-measured resistance is equal to or less than the specified value.
- Joints which are indicated as test points shall be bolted or clamped. Joints in tape, other than at test points, shall be made by the welding process. All welding joints shall be

with bitumen coating with non-rusting paints. Overlap of conductors shall be not less than 100mm.

- Joints and connections shall be protected by a coating which will form a seal and exclude moisture in all weather conditions. At connections to earth electrodes the coating shall cover all exposed conductors. Protective coatings shall be of a water proof, inert, tenacious material.
- Bolts, screws, nuts, washers and rivets shall be stainless steel of superior quality.

Equipment and Materials Requirements

The equipment and materials shall be suitable for outdoor installation and use at specified service condition without corrosion, deterioration or degradation of performance characteristics.

Main Earthing Grid	50 X 10 Mm	Flat
Interconnection To Cps	25 X 3 Mm	Flat
Local Push Buttons	14 SWG	Wire
Lighting Distribution Board	4 SWG	Wire
Lighting And Receptacle System	12 SWG	Wire
Outdoor Street Lighting	8 SWG	Wire
Ladder Rack And Cable Tray At Suitable Points	25 X 3 Mm	Flat
Hand Rails And Metallic Structures	25 X 3 Mm	Flat
Building Reinforcement	25 X 3 Mm	Flat
Incoming And Outgoing Process Services	25 X 3 Mm	Flat
Steel Structures Comprising Storage Tanks, Mezzanine Platform, Crane Rails, Air Handling Duct-work Systems Etc.,	25 X 3 Mm	Flat

Earthing Conductors

- Earthing conductor shall be copper conductor of soft drawn concentric stranding bare copper conductor.
- Ground leads running down from the lightning rod or air terminal rods shall be hard drawn galvanised steel and shall be provided with the required clamp supports mounted on the steel structure at approximately 1.5 m intervals.
- The cross sections of the various earth conductors shall be determined in accordance with IEEE standard / IS: 3043, however, the minimum conductor cross sections shall be as follows:

50 x 6 mm	HV and LV switchgear
25 x 6 mm	Motor
25 x 6 mm	Metal raceways and cable trays
25 x 6 mm	Intermediate terminal boxes, cabinets, panels
25 x 6 mm	Other metal parts as may be required

Ground Rods

- The ground rod shall be copper-covered steel of circular cross section, with a nominal diameter of 19 mm and not less than 3 meters long in section of 1.5 meters. If more than one earthing rod are necessary they shall not be less than 3 m apart.
- Each ground rod shall have a conical swaged point at one end and shall have a continuous smooth copper covering of at least 0.254 mm thickness molten-welded or copper bonded (electro-deposit) to a steel core. The copper clad or pressed type will not be accepted.
- Where earth plates are indicated, they shall be 600mm x 600mm minimum, of solid or lattice copper not less than 3mm thick.
- Electrodes shall be installed in undisturbed ground. The distance between any two electrodes shall be not less than the sum of the lengths of the two electrodes.
- Backfill immediately surrounding plate electrodes shall have a low specific resistivity and good water retention properties, and shall be well compacted.

Inspection Pits

- Unless otherwise indicated or required, connection between an earth conductor and its associated earth electrode system shall be in an enclosure.
- The enclosure shall have a removable top cover, which shall be flush with finished ground level. The enclosure shall be a purpose made inspection pit made of concrete. The earth electrode connection shall be just below the lid of the inspection pit with adequate access for testing purposes. The enclosure shall be clearly labelled to indicate the electrodes function and, where appropriate, its identification number.

Earthing Hardware

Steel Structure Earthing

- Every steel structure that carries insulators or apparatuses shall be connected to the earthing grid. To ensure contact even if a connection fails or a conductor is cut off,

every structure must be connected via two different risers to two different parts of the earthing grid.

- Steel structures with more than one leg shall have two legs connected to the grid, with one connection to each leg. The legs with the greatest spacing between shall be chosen for the earth connection.
- Circuit breaker framework is not considered as proper connections between steel structures. If there are no connections between the legs which are able to carry the current, all legs must be connected to the grid with their own risers.
- Operating mechanisms and motor drives placed on separate stands shall be connected as above.

Transformer Earthing

- The transformer tank shall be connected to earth following the same principles as for steel structures.
- The neutral point of transformers shall be connected to the earthing grid via an isolated link or conductor. The connection to the two earthing rods, which are also connected to earthing grid, shall be made by two independent copper strips from the neutral.

Earthing of Switchgear

- Earthing switches are to be connected via a direct earthing connection and not via the steel structure. Connections between any type of earthing device, e.g. earthing switch, and risers from the earthing grid shall be made through a copper wire connected between the earth contact of the earthing device and a riser. The neutral of the primary winding of Voltage Transformer, shall be grounded via a separate earthing connection to earthing rod and not via the steel structure.
- Each lighting arrester shall be grounded separately with a full rated earthing connection and not via the steel structure. In addition, an earthing rod shall be driven into the ground at each earthing point of a lighting arrester as close as possible to the lighting arrester and connected to it.

Earthing inside Buildings

- For potential equalising of the building an earthing grid of 8 mm reinforcement bars shall be cast into the surface concrete of all floors of all switchgear room or basements with power cables installed. The connection points shall be welded. The mesh size shall not be greater than 3 x 3 m. Suitable connection points shall be brought out of the

concrete to allow connection to the main earthing and to all parts of equipment and building to be earthed. The part of these connecting points which protrudes from the concrete shall be tinned. The earthing grids of the different levels shall be connected at 8 to 10 m. on the periphery distributed locations.

- The size of the main earthing shall be defined by earthing calculations. The design value for the main earthing grid shall be 40 kA (1 s) rating and with consideration of CADWELDED joints.
- To ensure that reinforcement grid is made electrical continuous, a sufficient number of connection points shall be brought out of the concrete. Together with the detailed civil Engineer-in-Charge drawings, the earthing design is to be checked before releasing for construction.
- The connections to these parts shall be of tinned copper of adequate cross section of at least 70 mm^2. Further similar connection points shall be installed at a number of places for the connection of portable earthing equipment when working in the station. All iron parts of the building and the reinforcement shall be connected to this common earthing installation.
- Generally, each electrical device must be equipped with an earthing screw of sufficient diameter for connection to the earthing system. The same applies to all metallic parts such as panels, doors, rails, fences, transformers, etc. are effectively connected by earth conductors.
- High voltage equipment and each GIS or metal enclosed switchgear bay shall be equipped with at least two terminal bolt M 16 in diameter or suitable earthing pads of adequate size to accommodate at least two bolts for proper connection to the earthing system.
- For connection to all kind of control, protection, LV, panels etc. an earthing grid shall be laid in all cable trenches of at least 50 x 5 mm tinned copper bar.
- Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to this tinned copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connections. In such a case, provisions for earthing must be made at one end at least.

Earthing outside Buildings

- As a minimum, one grading ring of galvanized steel strip shall be laid around each building at a distance of 1 m (each) and at a depth of 0.6 m.
- The connections to the building earthing installation shall be made within the building. An earthing grid of sufficient size, defined by earthing calculations and consisting of galvanised steel conductor with a maximum mesh size of 3 x 3 m shall also be installed in the transformer bays.
- All individual earthing grids shall be interconnected at spacing by not more than 5 meters. Buried in ground or supported on building structures, cable trenches, walls, etc. by means of brass clamps with spacing of not more than 1.25 m.
- Steel fences within and around the substation area shall be connected to the earthing system at least at two different points and at maximum 10 meters intervals. All metal parts have to be connected through by welding or suitable earthing conductors.

Other Earthing Arrangements

- Connection boxes for low voltage or control cables shall be connected via one 50 mm2 wire (35 mm2 copper if the terminal of the box does not allow more), irrespective of whether the box is mounted on an otherwise earthed steel structure or not.
- Poles for lighting and other types of metal structures within the substation area, not mentioned hitherto, shall be connected to the earthing grid one connection for each item.

Earthing Equipment

- To meet the safety regulations before any maintenance or repair works are started on the HV/ LV power equipment, the disconnected "live" parts of the equipment shall be grounded by means of mobile earthing sets. The portable or mobile earthing sets (Substation Earthing Sets) shall be supplied by the Agency. One earthing set shall be supplied per substation and voltage level.

Tests

General

The Agency shall carry out at his own expense all tests necessary to ensure the satisfactory design and manufacture of all earthing equipment and materials in accordance with Indian / IEC Standard.

Design Tests

Conductors, hardware's and materials shall be subjected to the design (or type) tests in accordance with applicable Indian or equivalent IEC standards. Even though the Engineer-in-Charge witnesses the required tests and the earthing, hardware's and materials meet the acceptance criteria, the Agency shall not be relieved of the responsibility of providing conductors, hard-ware's and materials conforming to all the requirements of the specification.

Quality Conformance and Routine Test

Earthing Conductors

The tests shall be performed in accordance with IEC 60621-2 and shall include, but not limited to the following:

- Tensile strength tests
- Elongation tests
- Conductor resistivity tests
- Dimension measurement
- Surface finish inspection
- Weight of conductor

Miscellaneous Hardware

The test shall be performed in accordance with IEC 60621-2 and the manufacturer standard. The routine tests shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

- General inspection
- Measurement of dimensions
- Tensile tests No. of samples required: 1 for 20-50 sets;
- 2 for 51-100 sets; and
- 4 for over 100 sets
- Galvanising tests

Earthing Materials

Quality conformance tests are required to verify the quality of materials and workmanship. They are to be made on fittings taken on random from the various lots offered for acceptance.

Routine Tests

These tests are intended to eliminate defective materials and fittings. They are to be made on all materials and fittings of the type to which they are applicable, per applicable standards and / or per Agency quality assurance methods if accepted by the Authoritys Engineer-in-Charge.

Field Tests

- Field tests and acceptance tests, if any shall be performed by the Agency as per IS: 3043 / IEC /IEEE-80 standard. The Agency shall provide instructions and acceptance criteria including the calculated value of the resistance of the installed earthing grid for field testing and measurement prior to energising the substation / equipment.
- Measurement of the earth voltage by the voltmeter/ ammeter method, test current 100 - 300 A or an equivalent approved method.
- Measurement of the step and touch voltage.
- The lightning protection shall be provided by the Agency as per code of practice for lightning protection – IS : 2309.

Main Equipotential Bonding Conductor

Main Equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

Equipotential bonding conductors shall have the following minimum sizes.

The Agency shall carry out insulation resistance tests by a megger of following rating

Control circuits up to 220 V - 500 V megger

Power circuits up to 1.1 kV - 1000 V megger

In general, the following checks shall be carried out on all the equipment/systems, as applicable.

- Name plate details according to approved drawings/ specifications
- Any physical damage or defect and cleanliness
- Tightness of all bolts, clamps and connections
- Oil leakages and oil level
- Condition of accessories and their completeness
- Clearances
- Earthing connections
- Correctness of installation with respect to approved drawings/specifications

- Lubrication of moving parts
- Alignment
- Correctness and condition of connections

Commissioning Tests

The following commissioning tests are to be carried out on all the equipment/systems, as applicable.

- Insulation resistance measurement of equipment, accessories, cabling/wiring etc.
- Dielectric tests on equipment, accessories, cabling/ wires etc.
- Phase sequence and polarity
- Voltage and current ratios
- Vector group
- Resistance measurement of winding, contacts etc.
- Continuity tests
- Calibration of indicators, meters, relays, etc.
- Control and interlock checks
- Settings of equipment and accessories
- Checking of accuracy/error
- Checking of operating characteristics, pick-up voltages and currents, etc.
- Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.
- Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.
- Complete commissioning checks of the system

SAFETY PROCEDURE AND PRACTICE

Following safety procedure and practice shall be provided by Electrical Agency in switch-board room/substation as per latest edition of I.S. 5216.

Rubber matting in front of LT PMCC Panel and other panels in substation room, Pump house MCC room etc

- One shock treatment chart in substation room,
- Caution/Danger Board on all panels, MCC, Switchgear,

- Sand buckets at substation room, PCC/MCC Panel Room, Chiller Pumps location
- Fire extinguisher at substation room
- One set of hand gloves at substation room
- Fire Safety

  The requirement of hand appliance in switchboard room, electrical equipment room shall be as per the latest edition of Fire Protection Manual by Regional Tariff Committee.

LIST OF APPROVED MAKES

Sr. No.	Item/equipment	List of Makes of various equipment
01	Squirrel cage Induction Motor (100 HP &above)	Kirloskar (KEC) /Jyoti / Siemens/ Crompton/ BHEL/ NGEF/ Bharat Bijlee/ GE
02	Squirrel cage Induction Motor (Below 100 HP)	Kirloskar(KEC)/Jyoti/ Siemens/Crompton/ BHEL/NGEF/GE/Bharat Bijlee/ GE/ Kirloskar (KBL)
03	VT/ Centrifugal water Pump sets (500 HP & above)	Kirloskar/ Jyoti/ M&P (Wilo) / FBM(Pentair)/ Grundfoss
04	VT/ Centrifugal water Pump sets (100 HP to 499 HP)	Kirloskar/ Jyoti/ M&P (Wilo) / FBM(Pentair)/ Aqua/ WPIL/ Grundfoss/ Flowserve
05	VT/ Centrifugal Water Pump sets (Below 100 HP)	Kirloskar/ Jyoti/ WPIL/ M&P (Wilo) / FBM(Pentair)/ Aqua/ Grundfoss/ Flowmore / Flowserve/ Beacon/ KSB/CNP/ Laxmi/Shakti
06	Effluent/ Sewage/ Sludge pumps	Kirloskar / Jyoti / WPIL/ M&P (Wilo)/ Voltas / KSB / FLowmore / Meghraj Machine / Aqua / Kishor/ Beacon
07	Submersible pump set	Kirloskar / Crompton Greaves/ Siemens/ NGEF/ KSB/ Voltas / Su-pump/ Aqua/ Kishor
08	Sluice Valve / Reflux Valve/ Butterfly valve	Fouress/ IVC/ Kirloskar/ IVI/Calsens/ VAG/ Patson/ Avishkar/Durga /Mayur/Dynamic/KPM/AVK
09	Air valve	Fouress/ IVC/ Kirloskar/ IVI/ ARI/Amflow/ VAG/ Avishkar/KPM/ Durga/Patson/ Mayur/ Dynamic/ AVK
10	Electrical actuators	Auma/ Marsh/ Rotark/ Siemens/Emtork
11	DG set (Alternator)	Crompton Greaves / Kirloskar Green/ Stampford / KEC/ Leroy somer
12	DG set (Engine)	Cummins/ Kirloskar Green/ Caterpillar/ Penta Volvo /Ashok Leyland /Mahindra & Mahindra/ Perkins
13	LT PVC / XLPE insulated cable (3.5 Core x 35 sqmm and above)	CCI (Tropodour) / Asian cables/ Gloster/ Nicco/ Torrent / Polycab/Universal/ Havells/Finolex
14	LT PVC / XLPE insulated cable (Up to 4 Core x 25 sqmm)	CCI (Tropodour) / Asian cables / Gloster/ Nicco / Torrent/ Polycab/ Universal/ Havells/Finolex/ KEI Incab / /Vishal/ Gulmarg/ /Indoasian
15	HT PVC / XLPE insulated cable	CCI (Tropodour) / Asian cables/ Gloster/ Nicco / Polycab/ Universal /Havells/Torrent
16	Cable Lugs & Glands	Dowells / Braco/ Jainson/ Siemens/ Comet

Sr. No.	Item/equipment	List of Makes of various equipment
17	Measuring Instruments, Ammeter, Voltmeter, etc.	Simco/ IMP/ Automatic/ GEC / MECO /AE/ Conserve/ Motwani / L&T/ Siemens /Industrial meters
18	Selector Switches, Rotary Switches	Simco/ IMP/ Automatic/ GEC/ MECO/ AE/ Conserve / Motwani/ L&T/Siemens /Industrial meters
19	Contactor / starters	Siemens/ Crompton/ C&S/ L&T/ ABB / GE / Schneider/Indo Asian
20	Timers- electronic solid state	ABB, BHEL, GE, Jyoti, L&T, BCH, Siemens, Minilec, Legrand, GIC, C&S
21	ACB/MCCB /MCB / ELCB/ RCCB/ SFU/ TPN/ Change over switch/ HRC fuses/ MCB Distribution Board	L&T/MDS/ABB/Crompton Greaves/GE/C&S/ Siemens/ Havells/ IndoAsian / Legrand/ Schneider/GEC/ Merlin Gerin/ Indokapp
23	LED street light/ flood light fittings	Philips/Crompton/ Bajaj/ Wipro/Surya/GE/ Havells /Asian/ Mahindra/Agile/Pharox
24	Bulk head fitting	Philips /Crompton/ Lumex / Bajaj / Wipro/ Havells/ Surya
25	LED lamps	Philips/ Osram/ Cree/ Edison / Nichiya/Syska
30	PVC Insulated copper/ Aluminum wire/flat Cable	Polycab/ Finolex/ KEI/ Fort/ Gloster/ CCI/ Asian/ Gulmarg/ Anchor/ Nicco/ RR cable/ Havells/ L&T/ Jonson/Vishal
31	Casing capping/ Conduit	Prestoplast/ Precision / Modi / Volex / Press Fit / BEC/ AKG/Finolex /Diamond
32	Holder/ ceiling rose/ switches/ modular switches/ Plug/ sockets	Anchor/ Leader /Cona / Harison/ Indo Asian/ Legrand/ MK / Crabtree/ ABB/ Precision /Wipro/ Vinay
33	Bell Buzzer	CONA/ MAX/ Anchor/ Leader/ SSK
34	Exhaust Fan/ Ceiling fan/ Air circulator/ Pedestal fan/ Bracket fan	Crompton Greaves/ Usha/ Orient/ GEC/ Almonard/ Khaitan/ Havells/ Bajaj/ Philips / Polar/ Anchor
35	AC Units / Central ACs	Hitachi / LG/ Samsung/ Voltas/ Blue star/ Carrier / Godrej/ Videocon/ Mitsubhisi /LLoyed
36	Capacitor Bank	ABB/CGL/Siemens/L&T/Asian/Powercap
37	Circuit Breaker (110kV / 132kV)	ABB/Alstom/Siemens/BHEL/Crompton
39	Air circulators	Crompton Greaves / Usha / GEC/ Alfa/ Unique/ Almonard/ Khetan/ Bajaj/ Havells
40	Fan regulator	Anchor / Roma/ Rider/ Jainex / Cona/ Legrand/ Leader/ Crabtree/ MK / Anchor
41	Electronic Energy meter	L&T/ Seimens/ Jaipur/ Mecco/ Enercon/ Udaipur/ Havells/ HPL/ IMP/ Secure/ Emco

Sr. No.	Item/equipment	List of Makes of various equipment
42	Electronic Ballast	Philips/ Crompton/ Bajaj/ Wipro / GE/ Surya/ Havells/ Anchor
43	MS tubular pole	Unique/ Singh profile/National/ India pole/Bombay tube pole/Laxmi/ Ajay
44	GI Octagonal Pole & High Mast	Philips/Crompton/ Bajaj/ Surya/ Wipro /Valmont/ Transrail
45	FRP Box	Sintex/ United/ Indo Asian/National /Siemens
46	Transformer (1000 KVA and above)	Bharat Bijlee/ Kirloskar/ Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP / Alstom / Siemens/ GEC/ Voltas
47	Transformer (Upto 750 KVA)	Bharat Bijlee/ Kirloskar / Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP/ Alstom/ Aditya/ Vijay/ Siemens/ GEC/ Voltas/ NGEF/ Mahati/ Telwane/ Rakesh / Transfab/ Shrihans/ Urja / Nanda Trans-former / Damsa Vidyut/ Volt–amp/ Saurabh/ Ramkrishna / Transdelta
50	Lighting arresters	ELPRO / ABB / BHEL/ OBLUM
51	Cable Termination & Straight Jointing kit	Raychem/ M-seal (3 M) / Xicon (CCI)/Densons / Mahaindra & mahindra
52	RSJ pole	TATA/SAIL/Jindal/ Zenith / Khandelwal
53	ACSR / AAAC Conductor	Apar/ Sterllte/ Kanti cable/ Pratik conductors/ Bombay wire products/ Vekateshwar wires / Prem cables/ Lunkad
55	HV indoor/ outdoor Circuit Breakers	Crompton / ABB/ Siemens/ Scheinder/Alstom (Areva)/ Jyoti / BHEL/Andrew Yule
56	LT Current Transformers	Pragati/ Kappa/ AE/ Jyoti / C&S/ L&T / MECO/ Gyro/Crompton/Schneider
57	HT Current Transformers	AE/ Jyoti / Crompton/ ABB/ Siemens /Scheinder/ Alstom Transdelta/Jain Electrical
58	LT & HT Capacitors	Prabodhan / Universal/ Crompton/ ABB/ BHEL/ L&T/ EPCOS/ Shreem/ Khatau Junker/Voltas/ Sie-mens/Schneider
59	Metering Kiosk	ABB/ Huphen/ Transvolt/ Transdelta/ Jain Electrical
60	Indication LED Lamp/ Push Buttons	L&T/ Siemens/ C&S/ Teknik / Rishab/ Asiatic/ Controls & Switchgear/ United Electric / Powergear / Pustron/ABB
61	Relay	Alstom (Areva)/ Siemens/ ABB/Jyoti/ BHEL/L&T/ Easun Reyroll/ GE/ Enercon (Conserve)

Sr. No.	Item/equipment	List of Makes of various equipment
62	DC Battery	Exide/ Amco/ Okaya/ SF Sonic/ Amaron/ AmarRaja
63	Battery charger	Usha Rectifier/ Hind Rectifier/ National Engineer-in-Charge Corporation / Suresh Electricals/Arti/ AE/ Suresh Electrical/Delta Electricals/Trinity Electricals/Panva
64	On line UPS, Servo Stabilizer, Inverter	AEI/ BHEL/ Hind Rectifier/ L&T/ NGEF/Siemens/ Hi-rel/ Autometer/ Enertech/ Pyramid/ APC/Dubas/ Luminous/ Microtech/TATA Libert
65	Bearing	SKF/FAG
67	Electromagnetic Flow meter	ABB/ Siemens/ Endress & Houser/Krohne Marshal/ Electronet/ Nivocontrol/ Mikamachi
68	HDPE pipes	Jain Irrigation, Kimplas, Timeplast, Duraline
69	DI pipes	Jindal, KOBOTA, Electrosteel, Lanco
70	CRANE & HOIST	Hercules, Electromech, Eddy Cranes, Consolidated Hoist, W H Brady
71	Air Compressor	Kirloskar Pneumatics,ELGI, Atlas Copco, Ingersoll-Rand
72	Reinforcement Steel	SAIL, VIZAG STEEL, TATA
73	Cement	ACC, Ambuja, Lafarge, Ultatech
74	Air Circuit Breakers	ABB/ Alstom/ BHEL/ CGL/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
75.	Alternators	AVK / SEGC/ Leyroy Sommers/ Stamford
76.	Annuciator (Facia Type)	Digicont/ Larsen & Toubro/ Procon
77	Anti Vibration Spring Mounts / Pads	E&B Rubber Metal (EGAMA)/ Resistoflex
78	Automatic Voltage Regulating Re-lay (AVR)	ABB/ Alstom
79	Balancing Valves	Advance/Zoloto
82	Bimetalic Overload Relay	ABB/ Larsen & Toubro/ Siemens AG
83	Buchholz Relay	Prayog / Equivalent
84	Bus Ducts / Bus trunking	Ducati/ Larsen & Toubro/ Globe Electricals/ Schneider/ Audco/Zoloto
86	Cables (Control & Instrumentation)	Delton/ Polycab/ Thermo Cables/ Universal/ RPG
87	Capacitor Bank (6.6KV)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
88	Capacitor Bank (415V)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
89	Change Over Switches	Control & Switchgear/ HPL/ Kirloskar

Sr. No.	Item/equipment	List of Makes of various equipment
90	Circuit Breaker (110kV / 132kV)	ABB/ Alstom/BHEL/Crompton/ Siemens AG
91	Connector Upto 32 Amps Screw less	LEGRAND/ Phoenix/Wago
92	Contactors / Auxiliary Contactors	ABB/ Larsen & Toubro/ Schneider/ Siemens AG
93	Control & Relay Panel (110kV / 132kV)	ABB/ Alstom / Areva/ Bharat Bijlee/ Siemens AG/ CGL
94	CT & PT (6.6/ 3.3 kV)	ABB/ Alstom/ CGL/Kappa
96	Distribution Boards (Lighting & Power)	Adlec/ Asiatic Switchgears/ Advance Panel & Swgr/ Hensel
97	Distribution Boards (PCCs / MCCs)	ABB/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
98	Engineer-in-Charge Plastics / GRP DB's & Panel Enclosures	Hensel/ Sumip/ Siemens AG/GE power
99	Feeder Pillar (Non-Magnetic Stainless Steel)	ABB/ Amptech Electric
100	Fusible Switches	ABB/ Alstom/ GE Power/ Larsen & Toubro/ Siemens AG
101	Glands (Brass - Single & Double Compression)	Comet / Dowell/ HMI/ Electromac/lotus/Leader
103	Isolator	ABB/ GR Power/ Siemens AG/ Elpro
104	Lightning Arrestors	ABB/ Alstom/ CGL/ Lamco/ CAPE ELECTRIC
105	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH/ Enterprising/ Poineer/ Resitech
106	Load Break Switch	ABB/ Alstom/ Siemens AG/ Larsen & Toubro/ H.H.E (Elecon)
107	Lugs (Copper)	Comet/ HMI/ Dowell/ Lotus
109	Moulded Case Circuit Breaker (MCCB)	ABB/ Alstom/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
110	Neutral Grounding Resistance	Cutler Hammer/ National/ Pioneer Electricals/ Ohmark/ Resitech/ RSI
111	Poles (FRP / GRP)	Bajaj/ Sumip
112.	Protection Relays (P.F. Correction)	ABB/ Alstom/ DUCATI/ Larsen & Toubro/SIGMA
115	Rotary / Toggle Switches	ABB/ Alstom/ Larsen &Toubro/ Switron/ Siemens AG/ Kaycee
116	Soft Starters	ABB/ CGL/ Schneider/ Siemens AG
117.	Vaccum Circuit Breaker (Indoor & Outdoor)	ABB/ Alstom / Areva/ Siemens AG

Sr. No.	Item/equipment	List of Makes of various equipment
118.	Vacuum Contactors	ABB/ Alstom / Areva/ BHEL/CGL/ Siemens AG
119.	Variable Frequency (Speed) Drives	ABB/ Larsen & Toubro/ Siemens AG
II CONTROL & INSTRUMENTATION		
120	Air Filter Regulator	Placka/ Schrader-Schovill/ Shavo-Norgren
121	Auxiliary Relays	OEN/ Siemens AG
122	Cable Glands	Comet/ Dowell's Elektro Werke/ Gland Mech Industries
123	Cable Trays - FRP / GRP	Densons/ Ercon/ General composites/ Indiana/ Premier/ Sumip
124	Cables (Control & Instrumentation)	CMI/ Delton/ Finolex/ Havells/ KEI Industries/ Lapp/ Nicco/ Polycab/ RPG/ Universal
125	Chlorine Measurement	ABB/E&H/ Chemtrac/ ProMinent GmbH/YIL/Hach
126	Control Desk, I/O Panels& PLC Panels / Consoles	Chemin/ Instrumentation Limited/ Siemens AG/ Lotus/Forbes Marshal/
127	DC Power Supply Unit	Aplab/ Siemens AG/ Schneider/ Phoenix
128	DCS Display Unit	LG/ Philips/Sony/ Samsung
129	DP type Flow / Level Transmitters	ABB/ Chemtrols (Fuji)/ Emerson (Rosemount)/ Honeywell/ Yokogawa/ Siemens AG
130	Fiber Optic Cables	Amp/ Krone/ Molex
131	Flow Switch	Krohne-Marshall / Siemens AG/ Switzer/ Levcon
132	Instrument Panels	Instrumentation Ltd/ Pyrotech/ Rittal
133	Instrument Tubing	Apex Tubes Pvt Ltd./ Choksy Tube Co Ltd./ Maharashtra Seamless Ltd./ Ratnamani Metal & Tubes Ltd./ Swagelock
134	Level (Ultrasonic Type) Transmitter	ABB / Chemtrols (Fuji)/ Endress & Hauser/ Emerson (Rosemount)/ Krohne Marshall/ Siemens AG/ Honeywell/ Yokogawa
135	Level Switch	Chemtrols (Vega)/ Endress & Hauser/ Switzer Instruments/ Krohne Marshall/ABB
136	Limit switches	Bhartia Cutler Hammer/ Electromag/ Electronic & Power Control Company/ Honeywell Automation (I) Ltd/ L & T/ Siemens AG/ Speed O Controls Pvt Ltd
137	ORP / pH / Conductivity Measurement	ABB/ Forbes Marshall / Siemens AG/ Yokogawa/ Honeywell/ ProMinent GmbH/ Ametek/ Emerson

Sr. No.	Item/equipment	List of Makes of various equipment
138	Plant Control System / Process Controller Distributed Control System (DCS)	ABB/ Emerson (Rosemount)/ Honeywell/L&T/ Rockwell Automation/ Schneider/ Forbes Marshall/ Siemens AG/ Yokogawa
139	Pressure / Differential Pressure Gauge	AN Instruments/ General Instruments/ KSB AG/ Waaree instruments/ Siemens AG/ Manometer India
140	Pressure / Differential Pressure Transmitter	ABB/ Chemtrols (Fuji)/ Emerson (Rosemount)/ Honeywell/ KSB AG/ Siemens AG/ Yokogawa
141	Pressure Relief Valve	Tyco Sanmar/ KSB AG/ Keystone valves Ltd./ Sebim valves
142	Self-Regulating Pressure Control Valve	Forbes Marshall/ Instrumentation Ltd./Keystone
143	Solenoid Valve	Asco/ Avcon/ Herion, Rotex/ Jucomatic/ Schrader-Schovill
144	Turbidity Measurement	ABB/ E&H/ GE Instrumentation/YIL/Forbes Marshal

SECTION – V

Technical Specification for Mechanical Works

1. VERTICAL TURBINE (VT) PUMPS:

1.1. General

Pumps shall be vertical and shaft-driven by vertical-shaft motors. Impellers shall be of the mixed or axial-flow multi-stage type, driven at a maximum speed of 960 rpm unless otherwise specified.

Operation of pumps shall be automatic with working and standby pumps operated in rotation such that no pump shall be operated continuously for longer duration.

The minimum clearance between adjacent pumps and between pump and wall shall be as per Hydraulic Institute Standards.

For all the pumps the selected model shall be such that the operating point shall lie nearest to best maximum efficiency point but towards the left of the maximum efficiency point.

The impeller diameter selected shall be such that there shall be a minimum of one diameter higher and one diameter lower size impeller is available for all the pumps.

The pump installation shall include SS 316 suction strainer, suction bell mouth, suitable length column pipe, discharge head, motor stool, lower stool, all the accessories, etc. complete.

The total suspension length shall be from suction point at bell mouth up to delivery point at common header as per design. The vertical column shall be suitably supported and anchored to prevent vibrations / movement.

The pumps shall confirm to IS: 1710 and IS: 5120. The pumps shall be capable of handling raw water from a reservoir with expected turbidity up to 1000 PPM.

Vertical-shaft driving motors shall be mounted on the discharge head above the discharge bend. Unless otherwise specified or approved, they shall be of the hollow shaft type, fitted with an axially-adjustable thrust bearing designed to carry the combined weight of pump and motor rotating parts, the drive shaft with couplings, and hydraulic loadings.

Support bearings shall be provided between each impeller stage. The impeller shaft shall be corrosion-resistive low-alloy steel, designed for low stress and long life.

The drive-shaft couplings shall be designed to preserve true shaft alignment in all operating conditions, and shall be close to bearings. Coupling design shall provide for accurate assembly and re-assembly within the limits of the permissible end-float of the shaft.

The drive shaft and couplings shall be designed to withstand the maximum accelerating torque of the motor, with a factor of safety of at least two. When required, the Agency shall provide his design calculations to demonstrate that the shaft size chosen meets the requirement for safety factor.

Unless otherwise specified or approved, the drive arrangement shall incorporate an approved ratchet arrangement to ensure that Pump not rotating reverse direction, if the pumps are driven in reverse for any reason, the motor is uncoupled from the pump. Unless otherwise specified, the discharge pipe work shall include an automatic air inlet/release valve, designed to vent the pipe work on pump start and to allow air ingress when the pump stops. The valve shall be sized to ensure that accumulated air shall not be passed to the delivery pipe work on starting. If draining the column pipe on pump stopping could result in reverse rotation of the pump, means shall be incorporated to ensure that the pump cannot be restarted before reverse rotation stops.

1.2. Codes and Standards

The design, manufacture and performance of the pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian or equivalent international standard. Some of the relevant standards are:

IS 1710	:	Vertical Turbine Pump for clear cold fresh water
IS 5120	:	Technical requirement for rotodynamic special purpose pumps

1.3. Features of Construction

The hydraulic design of the pump shall meet the requirements of high efficiency atleast 85%, low submergence, high reliability, optimum system design.

The shut off head shall be at least 110% of the total head and maximum of 130 % of total head.

The first critical speed for the pump rotor shall be at least 30% above the operating speed.

Pumps shall run smooth without undue noise and vibrations. The velocity of vibrations and the noise level shall be as per latest IS code. To detect excessive vibrations exceeding design limits as per standards, three axis vibration monitors shall be installed on the motor at top. The motor shall stop automatically when the vibration exceeds the limits.

The power rating of the pump motor shall be higher of the following:

115% of the power input to the pump at duty point at a speed corresponding to given frequency.

Maximum power input while operating single pump corresponding to the speed of 50 Hz.

Pump impeller shall be both statically and dynamically balanced.

The pumps of a particular category shall be identical. Components of identical pumps shall be interchangeable.

Pump shall be provided with non-reversible ratchet to prevent reverse rotation.

All pumps shall be provided with suitable protections including protection against overload, bearing failure, increase in bearing temperature etc.

All accessories required for proper and safe operation shall be furnished with the pumps.

Pump and motor shall be selected for VFD operation in variable frequency.

1.4. Reverse Rotation

Non-reverse ratchet arrangement shall be provided to prevent reverse rotation. However, the unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the valve fails to disallow reverse flow and non-reverse ratchet arrangement fails**.**

1.5. Noise and Vibration Level

Pumps shall run smooth without undue noise and vibration and noise level shall be limited to

a) Sound : 85db at a distance of 1.5 m.

b) Vibration : 4.5mm/s velocity. (Measured vertical, Horizontal and axial)

1.6. Column pipe

Column pipe shall be steel Manufactured from tubes confirming to either IS 1978:1982 or Gr A of IS 2062: 1984 for depths greater than 80m, the column pipe shall be manufactured from tubes confirming to IS 4270:1983.

The Standard lengths of column pipes shall be 1.5, 2.5 or 3m.

The column pipe may be threaded, flanged or provided with other methods of connection.

1.7. Gasket, Seal and Packing's

Gaskets, seals and packings used for clear, cold water pumps shall confirm with those specified in IS: 5120:1977.

1.8. Impeller:

The impeller shall be ASTM A 743 CF8M may be of the enclosed or semi-open type impeller shall be fastened securely to the impeller shaft with keys, taper bushings, lock nuts or split thrust rings.

They shall be adjustable vertically by means of a nut in the driver or an adjustable coupling between the pump and the driver.

Impeller shall be properly balanced dynamic balancing is recommended. Closed impellers may have a renewable sealing/wear ring fitted on to the front shroud or in the bowl or both.

1.9. Bowl

The Bowl shall be Cast Iron conforming IS 210:1978 and casings of bowl shall be free of blow holes, sand holes and other detrimental defects, the bowls shall be capable of withstanding a hydrostatic pressure equal one and a half times maximum discharge pressure (this included shut off head).

The bowls may be equipped with replaceable seal rings on suction side of enclosed impellers. Water passages shall be smooth and the bowls may contain bushes to serve as bearings for the impeller shaft.

1.10. Impeller Seal Ring:

The Wearing shall be ASTM A 743 CF8M wearing ring providing seal to enclosed impeller. It may be either on the impeller or in the bowl or on both.

1.11. Transmission Bearing Ring:

The Bowl-bearing/top bowl bearing shall be rubber; bronze conforming IS 318:1981 and bearing used for impeller shafts in each bowl.

1.12. Impeller/Line/head Shaft:

Impeller Shaft shall be stainless steel conforming IS 1570 (Part 5):1895 and it holds the rotating impellers and coupled to the line shaft.

1.13. Material of Construction

The material of construction for various components shall be as under:

Casing & Suction bell	: Cast Iron IS: 210, Grade FG 260
Bowl	: Cast Iron IS: 210, Grade FG 260
Impeller	: ASTM A 743 CF8M
Impeller Shaft	: AISI 410
Head Shaft	: AISI 410
Line Shaft	: AISI 410
Discharge Head	: MS IS 2062 Fe 410WA
Column pipe	: MS Fabricated
Transmission Bearing	: Rubber backed Bronze
Wearing Ring	: ASTM A 743 CF8M
Suction strainer	: SS 316

All fasteners including anchors bolts, foundation bolts, washers, nuts etc. in both in wet and dry areas Stainless Steel SS 316

1.14. Discharge head and mounting plate

The discharge head shall be a composite fabrication or casting. The supporting-plate assembly shall consist of a steel base plate, strong enough to carry the weight of the complete pumping unit without significant deflection. The assembly shall provide the motor mounting arrangement and support the pump. If required, the supporting plate shall be supplied with a flanged sleeve to facilitate mounting, with a puddle flange for building in.

The following shall be included:

- supporting plate with holding down bolts or studs;
- Bedplate ring with leveling screws and plates;
- Lifting lugs
- Fixings for motor and coupling;
- Provision for insertion of cables and level-recording equipment if required;
- Provision for access to service the shaft seal.

The discharge-head shaft seal shall be selected for long life with minimum maintenance, and may be of the mechanical. The pressure limit of mechanical seals shall be at least 50% greater than the pump closed-valve delivery pressure. Provision shall be made to return to the pump well any water leaking past the head seal.

1.15. Water-lubricated line-shaft bearings

Bearings shall be spaced at the intervals needed to ensure vibration less running at all possible pump operating speeds, with a maximum distance of 2.5 m apart. Guide bearings shall be of resilient synthetic rubber, mounted in spider bearing-retaining assemblies.

The arrangements for supplying filtered water shall ensure:

a) That filters used are duplex type so that one filter can be cleaned while the second remains in service;

b) That if required by the bearing design, a filtered water supply is provided to each bearing before the shaft begins to rotate.

c) That if the installed arrangement makes any reverse rotation possible on pump stopping, if required by the bearing design a filtered water supply is provided to each bearing until reverse rotation stops.

1.16. Rejection

If the shop testing at factory premises, the guaranteed efficiency considering the zero percent negative tolerance, is not met, the pump shall stand rejected.

1.17. Technical Data Sheet

The bidder shall submit detailed technical data sheet pump with their technical proposal during bidding covering all the details of pumps.

1.18. Name Plate

All Pumps shall have a stainless-steel nameplate on the body. Project name shall be printed by original manufacture

2. HORIZONTAL CENTRIFUGAL PUMPS:

2.1 General

The pumps proposed shall be suitable for installation at site whose altitude is as per site level and shall work under maximum ambient temperature. The pump and motor shall be capable of providing the required output when working under above conditions.

2.2 Specific Requirements

Design The design, manufacturing, performance of the horizontal execution pumps as specified hereinafter, shall comply with the requirements of applicable codes, the latest applicable IS standards, in particular and in that order of application, the following-

IS 5120	Technical requirements for rotodynamic special purpose pumps (Such as centrifugal pump axial flow, mixed flow, turbo pumps) for liquids other clear, cold, fresh water.
IS 6595	(Part 1 & 2):2002 Horizontal centrifugal pumps for clear, cold water specification.
IS 9137	Code for acceptance test for centrifugal, mixed flow and axial pumps-Class C.

The materials of the various components shall be as per data sheet or equivalent material conforming to applicable IS standards in that order of application.

2.3 DESIGN & CONSTRUCTION

2.3.1 Casing:

The casing shall be of robust construction and shall be tested to withstand 1.5 times maximum discharge pressure for 2min.

2.3.2 Impeller:

Impeller shall be balanced as per grade ASTM A 743 CF8M

2.3.3 Codes and Standards

The design, manufacture and performance of the pumps shall comply with all currently applicable statutes, regulations and safety codes in the area where the pumps will be installed and shall confirm to IS:6595 (Part 1& 2). The performance of pumps shall be guaranteed as per IS: 5120 and IS: 9137 with zero negative tolerance. The pump set shall be coupled to 3 Phase, TEFC horizontal mounted induction motor.

2.3.4 Features of Construction

- Operation of pumps shall be automatic with working and standby pumps operated in rotation such that no pump shall be operated continuously for longer duration.
- The minimum clearance between adjacent pumps and between pump and wall shall be as per Hydraulic Institute Standards.
- For all the pumps the selected model shall be such that the operating point shall lie nearest to maximum efficiency point but towards the left of the maximum efficiency point.
- The impeller diameter selected shall be such that there shall be a minimum of one diameter higher and one diameter lower size impeller is available for all the pumps.
- The Impeller shall be enclosed type, securely keyed to the shaft. Means shall be provided to prevent losing operation including rotation in reverse direction.
- The pump shall be provided with renewable type casing ring
- The first critical speed for the pump rotor shall be at least 30% above the operating

speed.

- Replaceable shaft sleeves shall be provided to protect the shaft where it passes through stuffing boxes.
- Stuffing boxes shall be of such design that they can be repacked by removing the mechanical seal and lantern ring.
- Pump shall be furnished complete with flexible coupling. Coupling guard made of expanded metal bolted to the base plate shall be furnished.
- The base plate for pump and motor shall be common. Suitable holes shall be provided in the foundations for fixing of bolts and grouting. Foundation bolts shall be complete with nuts and washers.
- The gland and cooling water shall be collected and led by suitable pipeline up to the sump pit.
- Suction and discharge connections shall be flanged.
- Pump impeller shall be dynamically and statically balanced.
- The pumps of a particular category shall be identical. Components of identical pumps shall be interchangeable.
- The pump shall be capable of developing the required total head at rated capacity for continuous operation. The pumps shall operate satisfactorily at any point on the H-Q characteristic curve over a range of 50% to 130% capacity.
- The shut off head shall be at least 110% of total head and maximum of 130%.
- Pumps shall run smooth without undue noise and vibrations. The velocity of vibrations and the noise level shall be as per latest IS code. To detect excessive vibrations exceeding design limits as per standards, three axis vibration monitors shall be installed. The motor shall stop automatically when the vibration exceeds the limits.

  a) Sound : 85db at a distance of 1.5 m.

  b) vibration : 4.5mm/s velocity.
- The pumps shall be with zero negative tolerance (and not 5% as indicated in IS–5120).
- The total head capacity curve shall be continuously rising towards the shut-off point with the highest head at shut-off.
- The pump that works at the best efficient point for specified duty conditions would

only be selected. However, the pump shall have a very good efficiency when it works at lower heads due to higher level in the sump.

- Tappings at suction and discharge nozzles shall be provided for pressure gauge connection. Casing drain connection with stainless steel collared plug shall be provided.

The pump shall be provided with the following accessories;

- Pressure Gauge of suitable range with stainless steel connecting pipes, gooseneck, cocks etc. complete.
- Priming Cock.
- Suitable piping for collection and leading off gland leaks etc. up to discharge point.

The power rating of the pump motor shall be higher of the following:

115% of the power input to the pump at duty point at a speed corresponding to given frequency.

Maximum power input while operating single pump corresponding to the speed of 50 Hz.

- All accessories required for proper and safe operation shall be furnished with the pumps.
- Pump and motor shall be selected for VFD operation in variable frequency.
- Pump rated efficiency of minimum of 85%

2.4 Material of Construction

The material of construction for different components of pump shall be as below.

S. No.	***Component***	***Material***
1	Casing	Casting Grade FG 260 of IS 210
2	Sealing	Mechanical seal.
3	Impeller	ASTM A 743 CF8M
4	Wearing rings, Inter Stage Ring	ASTM A 743 CF8M
5	Shaft	AISI 410
6	Shaft Sleeve	AISI 410
7	Fasteners, Anchors bolts, Foundation Bolts etc. both in wet and dry areas	Stainless Steel: 316
8	Base Plate	MS with epoxy coated

2.5 Performance Data

Pump performance curves flow rate Vs head, BKW, efficiency, NPSHR from zero flow to maximum flow and torque-speed curve with operating points clearly indicated shall be submitted and verified at the time of testing and commissioning of the installation.

2.6 Testing

Pumps shall be tested for performance at manufacturer's work and at site.

All pumps shall be tested at factory as per relevant BIS codes.

Hydro-test pressure on casing shall be 1.5 times maximum discharge head or twice Differential head whichever is higher. (Maximum discharge head = shut-off head + Maximum suction head). Unless otherwise stated in data sheet A, the hydrostatic tests On the casing shall be conducted for a minimum duration of 30 minutes.

The pumps shall be tested as per IS 5120, at rated speed at MANUFACTURER's Works to measure capacity, total head, efficiency and power. The negative tolerance on Efficiency shall be limited to 2.5% and not 5% as indicated in IS 5120. These tests Shall form the basis for acceptance of pumps except for vibration and noise. The Pumps shall be tested over the range covering from shut-off head to the maximum flow. The duration of the test shall be minimum one (1) hour. Minimum five (5) readings approximately equi-distant shall be taken for plotting the performance curves.

After installation, the pumps shall be subjected to testing at site also. If the site performance is found not to meet the requirements regarding vibration and noise as specified, the equipment shall be rectified or replaced by the VENDOR, at no extra cost.

2.7 Quality Assurance Plan (QAP)

Detailed dimensioned general arrangement drawing of pump and driver. This drawing Shall indicate all the design data and information furnished. Foundation drawing of Pump and driver with static and dynamic loads, details of fixing, grouting and all Relevant data required for design of foundation.

Cross-section drawing of the pump with complete part list, materials of construction And relevant standards for each part.

Scheme for pump sealing, lubrication and cooling.

Driver dimensional drawing.

Surface preparation and painting procedures.

Catalogues, data sheets and drawings for instruments.

Installation, operation and maintenance manual along with lubrication schedule

2.8 Name Plate:

All Pumps shall have a stainless-steel nameplate on the body. Project name shall be printed by original manufacture.

2.9 Submittals

Submittals include the following and shall be specific to this project. General Submittals not to be accepted.

- Sequence of operation
- Shop drawing indicating dimensions, required clearances and location and size of each
- Field connection.
- Power and control wiring diagrams.
- Pump data sheets.
- Compliance statement of all technical requirements shall be attached with submittals.
- 2 sets of submittal copies shall be submitted for Engineer-in-Charge Incharge Approvals for all mechanical equipment.

2.10 Quality Assurance

The pumping package shall be assembled by the pump manufacturer. An assembler of pumping systems not actively engaged in the design and construction of centrifugal pumps not to be considered a pump manufacturer. The manufacturer assumes “Unit Responsibility” for the complete pumping package. Unit responsibility shall be defined

as responsibility for interface and successful operation of all system components supplied by the pumping system manufacturer.

The manufacturer have a minimum of 15 (Fifteen) years of experience in the design and construction of variable speed pumping systems.

The local supplier of water supply Variable Speed Pumping System have relevant expertise in all aspects of design, application Engineer-in-Charge, installation, programming, interfacing, commissioning and after sales service. Supplier must have commissioned minimum 25 sets of water supply Variable Speed Pumping System

All functions of the variable speed pump control system be tested at the factory prior to shipment. This test shall be conducted with motors and it shall test all inputs, outputs and program execution specific to this application.

The manufacturer shall be fully certified by the International Standards Organization per ISO 9001. Proof of this certification shall be furnished at time of submittal.

Manufacturer shall be listed by Underwriters Laboratories as manufacturer of packaged pumping systems.

Tenderer comply with all sections of this specification relating to packaged pumping systems. Any deviations from this specification shall be clearly defined in writing at time of bid. If no exceptions are taken at time of bid, the supplier be bound by these specifications.

2.11 Manufactured Units

Furnish and install as shown on the plans a Variable Speed Pumping System as per approved manufacturers.

The control system include as, a minimum, the programmable logic pump controller, adjustable frequency drive(s) and remote sensor / transmitters as indicated in the drawings on the plans. Additional items shall be included as specified or as required to properly execute the sequence of operation.

The variable speed pump logic controller, adjustable frequency drives, AFD bypass and remote sensor / transmitters shall be shipped as individual components to the job site.

Pump logic controller, adjustable frequency drives, sensor / transmitters and related equipment shall be installed by the mechanical Agency as shown on the plans.

Power wiring shall be installed by the mechanical Agency as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

Low voltage wiring shall be installed by the mechanical controls Agency as shown on the field connection drawings and wiring diagrams supplied with the pumping package.

3. Flanges

Valves shall be flanged and the flange face at right angles to the valve

Centerline. Backside of valve flanges shall be machined or spot faced for proper Seating of the head and nut.

Flanges shall be machined on faces and edges to IS 6392 or BS 4504 or ANSI B16.5 for flanges. For PN 16 nominal pressure rating unless otherwise required. Flange drilling shall conform to IS 1538.

Flanges of entire intake well, rising main, WTP, clear water pumping main shall selected from unique standard to maintain the minimum inventory spare. Accordingly, the valves flanges also shall be selected.

4. Dismantling Jointing

4.1 Design Requirements

a. Dismantling joint shall be designed such that adequate space can be created by collapsing the dismantling joint, for removal and for reinstallation of adjacent valves.
b. (b) All parts of dismantling joints shall be amply proportioned to take care of all stresses that may occur during installation and in operation.
c. Dismantling joints shall have end, thrust and follower flanges and rubber sealing ring.
d. Tie rods shall be provided for rigid fixing after installation to enable transmission of thrust. Tie rods shall be provided for minimum 30% of the holes.
e. With the use of dismantling joints, it shall be possible to have an approximate clearance of 25 mm with the adjoining fittings.
f. All dismantling joints on the suction side shall be designed for a pressure of 2.5 bar and on delivery side shall be designed for a pressure of 10 bar.

4.2 Features of Construction

a. Outside of inner sleeve and inside of outer sleeve shall be machined to close tolerances.
b. Inner sleeve end shall be chamfered for easy introduction of rubber ring.
c. Sleeves shall be of uniform bore and straight in axis. The flanges shall be square to the axis of sleeve. The faces of flanges shall be parallel. The bolt holes circle and outside periphery shall be concentric with the bore and bolt holes equally spaced. Bolt holes in one flange shall be located in line with those in other.
d. Bolt holes on flanges shall be drilled with the help of drilling jig.
e. Flanges shall be machined flat faced and shall be full or spot faced on the back side. Flange thickness shall be uniform throughout. Flange periphery also shall be finished smooth. Flanges shall be as per relevant applicable standard corresponding to design pressure. The flanges of dismantling joints mating with valves shall have drilling stranded matching with that of the valve.

Materials of Construction

a. Body : CI IS: 210 Gr FG 260
b. Flanges : CI IS: 210 Gr FG 260
c. Seal ring : EPDM Rubber
d. Tie Rods, Bolts, and Nuts and: SS 304 Washers

4.3 Design parameters

a. Rating (bar) : 10

Data to Be Furnished by Agency after the Award of Contract.

Dimensional and cross section drawing of valves and dismantling joint.

5. Pressure Indicators:

Direct reading, pipe mounted Pressure gauges with siphon & cock valve of Stainless Steel with 6-inch phenolic dial (white dial with black numerals), 316 SS Bourdon tube, nylon movements and micrometer type adjustable aluminium pointer with accuracy of +/-1% of span including accessories like siphons, snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services and name plate, etc.

Material of accessories shall be SS. IP65 degree of protection for enclosure. Over range protection shall be 50% above maximum pressure. Armoured capillary of 15 M shall be provided as required.

All pump suctions shall install compound gauge as per following detail

a. range : -1 to 1.5 kg/cm^2

b. least count: 0.05 kg/cm^2

All delivery line shall install pressure gauge as per following detail

a. range : 0 to 10 kg/cm^2

b. least count: 0.2 kg/cm^2

6 AIR VALVE

Air valves are used to protect the pipe line by filling air during draining, venting air during filling and Continues venting of entrapped air during operation. Air valves shall match with the following specifications

6.1 Material of Construction for DN 50mm to 150mm (PN 16 Bar)

Body	:	Ductile Iron ASTM A 536
Air & Vacuum Float	:	Polypropylene
Air & Vacuum Seal	:	EPDM
Automatic Float	:	Polypropylene
Rolling Seal	:	EPDM
Discharge Outlet	:	Polypropylene
O-Ring	:	EPDM
Discharge Outlet Seal	:	EPDM
Bolt	:	Stainless Steel SAE 304
Flange Standard	:	DIN 16

6.2 Material of Construction for DN 200mm (PN 16 Bar)

Body	:	Ductile Iron ASTM A 536 / EN 1563
Cover	:	Ductile Iron ASTM A 536 / EN 1563
Float	:	Polycarbonate
Orifice Seat	:	Bronze
Orifice Seal	:	EPDM

Automatic Valve -

Body	:	Reinforced Nylon
Rolling Seal	:	Rubber E.P.D.M.
Clamping Stem	:	Reinforced Nylon
Float	:	Foamed Polypropylene
Base	:	Reinforced Nylon
O-Ring	:	BUNA-N

7 WAFER TYPE BUTTERFLY VALVES

Wafer type butterfly valves are used to isolate Air Valve as and when required for Isolation or Maintenance Purpose.

7.1 Specifications:

- Body and Disc shall be Ductile Iron GGG40 having fully vulcanized liner seat
- Shaft shall be made with Stainless Steel
- Body shall Coated with Epoxy
- Valves shall be supplied with Hand lever up to 150 mm diameter and for the sizes above 150mm with Gear Arrangement
- Face to face dimensions shall be confirming to ISO 5752

7.2 Material of Construction

Body	:	Ductile Iron GGG 40 + EPDM
Disc	:	Ductile Iron GGG 40
Shaft	:	SS 420/SS416
Bushing	:	Bronze/ Nylontrol
O-Rings	:	NBR/EPDM
Cover joint	:	Steel
Washer	:	Stainless Steel
Bolts	:	Stainless Steel

8 PUMP CONTROL VALVE (UPTO 400MM)

8.1 SPECIFICATION

The Pump Control Valve shall open fully or shut off in response to electric signals. It shall isolate the pump from the system during pump starting and stopping, to prevent pipeline surges during Pump ON/OFF.

Valve Shall be with Rapid-action piston for Fast Opening/Closing action to facilitate stable and accurate control.

Valve shall have High Kv factor e.g. 4" valve shall have KV value of 475 m3/hr,

Valve shall have Low head loss at high flow rates,

Valve shall be strong, lightweight and corrosion proof surfaces, which resist cavitation Damage, thus increasing service life and reducing operation & maintenance cost.

Valve shall have Linear flow, Low turbulence to minimize cavitation, and allow high flow velocities with low noise and vibration.

Valve shall have "Soft closure" feature to prevent water hammer.

Multi-Valve modular configuration Full redundancy enabled. Individual valves can be possible to separately remove for maintenance or replacement which reduces downtime and maintenance costs & allows maintenance work to be done without halting water flow.

8.2 MATERIAL OF CONSTRUCTION:

Valve Body	: Reinforced fiberglass nylon or Polypropylene
Pistons, Bushing, Front and Rear Cups: Reinforced fiberglass nylon or Polypropylene	
Main seal	: NBR, VITON or EPDM rubber,
O-rings	: NBR or EPDM rubber
Inlets, outlets	: Stainless steel/ Reinforced fiberglass nylon
Clamps, bolts	: Stainless steel
Multi-Valve manifolds	: Spheroid iron with polyester or epoxy coating
Pressure Rating	: PN 16

9 PUMP DISCHARGE VALVES (500mm and above)

a. Change Level to Lever.

b. Radial Plunger / External Gear Pump. 2 Pumps: One operating & one stand-by with automatic switch-over facility in case of the operating pump failure to be provided.

c. Local Electrical Control Panel attached to the HPU. The LCP should have facility to hook-up with System Scada/ DDCMIS for Remote control also.

Pump Discharge Pressure: Can be up-to 175 Bar because 230 bar Rated Gear pumps are easily available in market. This will make the system more compact & cost competitive.

In case of Pump failure: Bladder type Accumulator should be provided which can open the valve 2 times without pump flow being available.

PD Valve Opening from 0% to 100%: Hydraulic System can achieve this. However, it is not advisable to operate any conventional Butterfly Valve below 10% opening continuously due to cavitation & erosion considerations.

Add: The Hydraulic Cylinder actuator should have cushioning at the full close end. To the extent of 5 to 10% of stroke: adjustable.

Closing Time:

Normal: Planned Shut-down: 90% in 40 to 50 sec. & balance in 10-20 Sec.

Emergency (Main pump motor trip): 80-90% in 10-20 sec. & balance in 10 Sec.

Opening Time:

Upto 1200 mm Dia BFV: Upto 60 Sec. Larger than 1200mm BFV: upto 90 Sec.

5 Limit Switches: FO, FC, Crack Open, Intermediate Open & Creep to be provided.

Mechanical lock with Electrical interlock at full open & Full Closed positions required.

Position Transmitter for hooking up position of the valve with remote Control required.

Local control Panel to be mounted integrally on the Hydraulic Power Unit. This unit is to be located at Valve floor level & can be hooked up with the SCADA/ DCIS. LCP to be provided with pushbuttons & indicator lamps & selector switches.

Foundation with Sole Plate, Anchor Bolts & fasteners required.

Hydraulic Actuator should be body mounted.

9.1 CONSTRUCTION

Flanged /Wafer offset /Wafer Liner	:	Double Flanged
Rating	:	PN 1.6
Governing Standard	:	For upto size 2000 mm dia AWWA C 504
For above size 2000 mm dia	:	AWWA C 516
Flange Drilling Standard	:	AWWA C 207

9.2 Material of Construction

Body & Disc (Fabricated)	:	Mild Steel IS 2062 Gr. B
Shaft, Shear Pin	:	Stainless Steel AISI 431
Disc Seal Ring	:	Nitrile Rubber
Body Seat Ring	:	Stainless Steel AISI 304
Bearing Bush	:	Steel Backed PTFE Self Lubricated

Clamping Ring : Stainless Steel AISI 304

MODE OF OPERATION

Hydraulic Actuator Hydro-Electrically operated complete with counter weight arrangement and accessories.

ACCESSORIES With bypass sluice (01 MANUAL)

TESTING

Seat Test Pressure (Hydro Test) 16 Kg/cm2

Body Test Pressure (Hydro Test) 24 Kg/cm2

10 SLUICE VALVES (Resilient seated Gate valve/Sluice Valve from DN 50mm to DN 1200mm)

10.1 Constructional Features

DI D/F non-rising spindle soft seated glandless Gate Valves with body and bonnet of ductile cast iron of grade EN-JS 1050, wedge with fully encapsulated EPDM rubber (approved for drinking water). The valves should be with replaceable stem nut. Valve stems shall be of single piece thread rolled. Valve shall have 3 "O" rings of NBR for stem sealing. Gate valve shall be compatible for buried applications without valve chamber. Face-to-face dimensions as per BS 5163-89/IS 14846-PD/EN 558F4 & F5 and flange connections as per EN 1092-2 / IS 1538, Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue with minimum coating thickness of 250 microns.

Material of Construction:

Body, Bonnet : Ductile Iron EN-JS- 1050

Wedge : Ductile Iron EN-JS-1050) encapsulated with EPDM rubber.

Spindle/Stem : SS: AISI 420

Stem Nut : Copper Alloy

Bonnet Gasket : EPDM Rubber Grade W-270

Internal Fasteners: Steel 8.8 with geomet coated

Stem Sealing : Toroidal NBR sealing rings (Min 03 'O' Rings)

Coating : Inside & Outside epoxy powder coated; DFT minimum 250 microns, shade RAL 5015 (BLUE)

Mode of Operation: Hand wheel/ Actuator

11 BUTTERFLY VALVES

(All Size of Butterfly valves selection shall be same size of pipe Diameter)

11.1 Constructional Features

DI D/F Resilient Seated Vacuum tight Butterfly Valve suitable for bidirectional flow with Body and disc made of EN-JS 1030. Valve shall conform to double eccentric design with specially designed wave form disc. The disc shall contain pressure supported sealing system made of EPDM. The Body seat shall be PTA (Plasma Transferred Arc) weld deposited with nickel chromium and micro finished. Closed Disk Eye with dry shaft design made of Stainless steel with 13% chromium of grade 1.4021 connected with Medium free Bearing Bronze with double O-ring sealing of EPDM. The shaft ends shall be of Polygon Plug Connection to ensure absolute **clearance free connection to the disc.** The Valve shall be compatible for Buried application without chamber. The Coating and the rubber parts shall comply with DVGW / KTW / W270 standards. The gearbox shall be of Slider Crank Mechanism type with stable adjustable end stop, with IP-68 protection class and mechanical position indicator. The Valve shall be according to EN593/IS 5163, the face-to-face length shall be EN 588-1, basic series 14/BS 5155(Long Body)/ IS13095 (Long Body) and drilling according to EN 1092-2/IS 6418. Epoxy or liquid Epoxy coating with minimum thickness of 250 microns according to GSK both applied inside and outside of both body and disc. (EP-P □ it is a resi-coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C).

11.2 Material of Construction:

Body	: Ductile iron to EN-JS 1030
Disc	: Ductile iron to EN-JS 1030
Retaining Ring	: Stainless Steel encapsulated with EPDM up to DN600. Steel from DN700.
Shaft	: Stainless Steel 420 with 13% chromium (1.4021)
Shaft Bearing Bushes	: Bearing Bronze
Seat	: Integral Ni-Cr weld overlay, (Ni > 67% Cr = 19.5 %) micro finished

Disc Sealing & 'O' rings: EPDM Rubber [W 270 Clause]

Surface Protection	: Epoxy powder coating or epoxy liquid lacquer min. 250 microns thickness, colour Blue

12 Electric Actuator

For Sluice/Butterfly valves installed on the Trunk network

Actuators shall be suitable for the medium, climatic, environmental and pressure conditions of the system in which they are to be fitted.

Actuators shall be provided with:

a. AC Electric Motor.
b. Reduction gear unit.
c. Torque switches mechanism.
d. Limit switch mechanism complete with set of limit switches and additional two spare sets for suitable position.
e. Hand wheel, for manual operation.
f. Valve position indicator.
g. Hand-auto lever with suitable locking arrangement.
h. 10 W single phase space heater in the switch compartment.
i. Blinking light throughout the valve operation.
j. Junction box for terminating power and control cables.
k. With additional accessories for integrating with PLC system.

The actuator shall be suitable for operation on 415V, 3 phase, 50 Hz power supply. The motor winding insulation shall conform to class B as per relevant BS and motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1 1/2 times the required operator torque at the required time cycle of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at actuator end and one at valve end with universal couplings at suitable places. The required number of switch/contacts meets for requirements for PLC system. The electrical actuator for butterfly valves acting as flow controllers shall comprise of the additional necessary electronic card/ accessories required for generating a 4-20 ma signal and for integrating it with the PLC system.

The electric motors shall be of the squirrel cage type as per IS 325 with insulation to IS 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 15 minutes. They shall also be suitable for operating on the specified electric supply and

shall satisfactorily open and close the valve under variations of electric supply specified.

Motor shall be protected by suitable overload protection device.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating fed from a 110 Volt control transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be of 650/1100-volt grade PVC insulated stranded copper conductor of minimum 1.5 sq. mm for control circuits and of minimum 4 sq.mm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC insulated/ sheathed, armored cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose proof to IP 67 and shall be fitted with an anti-condensation heater, which shall be switched off when the motor is running.

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed.

The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during the opening cycle or when the valve is fully open.

The mechanism shall facilitate adjustment of the torque at which the switches are required to operate.

Non-adjustable limit switches shall stop the motor and give indication when the disc has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired value position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to give an indication whether the valve is fully open, fully closed or in an intermediate position.

Settings and emergency operation shall be possible with the use of a hand wheel. The Hand wheel shall be of stainless steel and the drive mechanically independent of the motor drive and any gearing shall limit the operating torque at the hand wheel to less than 15 kg and be such as to permit emergency manual operation in a reasonable time. During electric operation, the hand wheel shall not rotate.

Actuators shall be adjusted at the manufacturer's works to ensure that they provide the correct, fully, open position and fully closed position. Mechanical adjustable stops shall be provided to prevent over-travel of the valve in the open and closed positions.

SECTION - VI

Technical Specification for Instrumentation, Control Systems & SCADA

1. INTRODUCTION

The potable water needs of Amravati capital city are such that the total ultimate capacity of the scheme can be fully utilized at all times. Therefore, the throughput of the system will be driven primarily by the capacity of the water treatment plant rather than the demand. The Agency shall appoint experienced specialized SCADA agency as per the approved list.

1.1 Purpose of Control System and Design requirement:

The purpose of the raw water and clear water pump control system are as follows:

- To ensure continuity of raw water and clear water flow through the system.
- To ensure satisfactory operation during transient conditions such as during start up and shut down of the system.
- To ensure the capacity of water treatment plant is not exceeded.
- To monitor at a central point, the operation of the complete pumping installations.
- To allow change of system control set points from a central location.
- To provide facilities for alarm announcement and management, and in the event of system faults, to take appropriate action to protect the faulted item and to effect where possible remedial actions (i.e., in the event of a drive fault to raise an alarm and initiate operation of a standby drive, if available).

In addition, the control system would permit:

- Trending of operational variables.
- Preparation of operational data archives.
- Preparation of on-demand periodical operational management reports.

1.2 Objectives for Introducing Control System:

The objectives of providing Instrumentation, Automation and Local SCADA for each pumping station and the entire system network in general are as follows. Hydraulic parameters monitoring and control.

- Electrical Energy monitoring.
- Supervisory Control & Monitoring of equipment i.e. pump, motors etc.

- Shutdown sequence and emergency tripping conditions of all the individual and complete system have to be defined.
- Two levels of Supervisory control shall be adopted for HMI and Control room levels.
- Emergency response for stopping pumping station.
- Data acquisition of pump parameters and Pumping system efficiency monitoring.
- Optimization of pumping system.
- Monitoring, measurements and Control of Reservoir, Tapping points, Air valves, District Outlets, Distribution Centers& Water Meter.
- Minimization of human errors.
- Aid to man power.
- Logging, reporting, preventive maintenance, safety etc.

1.3 Minimum Requirements of Control System in Pumping Station:

The monitoring and Control for Pumping Stations will comprise of PLC based system equipped with Combination of optical fibre network and Ethernet network by using media converts. This system will aid the operator to monitor and control the pumping station Equipment both locally and remotely from Central SCADA.PLC at Pumping Station will communicate to Central SCADA over both Wireless Communication and Optical Fibre Network. Network including Raw Water, WTP, Clear Water Pumping Station and Water Distribution Centre are interconnected using Optical Fibre as primary communication media and wireless as secondary. Control System will be designed accordingly maintaining Interdependency between Pumping station and WDC's. Following sites will be provided with PLC based control System

- Raw Water Pumping Station
- Clear Water Pumping Station
- GLSR based Pumping Stations

1.4 Salient Features of Programmable Logic Controller (PLC):

i. Programmable Logic Controller (PLC) provided shall be of Hot Standby Architecture for smooth, reliable, safe, efficient & trouble-free operation with

optimum monitoring and control of process plant and equipment. In adverse condition, i.e. In case of Failure of Primary PLC, Standby PLC will come into action and maintain control process for smooth working of plant.

ii. All Controllers proposed for SCADA system shall be provided with facility to download the modified logics online i.e. even during the operation of the plant. In any case loading of the controller with modified logics & parameters shall not stop any equipment used in Intake well and WTP.

iii. Indefinite High Resolution (IHR) controllers with inbuilt CPU having less scan time shall be used for data acquisition & Control of Electrical signals i.e. for Substation and all LV and HV switchgear controlling.

iv. Normal PLC with inbuilt Analog, Digital I/O cards can be used for data acquisition and control of all remaining auxiliary signals.

v. The PLC will be of reputed make, proven technology, and microprocessor based, with its control and monitoring functions distributed geographically & functionally and designed for fault avoidance by proper selection of components.

vi. It will have high availability, high reliability & high maintainability.

vii. The system will be modular in nature and will have facilities for easy expandability of modules to enhance its functionality or performance if required in future.

viii. The system will be versatile, rugged and suitable for continuous duty in normal industrial environment.

The offered system shall have following software based functions:

1. "Financial Modeling and sensitivity Analyses" to create a Business Financial Model with implementation plan that shall analyze investment returns based on a full range of varied cost inputs.
2. "Total System Optimisation" feature that uses the result of financial modeling to optimise the design and operation of plant distribution piping and energy transfer stations. This will include preparation of control system sequences that will implement the optimisation strategies.

The PLC will be suitable to meet the specific process requirement of Pumping Station including monitoring, control, interlocking & sequential operation of the process and

will also be designed accordingly. Application software of the PLC will be developed based on the functional requirements of the process.

Each system is connected to Programmable Logic Controller and the functional distribution of hardware in a multi-level hierarchy to meet specific plant requirements for monitoring, control, process visualisation & optimisation of pumping system. One number Human Machine Interface (HMI) is provided in the PLC panel for monitoring & controlling of the pumping station.

All Field Instruments and Electrical drives related inputs and outputs are connected to PLC. Electrical system parameters are connected to PLC system to detect abnormalities in electrical system. Each PLC System shall have 20% spare IOs for future requirement. The Raw Water Pumping Station, WTP & Clear Water Pumping Station shall be communicating over Fibre Optic Communication Network.

1.5 Sequence of operation:

Total operation of the plants shall be through proper defined starting and shut down sequences and for emergency plant tripping sequence shall be designed with specific time and approval from EIC shall be taken during design phase.

2. SPECIFICATIONS FOR RAW WATER INTAKE P.S.

2.1 General

It is proposed to have fully automatic and fail-safe operation of the pumping station to meet the varied demand of clear water in most efficient manner. An Optical fibre network shall be created so as to meet the requirement at Intake Pumping Station depending upon current state of Clear water pumping station. The scope of work would cover conceptualization, design, pre-dispatch inspections, supply, installation, and pre-commissioning test, commissioning tests, commissioning, trial run and maintenance of the entire Automation, Instrumentation and Control (PLC) system. Design of the complete system along with the detailed specifications of the equipment proposed to be installed shall be submitted for necessary approval of the Department. The design of the system shall adhere to the principles detailed in the respective Chapter of "Specifications for Automation Instrumentation and Control.

Irrespective of the detailed specifications of the respective items detailed in the chapters of pumping stations and filter plant, it shall be required to provide all equipment,

accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic etc. to achieve the objectives listed below.

The entire PLC system is required to receive, store and control the information From Electrical, Mechanical & Instrumentation Equipment.

2.2 Electrical System:

- Input voltage and amperage of 33 KV/6.6 KV and input voltage and amperes of 0.415 kV to individual motors.
- Power consumption (kWH) and power factor on 33KV/6.6 KV system, transformers and all individual HT&LT motors
- Status of all circuit breakers
- Status of all relays used in electrical installations controlling LT motors
- Status of all LT motors (on/off)/ & all parameters of Frequency Drives, etc.

2.3 Mechanical Equipment

- Status of all HT&LT pumps
- Status (on/off/percentage open) of all Butterfly/Pump Control Valves, on individual pumps delivery
- Temperature monitoring of HT&LT pump and motors for bearing and winding, etc.

2.4 Instrumentation Equipment

- Flow data (instantaneous flow rates and total flow) from the pump house (through flow meter & transducers installed on delivery manifold.
- Level of water in the intake.
- Pressures at delivery of each pump & manifold, etc.

2.5 Process the above information to Control

- Shut down of pumps in case of any non-transient abnormal conditions such as low/high voltage, high current drawl, and thermal over load, etc.
- Shut down of pumps in case of low levels of water in sumps.
- Operation of all butterfly/Pump Control Valves to desired state.
- Generation of reports, etc.

2.6 Alarm Situations

The alarm schedule is indicative of what is required. It shall provide for the annunciation of all alarms necessary in order to achieve control and monitoring requirements

- 33KV/6.6 KV power failure
- Tripping of outdoor VCB in 33KV/6.6 KV switchyard
- Tripping of any indoor ACB on transformer out-comers.
- Power Frequency in 33KV/6.6 KV abnormal Low/High
- Abnormal pressures in manifold
- Motor tripped on over-load.
- Pumps failed to start/stop.
- Valves unable to open/close
- Emergency stop operated
- UPS failure, etc.

2.7 Hardware & Software Requirements in PLC system

Each PLC system shall be supplied with:

- Redundant Central Processing Unit (CPU).
- Memory Unit
- Input/output Modules
- Programming Unit consisting of one desktop computer with requisite software
- The human machine interface (HMI) consisting of 15" Screen installed on the Panel
- GPRS Modem for communicating with Central Control Web SCADA
- Fibre Optic Modem and LIU boxes for communication with WTP SCADA System, etc.

2.8 Requirement of Instrumentation

To achieve the objectives listed above in scope of work, It shall provide the required numbers of equipment/sensors. Main equipment required is as listed below. The list is not comprehensive and the scope of contract shall not be limited by the list but shall include all probes level sensors, input-output modules, interfaces, other sensing elements, cabling, ducting, earthing, providing lightening protection, providing facilities of local display of readings from instruments, etc.

The main equipment required are as listed below but not limited to:

Full bore electromagnetic flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter and flow indicator and integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer and in line with the applicable standards. Agency shall finalize the exact location of flow meter in consultation with Representative of Authority.

Flow measurement shall not be affected by physical properties of water viz., temperature, pressure turbidity etc., within given limits. Agency shall provide compensating Electronic circuits, if required. A lockable enclosure shall be provided for the flow transmitter cum computing unit, if required.

Flow meters shall be suitable for the water turbidity at site during various seasons. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow tube shall have waterproof construction and shall be suitable for installation on underground /above ground pipe lines.

The flow computer and transmitter shall be a single unit suitable for panel mounting. It shall accept inputs from flow tube, process the signals and shall provide an output proportional to the flow rate. The distance between transmitter and flow tube shall be maximum 250 mtrs. Taper pieces required for installation of flow meter shall not exceed an angle of 8° in order to avoid disturbance in flow profile.

- Level sensors, transmitter and digital level indicators -1 Nos. at each Sump/Reservoir
- Providing pressure gauges and other instruments at each suction and delivery manifold of each pumping section based on design requirement.
- Pressure switches or transmitters and indicators at each manifold and delivery pipes of each pump.

2.9 Instrumentation, Automation, Communication Control Panel (IACC)

It shall provide Design, Catalogue of manufacturing, installation & commissioning of Instrumentation, Automation & communication control panel for Pump House

The IACC Panel at each head works shall include following

- Digital display meter for flow, water level.
- Automation components such as PLC, Digital IP, OP
- Communication components such as FO network, GPRS Modem, Converters, Network switches and LIUs etc.

- The control panel shall display all the sensors & recordable parameters on the HMI of control panel. The following parameters shall be monitored:
  - Water Level in Reservoir
  - Motors: Start/Stop/Trip feedback and start /stop control from remote
  - Motorized Valves/PCV: Open/Close feedback and open close from remote
  - Flow Meters: Process Values and Set point settings for remote operation
  - Pressure reading: Process Values and Set point setting for remote operation
  - Each Motor has kWh meter with Modbus port available in MCC panel. This parameter needs to be communicated to the SCADA system
  - Pump House Incomer will have a multifunction meter with Modbus port. All Electrical parameters from this meter may be used for logging in the SCADA

The work shall include panel, all indicators, PLC, internal wiring, cabling, conduits, input and output facilities complete in all respect. The work will include providing cable from field sensor up to the IACC and connecting them with field sensors and all conduits, fixing arrangement. The work shall also include providing, fixing etc of instrumentation & control cabling from & to all sensor/control elements

2.10 Control Room Furniture (System Console)

In addition to the HMI system equipment, it shall provide furniture system consoles if required to complement or match both the color and styling of the equipment. Control room furniture shall comply with relevant IEC standards for ergonomic design. Details and design of system consoles shall be submitted to the Engineer-in-Charge for approval.

Typically, it shall provide two fabric-covered adjustable armchairs with casters, a rigid and lockable steel cupboard for the storage of operating and maintenance manuals, drawings, logger paper, charts, disks etc.

3. SPECIFICATIONS FOR WTP (Water Treatment Plant).

Water shall be pumped from Raw Water pumping station to WTP for further treatment. There will be a parshall flume constructed for the measurement of water entering into the plant. An open channel ultrasonic type flow meter shall be installed for this measurement. Further water from parshall flume will be carried to flash mixer using a raw

water channel. A Raw water quality-monitoring sensor consisting of Online Turbidity, Online pH, Online Conductivity, Online DO etc. will be monitored at control room. Necessary sampling accessories will be installed accordingly.

Provisions shall be made available at outlet of Flash mixers to connect the clarifloccu-lators. The operation of flash mixers and clarifloccculators will be done from the pro-posed SCADA system. Sludge valves for each clarifloculator will be operated based on measured sludge level by the sludge blanket level instrument. The clarified water then flows into the plate settlers.

Further for the Filtration System a fully automated backwash system will be envisaged. All the motorized gates/ valves in the filtration plant will be operated from PLC-SCADA system. Turbidity analyzers are proposed to install at backwash line of each filters. Loss of head instruments are proposed for the difference in the headwater levels in each filter. Air flow and pressure from air blowers shall be measured by respective instruments.

3.1 The Instrumentation and Control System Requirement.

The entire PLC system is required to receive, store & control the information From Electrical, Mechanical & Instrumentation Equipment.

- **Electrical System:**
  - ✓ Input voltage and amperage of 33 KV/6.6 KV and input voltage and amperes of 0.415 kV to individual motors.
  - ✓ Power consumption (kWH) and power factor on 33KV/6.6 KV system, transformers and all HT & LT motors
  - ✓ Status of all circuit breakers
  - ✓ Status of all relays used in electrical installations controlling HT&LT motors
  - ✓ Status of all HT & LT motors (on/off)/ & all parameters of Frequency Drives (if provided), etc.
- **Mechanical Equipment**
  - ✓ Status of all HT & LT pumps
  - ✓ Status (on/off/percentage open) of all Butterfly/Sluice Valves/Pump Control Valves, on individual pumps delivery
  - ✓ Temperature monitoring of LT pump and motors for bearing and winding, etc.

- **Instrumentation Equipment**
  - ✓ Flow data (instantaneous flow rates and total flow) from the pump house (through flow meter & transducers installed on delivery manifold.
  - ✓ Level of water in the clear water reservoirs and elevated service reservoirs
  - ✓ Pressures at delivery of each pump & manifold, etc.
- **Processing of above information will facilitate control below mentioned.**
  - ✓ Shut down of pumps in case of any non-transient abnormal conditions such as low/high voltage, high current drawl, thermal over load.
  - ✓ Shut down of pumps in case of low levels of water in sumps.
  - ✓ Operation of all butterfly/sluice valves/Pump Control Valve to achieve desired state.
  - ✓ Generation of reports, etc.
- **Alarm Situations**

The alarm schedule is indicative of what is required. It shall provide for the annunciation of all alarms necessary in order to achieve control and monitoring requirements.

- ✓ 33KV/6.6 KV power failure
- ✓ Tripping of outdoor VCB in 33KV/6.6 KV switchyard
- ✓ Tripping of any indoor ACB on transformer out-comers.
- ✓ Power Frequency in 33KV/6.6 KV abnormal Low/High
- ✓ Abnormal pressures in manifold
- ✓ Motor tripped on over-load.
- ✓ Pumps failed to start/stop.
- ✓ Valves unable to open/close
- ✓ Emergency stop operated
- ✓ UPS failure, etc.

- **Hardware & Software Requirements in PLC system**

Each PLC system shall be supplied with:

- ✓ Redundant Central Processing Unit (CPU).
- ✓ Memory Unit
- ✓ Input/output Modules
- ✓ Programming Unit consisting of one desktop computer with requisite software

- ✓ Instrument Control Panel (I.C.P.) / Control Desk

The man machine interface (MMI) consisting of:

- ✓ Personal Computers with minimum 19" color monitor with other accessories
- ✓ 12 PPM, A4 sized Laser Printers
- ✓ Panel Power Supply via an uninterruptible power supply (UPS) of one-hour capacity, etc.

3.2 Requirement of Instrumentation

To achieve the objectives listed above in scope of work, It shall provide the required numbers of equipment/sensors. Main equipment required is as listed below. The list is not comprehensive and the scope of contract shall not be limited by the list but shall include all probes level sensors, input-output modules, interfaces, other sensing elements, cabling, ducting, earthing, providing lightening protection, providing facilities of local display of readings from instruments, etc.

The main equipment required are as listed below but not limited to:

- Full bore electromagnetic flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter and flow indicator and integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer and in line with the applicable standards. Agency shall finalize the exact location of flow meter in consultation with Representative of Authority.
- Flow measurement shall not be affected by physical properties of water viz., temperature, pressure turbidity etc., within given limits. Agency shall provide compensating Electronic circuits, if required. A lockable enclosure shall be provided for the flow transmitter cum computing unit, if required.
- Flow meters shall be suitable for the water turbidity at site during various seasons. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow tube shall have waterproof construction and shall be suitable for installation on underground /above ground pipe lines.
- The flow computer and transmitter shall be a single unit suitable for panel mounting. It shall accept inputs from flow tube, process the signals and shall

provide an output proportional to the flow rate. The distance between transmitter and flow tube shall be maximum 250 mtrs. Taper pieces required for installation of flow meter shall not exceed an angle of 8° in order to avoid disturbance in flow profile.

- Level sensors, transmitter and digital level indicators – 1 Nos. at each Sump/Reservoir
- Providing pressure gauges and other instruments at each suction and delivery manifold of each pumping section based on design requirement.
- Pressure switches or transmitters and indicators at each manifold and delivery pipes of each pump.

3.3 Operation of WTP

It is proposed to have MCC (Mater Control Centre) at the WTP premises. Water Treatment Plant is required to be automated using latest PLC System as specified in this section & other sections of this tender. The automation includes all the machinery and processes of WTP as explained.

Entire backwash operation of filter beds right from sensing of bed choking to initial backwash operation and complete cycle as per process design shall be completed automatically through PLC to be provided at main control room. Further the plant pumps / process equipment, shall operate in auto mode through PLC at ICP /main control room and necessary instrumentation for the same shall be included in the scope as per the scope / operation philosophy specified in the tender.

Auto backwash operation through PLC HMI/SCADA at main control room and the status indication shall be provided at PLC HMI / SCADA All valves of a bed & air blowers shall be possible to operate automatically as per logic for all pneumatically operated Valves & Gates shall be monitored for full open and full close position and all electrical drives for various equipment of WTP shall be monitored for on, off and trip status at PLC HMI / SCADA. Green indication for Valve close / motor off status and Red indication for Valve open / motor on status shall be provided. Indication for Trip shall be Amber.

Backwash tank water level sufficient for backwash operation shall also be indicated at PLC HMI / SCADA. All valves shall be able to operate in the following modes: - LOH/ROF level indication of associated bed shall be displayed at PLC HMI / SCADA.

- In Auto Mode: - Entire filter back wash shall be in auto mode with all valves / back wash blowers shall operate in fully automatic mode through PLC.
- Semi-Auto Mode: - Where the operation of the valves/blowers is controlled from the HMI / SCADA console through soft push button/selector switches by operator.
- In Off Mode: - Valve/Blower/compressor shall be operated manually from Filter bed or locally in case of failure of PLC/Scada system.

Following shall be provided as a minimum in Automation System at main control room to achieve the above objective:

- Selector Switch for Auto – Off – Semi-auto mode selection
- Open / Close Selector Switch or Open & Close Push Buttons for operation of each filter bed valve (Soft).
- On / Off Selector Switch or On & Off Push Buttons for each of the back wash air blowers for blower operation (Soft)
- On, off and Trip Indication Lamps (hard wired) & indication at HMI/SCADA console for monitoring status of each air blower.
- Air Pressure Adequate Indication Lamp (Green, hard wired), which if ON shall indicate sufficiency of air pressure for operation of pneumatic valves and OFF state shall indicate vice versa as well as soft indication at HMI/SCADA.
- Backwash Water Adequate indication lamp through necessary level switch to be provided in back wash tank when backwash water level is above the middle level of tank liquid depth as well as soft indication at HMI/SCADA.
- Backwash Water Inadequate – Start filling indication lamp through necessary level switch to be provided in back wash tank when backwash water level is at or below middle level of tank liquid depth as well as soft indication at HMI/SCADA. This signifies that water may or may not be sufficient for complete wash of one bed.
- Backwash Not Possible indication lamp to be provided in back wash tank when backwash water level is at low level tank liquid depth as well as soft indication at HMI/SCADA.

- Filter Bed Clogged Indication Lamp on reaching the condition when LOH exceeds design / set level and ROF is below the set level indicating the choking of bed requiring backwash as well as soft indication at HMI/SCADA.
- Filter Bed In-Line or Standby selector switch. When in standby, the filter inlet valve shall remain closed isolating the filter bed (filter outlet valve shall remain open). When taken in-line, the filter inlet valve shall open and the bed shall operate as per process logic depending in the selection of operation mode.
- LOH and ROF indication at HMI/SCADA. The scope of PLC in general is to control working of entire water treatment plant including Rapid Gravity Filter Units by way of allowing operation of all pneumatically operated filter bed valves in auto mode for auto backwash or in semi-auto mode through selector switches at ICP/HMI/SCADA/JB depending on the mode of operation selected and similarly operating the clarifier de-sludging valves as well. Monitor, display & data logging and control, as applicable, various process parameters of the plant like that of inlet & outlet parshall flume flow and other flow meters as applicable, water quality analyzer (pH, turbidity, residual chlorine, DO, etc.), display/control/alarm, as applicable, the status of operation of all pneumatically actuated valves of the plant, status of level in tanks/sumps for which level instruments are provided, status of operation of electrical drives (on, off and trip) etc. Annunciation shall be provided for various alarm conditions like quality parameter, flow, loss of head/rate of flow of each filter unit, limits for backwash, drive trip status, valve failure status, process equipment status, low and high level of various sumps, low level of particular alum/poly solution tank in use at that time etc. It shall be possible to carry out backwash operation of each filter bed in fully automatic mode by sensing the required inputs from LOH/ROF indicators, fully automatic operation of all pumps / blowers / air compressors / process equipment with necessary interlocks (with on, off and trip indication), as applicable, by providing necessary instrumentation for auto operation, and also operation of valves and electric drives through various LCPs by selecting suitable mode of operation through PLC based panel.
- The purpose is to minimize human intervention and increase reliability and ease in operation of entire treatment plant. The PLC shall have necessary communication port for communication with necessary field instruments specified like LOH/ROF

instruments, analyzers, etc. as applicable. Instrument Panel / PLC Panel shall be free standing, floor mounting cabinets of Rittal / BCH / Enklotek / equi. Make. It shall refer panel specifications provided in this tender. PLC Supplier shall provide a copy of all working programs/ application program / programming codes on Compact Disk or suitable permanent media including necessary licenses where applicable (for software's specified for supply in this specifications), as well as a printed program listing. PLC supplier shall also hand over all the access passwords and the PLC Key (as applicable) for PLC/SCADA programming to client on acceptance of the system. It is clearly to be noted that all the software/ programs/ programming codes / pass word codes/PLC Key, etc. shall be the property of Amravati Development Corporation All the application programs handed over to Client shall not be password protected or requisite password shall be furnished

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auto operation, and also operation of valves and electric drives through various LCPs by selecting suitable mode of operation through PLC based panel.

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4. PROGRAMMABLE LOGIC CONTROLLERS (PLC) SYSTEM SPECIFICATIONS

Codes and Standards

PLC shall comply with International standards such as NEMA, IEC, ANSI, ISA, IEEE, DIN and VDE.

5. DESIGN AND CONSTRUCTION REQUIREMENTS

PLC H/W & S/W shall be from the same family and shall be sourced from renown Vendors/System Integrators.

Programmable logic controller (PLC) shall be microprocessor based with 32/64 bit Redundant processor and be fully programmable and capable of performing control relay logic, including timing, counting, sequencing, and interlocking to provide the required functionality.

The PLC shall be high performance processors suitable for real time process application. High inherent reliability, self-checking, error-recovery and trouble-shooting features shall be some of the features of PLC. The PLC shall have a modular / modular chassis design which allows for ease of future expansion. The processor module shall be easily removed from the I/O chassis for service or repair. The I/O chassis shall have slots for installing I/O cards, communications, or other special function modules. All I/O cards and modules shall be capable of being installed in any open slot in the chassis or shall be DIN rail mounted. Module and channel level diagnostics shall be standard feature.

The PLC shall have a suitable power supply and can be easily serviced or replaceable. The system shall be capable of being powered on 120VAC / 230VAC / 24V DC as per mfr. Std. The PLC shall be rated to operate from 0 to 60 Degrees C, with a humidity rating of 5 to 95% (non-condensing). All module circuit boards shall be encased and protected such that, when properly installed, they are not exposed to accidental contact by personnel or other

The PLC shall be of high quality and reliability with replacement processors, power supplies, chassis, I/O and specialty modules that are readily available on an urgent or emergency basis. All PLC products shall be fully supported and spares shall be available for purchase for up to ten (10) years from the date of the original system purchase.

After completion of the automation and actual plant operation starts working on PLC/SCADA System the concerned staff likely to run plant is required to be fully trained by the executer for the operating features and preventive maintenance aspects and preliminary trouble shooting methods of the offered system. This training at site shall be of one day duration which shall be attended by 4-6 persons of client to be deputed from various levels. Additionally, it shall also consider to provide class room training of required duration (up to 7 days) for up to 2 persons of SMSS at PLC supplier's /Clients training centre within the country covering the selection & programming aspects of PLC / SCADA system.

5.1 Basic Processor Functions

The system shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.

Redundant system with hot back up redundancy feature shall be built in the CPU. Software Engineer-in-Chargeed hot backup systems are not acceptable. CPU shall have the memory expansion capability up to 7 MB. Both the CPU's shall have separate backplane and associated hardware for redundancy. CPU system shall be able to communicate with GPRS Modem to communicate with Web SCADA. SCADA connectivity with the CPU will be on Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA. PLC Components like CPU and I/O modules, Remote IO Modules shall be of the same logic family. It shall take note on the importance of this obligation. The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes. The PLC system shall be expandable and shall be modular in construction, so as to capable of future expansion without hardware modifications. The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone. Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 % for each IO card. Each IO card shall be able to accept at least two more I/O cards without requiring replacement of, or additions to, the original equipment. The system shall be modular and capable of integrating into a network with Central SCADA Monitoring Centre (CSMC).

5.2 Features:

- Real-time control of output points for turning on and off digital devices such as motor starters and solenoids.
- Read the status of real world digital inputs from limit switches, float switches, and other field devices.
- Real-time control of analog process control variables.
- Read the status of real world analog set points and feedback values.
- Perform timing, counting, sequencing, and interlocking functions for pump/equipment control.

- Process local alarm handling functions
- Math and Advanced Functions
- Four function math in floating point or signed integer format
- Convert to/from BCD
- Data comparison and manipulation
- Scaling from integer data into Engineer-in-Charge units such as flow, level and pressure
- Full PID Instructions for control of process control variables such as flow, level and pressure.
- Compute Instruction which executes a mathematical expression and can be used for totalizing functions
- Trigonometric and Exponential math functions
- Real-Time Calendar Clock for time stamping alarms and events.
- Automatic restart of the system on resumption of power shall be provided.

5.3 Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in Memory Card or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup. The battery backup provided shall support the memory on loss of power. The battery life shall be at least 2 years.

5.4 I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules shall be of the same family as that of PLC CPU. It shall take note on the importance of this obligation. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. 20% extra modules of installed capacity for each type of module shall be provided as

spare. Provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity.

5.5 I/O modules shall be as follows:

- Inputs shall be optically isolated.
- filters shall be provided for noise rejection for Analogue
- output status shall be indicated by an LED
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module
- all the modules shall be of addressable type.
- Ethernet, I/O modules (If considered) shall be connected to the PLC by on board Ethernet 10/100 Base-T connection port. Ethernet, I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

1.	Discrete input/output	10	Latch/unlatch relays
2.	Analog input	11.	Counters
3.	Analog output	12.	Comparators
4.	Timers	13.	Ladder logic
5.	Pump Controller	14.	Flow Totalization/Integration
6.	Pump Alternation	15.	Intrusion Detection
7.	Mathematical Function Blocks	16.	Time of Day Control w/Lockout
8.	Stage Blocks	17.	Ramp Blocks
9.	Trending	18.	Data Logging

5.6 PLC Programming

PLC programming shall be carried using Ladder/FBD. The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance. The system shall support a simple programming of the application software comply with IEC

61131-3. The system shall support a structured, modular programming. At following standard operations are expected:

- Logic functions
- Timer functions
- Counter functions
- Skip functions
- Comparison functions
- Limit value functions
- Arithmetic functions
- Physical unit functions

It shall submit the logic diagrams for review. It shall include the as-built logic in the final submission.

5.7 Programming Unit

The programming unit shall be of the portable type, industrial model designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a CRT or TFT display.

At least the following functions is expected

- On-line programming
- Off-line programming
- Flexible corrections during input
- Full screen editing functions
- Absolute and symbolic programming
- Input of comments and title blocks for complete documentation
- Complete application software documentation functions. Printouts of application software logic functions shall preferably be in Ladder logic diagrams.
- Load and transfer functions

The computer shall be provided complete with proprietary PLC programming and SCADA software complete with plant mimics and documentation software. Communi-cation cables required to interact with the PLC, (E.g. Modbus Cable) would be supplied.

The software shall provide facilities for:

- insertion of comprehensive program subroutine and rung comments;

- search and find and search and replace ‘contacts’ and ‘coils’;
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs;
- preparation of coil and contact list and their locations and memory maps;
- upload and down load programs to the PLC on line;
- Carry out on line maintenance and fault finding on the PLC.

5.8 Supervisory Control and Data Acquisition System (SCADA/HMI)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and automatic plant control can be achieved. The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room

SCADA/HMI system would be Dual Redundant server system. The system shall be designed and implemented such that the failure of a central processor does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

5.9 Hardware

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7-layer reference model.

5.10 Computer

The computer hardware shall be of current technology at the time of installation. Standard server stations, Standard PC technology with modern hardware, Windows operating

system and data transmission over Industrial Ethernet must be used for the Engineer-in-Charge workstations.

The Engineer-in-Charge system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL etc. It must be possible to import/export messages to/from Excel and Access for simple processing. Removable memory media must also be provided for each workstation. It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline. The specs for computer hardware shown are indicative only.

It is to select the appropriate hardware to suit the process requirements and data archiving. The computer shall, as a minimum comprise of a personal computer (PC) type architecture, with IBM compatible Pentium IV based system or better, capable of running a multi-tasking real-time operating system suitable for process control applications:

- All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions.
- The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC‟s) over an RS-232/RS-485/Ethernet using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Engineer-in-Charge.
- A historical data storage system with removable media for archive and backup will be provided. The data storage system shall store alarms and events, with the time of occurrence for one month and selected analogue signals connected to the system. All alarms and events shall be archived in a first in first out buffer, for a period of 40 days.

5.11 Visual Display Unit (VDU):

Visual Display Units (VDU's) shall be color monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats.

Monitors shall simultaneously display a minimum of 256 colors, non-interlaced, low radiation, and flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less than 1024 by 768 pixels and a refresh rate of not less than 70 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LCD VDUs shall be flat screen. Minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels, 55 inch.

5.12 Printers:

- **Color Laser Jet Specifications and features:**

All-in-one functions	Print, copy, scan, fax, standalone scan-to email, photo card slots
Multitasking capability	Yes.
Print speed, black (normal quality mode)	Up to 21 ppm
Print speed, color (normal quality mode)	Up to 21 ppm
Print speed footnote	Exact speed varies depending on the system configuration, software program, and document complexity.
First page out (color)	As fast as 17.9 sec
Monthly duty cycle	Up to 40,000 pages
Footnote for duty cycle	Duty cycle is defined as the maximum number of pages per month of imaged output. This value provides a comparison of product robustness in relation to other LaserJet or Color LaserJet devices, and enables appropriate deployment of printers and MFPs to satisfy the demands of connected individuals or groups.
	Paper Heading:
Paper handling standard, input	50 sheet multi-purpose tray 1, 250-sheet input trays 2 and 3, 50-sheet ADF
Paper handling standard, output	150-sheet face-down output bin
Envelope capacity	Up to 30 envelopes
Envelope feeder	No
Duplex printing (printing on both sides of paper)	Automatic (standard)

Document finishing	Sheet fed
Media sizes, standard	Letter, legal, executive, envelopes (No. 10, Monarch)
Media sizes, custom	Tray 1: 3 x 5 to 8.5 x 14 in; Tray 2, Tray 3: 3.94 x 5.83 to 8.5 x 14 in
Media types	Paper (bond, brochure, colored, glossy, letterhead, photo, plain, preprinted, prepunched, recycled, rough), transparencies, labels, envelopes
Media weight	Tray 1: 16 to 47 lb (up to 58 lb with Color Laser glossy photo papers); tray 2, tray 3: 16 to 43 lb (up to 47 lb with postcards, up to 58 lb with Color Laser glossy photo papers)
Weight	71.2 lb
Processor speed	450 MHz
Memory, standard	160 MB
Memory, maximum	416 MB
	Scanner Specification:
Scanner type	Flatbed, ADF
Scan resolution, optical	Up to 1200 dpi
Bit depth	42-bit
Scan size, maximum (flatbed)	8.5 x 11.7 in
Scan size, maximum (ADF)	8.5 x 14 in
Scan speed (default)	Up to 15 ppm
Automatic paper sensor	No
	Copier Specification:
Copy speed (black, best quality, A4)	Up to 20 cpm
Copy speed black (best, letter)	Up to 20 cpm
Copy speed color (best, letter)	Up to 20 cpm
Copy resolution, black	Up to 600 x 600 dpi
Copy resolution, color	Up to 600 x 600 dpi
Copy reduce/enlarge settings	25 to 400%
Maximum number of copies	Up to 99 copies
	Fax Specification:

Faxing	Yes
Fax transmission speed (seconds per page)	3 sec per page
Fax memory	Up to 250 pages
Fax note	Based on standard ITU-T test image #1 at standard resolution. More complicated pages or higher resolution will take longer and use more memory.
Fax resolution, black (dots per inch)	Up to 203 x 196 dpi
Speed dials, maximum number	Up to 120 numbers
Auto redial	Yes
Fax delayed sending	Yes
Fax broadcast	119
Junk fax barrier	Yes
Polling	Yes (receive only)
Remote retrieval	No
Fax forwarding	Yes

6. Central SCADA/HMI Application:

The central SCADA/HMI shall comply to the below mentioned specifications:

6.1 INDUSTRY STANDARDS:

The system is expected to comply the industry standards, but not limited to:

- ODBC
- OLE
- ActiveX
- COM/DCOM
- DDE and Advance DDE
- Microsoft Windows 7/windows10
- TCP/IP
- OPC DE
- OPC Alarm and Events (A&E)
- XML

- .NET

6.2 Graphical User Interface for WTP SCADA:

- The editing package shall include a Wizard / Symbol / Object Library to permit the inclusion of pre-developed or third party graphic objects.
- The editor shall include a utility or tool for determining which points are referenced in a screen, which objects reference them, and which points are not currently defined or known to the software. This tool shall also include provision to search and replace point names - for both single objects and groups of objects.
- Graphic objects on these screens can be linked by name to actual device and virtual data through the distributed point database, direct OPC-DA, and Historical expressions in either a real time or historical sense.
- The software shall support the following dynamic attributes:
  - ✓ Annunciation, movement, blink, rotation, and fill (uni-directional and bi-directional)
  - ✓ Gradient fill
  - ✓ Object border animation
  - ✓ Object visibility
  - ✓ Blink fill and blink rate
  - ✓ Transfer tags for screen transfer or popup windows
  - ✓ Procedure tags to invoke user defined scripts/programs
  - ✓ Object and or application help screens
  - ✓ Alarm information
  - ✓ Trends charts
  - ✓ Set point tags for point value changes
  - ✓ Animated frames that can include other graphic objects
  - ✓ Zoom to Best Fit, Resize Window to Zoom
  - ✓ Manual and automated rubber band zooms
  - ✓ Automatic font scaling when changing window sizes
- Graphic objects shall include:
  - ✓ Embedded OLE, including ActiveX objects, sound, video, clip art, spreadsheets, etc.
  - ✓ SPC charts

- ✓ Trend charts
- ✓ Historical Data displays
- ✓ Alarm displays
- ✓ Arcs
- ✓ Lines
- ✓ Circles
- ✓ Ellipses
- ✓ Lines
- ✓ Polylines
- ✓ Polygons
- ✓ Rectangles
- ✓ Text strings
- ✓ Buttons
- ✓ 3-Dimensional Piping creator

- Graphics screens shall support compliant scripting language. The graphical editor and viewer shall be capable of being an ActiveX container and shall support ActiveX "methods". The methods may be used by the compliant scripting language.
- The graphical interface shall have historical playback and review capabilities. The user shall be able to select a period of time and then replay the graphical screens and watch the process parameters change on the screen in replay mode.
- The graphical runtime shall be able to optimize the display using anti-aliasing.
- The handling of graphic images shall be such that they can be scaled without distortion.

The software shall provide the following defined user access levels as a minimum and additional levels as instructed by the Engineer-in-Charge:

- **Default level**:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

- **Operator level:**

The operator level shall permit authorized users to access default level activities in addition to the following:

- ✓ Perform control actions;

- ✓ Acknowledge alarms;
- ✓ Enter or modify manually entered data for inclusion into reports.

- **System manager level:**

The system manager level shall permit authorized users to access default level and operator level activities in addition to the following:

- ✓ Modify alarm and control set points, dead bands and time delays;
- ✓ Enter or modify historical data;
- ✓ Add, delete or modify individual I/O points or point attributes;
- ✓ Add, delete or modify field device configurations;
- ✓ Create, delete or modify control algorithms;
- ✓ Create, delete or modify graphic displays;
- ✓ Create, delete or modify system reports;
- ✓ Configure trend displays;
- ✓ Access the operating system;
- ✓ Assign access levels and user passwords;
- ✓ Perform any other system maintenance function

6.3 Web Technology

- The Central Control room shall also consist of Web Clients capable of displaying entire data right from Intake well to water supplied to end user.
- The web-clients shall be available without a need to load any additional client software on the user's PCs.
- Users must be able to view the information as well as with sufficient password protection, enter or modify information of Pumping station and Distribution Network.
- In addition, the software shall provide the ability to view point and alarm reports in excel, pdf format in standard web browsers.
- The web server software shall allow for point data to be transferred between servers across the Internet with proper security.

The Web SCADA at Central Control Room shall provide following features:

- Displaying the entire pumping station data such as Pump health, ON/OFF status, flow rate and Pressure, total time of operation, Electrical parameters.

- Displaying the entire data from Tapping Points, Water Distribution Centers, District Outlets, Air-Valves, Surge Protection System, and Water Meters etc.
- Control of all the Pumps, Valves, Tapping Points, Water Distribution Centers & District Outlets etc.
- Display the communication healthiness of field units and PLC System
- User will be able to change valve operation timings from the graphical screens.
- Control center shall be capable of Downloading data to FCU Units and Uploading data from the FCU Units.
- Control Center will have a program to design and display an event report for each Pumping Station and Distribution water network.
- Printer interface facility for printing report.
- The user shall be able to define all field Units and their associated configurations,
- The user shall be able to define all software application functionality and download (send) the data to the field units, in order for them to perform the on-site function.
- The user will be able to upload the existing data from the field units in order to monitor the entire system.
- The Control Centre shall provide the ability for the user to "zoom in" to the level of single element characteristics (i.e. Input/Sensor, Output/Valve etc.) at each site.
- The user can able to monitor site conditions like inside, Battery Voltages, GSM/Radio signal strength.
- The user can able to monitor the Panel door status at central.

6.4 Redundancy for WTP SCADA

- The system must support software based redundancy solution as well as hardware dependent, high availability architectures as well.
- Redundancy applies to both hardware and software, and implies minimal loss of continuity during the transfer of control between primary (active) and redundant (backup) components.
- The system shall support Server Redundancy.
- Server redundancy involves a primary factory monitoring server and a redundant "Hot Standby" server. The redundant server is essentially a mirror image of the primary server, running alternate monitoring/control processes and applications.

- Data collection is performed via independent or shared network paths to the same devices, depending on the protocol.
- Upon detection of failure of the primary server, the secondary server can assume control of data collection, alarm functions, applications, and allow user access with minimal loss of continuity. When the primary server comes back on line, control can be transferred back, and the secondary server will resume its backup role.

7. SCADA ROOM POWER & UPS:

The SCADA room processor(s), Monitors, logging printer and communications equipment shall be powered through an uninterruptible power supply (UPS) via a dedicated distribution system. The UPS shall provide for full functioning of this equipment for a minimum of four hours in the event of a power failure. UPS capacity shall be oversized in terms of rating and power duration by 100% to provide for future additional equipment. UPS batteries shall be sealed lead acid maintenance less type.

The UPS distribution cable sheaths shall be of a color which distinguishes them from other service cabling. Each master station device shall be provided with a local isolating device such as a fused spur or switched socket outlet.

- **Master Control Room Furniture:**
- **Control Command Centre (C3) at WTP:** Main control command centre located at WTP, shall collect the data of from Intake well to all WDCs shall monitor on Video wall and control. Provision need to be made connecting to C4 (City control command centre). It shall comprise of Engineer-in-Charge station, historian station along with real time data acquisition server.
- control command centre (C3) located at WTP, shall collect the data from Intake well, Raw water raising main, WTP, Clear water pumping station, Clear water pumping main, WDCs shall monitor on 2 Nos 90" Video wall & control, CC footage of WTP. Provision need to be made connecting to C4 (City control command centre). It shall comprise of Engineer-in-Charge station, historian station along with real time data acquisition server
- Control command centre (C3) room shall consist of Reception furniture, visitors lobby, visitor seating furniture, 3 operator work station, 3 nos Engineer-in-Charge

work station, announcement facility, two nos 90” inch video wall (16:9 ratio), false ceiling interior, glass patrician between visitor lobby and video wall station.

- Video wall: Advance technology with various content, IP camera, and multi-PC playback with scheduling, display upto 250, linear and asymmetric, Scheduled play, Multiple aspect ratios, Full HD on every screen, Display multiple sources, Display images across single or multiple screens, HDCP support, Image rotation, Remote monitor management, Live camera and PC feeds,
- Connectivity Technology: Set Back Box (SBB) for each display, Magic Info Player I & Network switch/LAN/Gb Ethernet
- In addition to the SCADA/HMI system equipment, it shall provide furniture (system console) to complement or match both the color and styling of the equipment. Control room furniture shall comply with relevant IEC standards for ergonomic design. Details of the control room furniture shall be submitted to the Engineer-in-Charge for approval.

It shall provide 6 fabric-covered upholstered swivel-type adjustable arm chairs with casters for Engineer-in-Charge and operators, 6 nos laptop for work station, 9 seats sofa and glass top table, carpet flooring in visitor lobby, receptionist table with swivel-type adjustable arm chairs, a rigid and lockable steel cupboard for the storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like.

The visual display unit consoles or VDU desk shall incorporate at least one drawer unit with drawers for operators use and for standard files.

Laptops Configuration for Portable Programming Unit & Administrators, Engineer-in-Charges Usage:

Latest operating system software that shall be compatible with all Engineer-in-Charge Software's including Automation Software's

Intel Core i7 (3.4 GHz/2.4 GHz)

Turbo Boost Technology

4 GB GDDR5, 4 GB RAM & 1

8. FIBER OPTIC CABLE

8.1 Scope:

This specification defines the minimum requirements on manufacturing, installation, splicing and testing and delivery of the fiber optic cable to be used for the “AMARA-VATI CAPITAL CITY Project". The cable shall serve as the transmission medium for a fiber optic data transmission system between Raw water, WTP, Clear Water Pumping Stations, WDC’s and the Master control room building. For the laying of the fiber optic cable, the HDPE conduit and the data transmission system reference following section” Fiber Optic Cable Conduit and FOC Installation”

8.2 Codes and Standards:

The manufacturing, construction, labeling and testing of the fiber optic cable system shall meet the requirements established in the following codes, standards and recommendations and in the enclosed data sheet.

8.3 Standards for Cable:

- Optical fibers
- ITU-T G.652 characteristics of a Multi-mode optical fiber cable, and/or IEC 60793-1-1 optical fibers - generic specification IEC 60793-2 optical fibers - product specifications
- Fiber optical Cable
- ITU-T L.10 Optical fiber cables for duct and tunnel application, and/or IEC 60794 -1

Optical fiber cables - generic specification IEC 60794 -2 Optical fiber cables - indoor cables IEC 60794 -3 Optical fiber cables - outdoor cables.

8.4 Standards for Measuring Methods:

IEC 60793-1-2 Optical fibres – generic specification – measuring methods for dimension IEC 60793-1-3 Optical fibres – generic specification – measuring methods for mechanical characteristic

IEC 60793-1-4 Optical fibres - generic specification - measuring methods for transmission and optical characteristic

IEC 60811 Common test methods for insulating and sheathing materials of electric and optical cables.

8.5 Other Standards:

ITU-T K.25 Protection of optical fibre cables IEC 60304 Standard colours for insulation for low-frequency cables and wires wherever codes, standards and recommendations are mentioned, the latest published revision or issue shall be applicable.

8.6 Transport, Unloading and Storage:

All of this material shall be brought on site, unloaded and stored (if necessary) in such a way that damages are avoided. Storage supports and stacking heights must be selected in such a way that steady deformations of the cable conduits are avoided. Drums shall be secured against roll off.

8.7 Fiber Optic Cable:

The fiber optic cable will be laid in a buried cable conduit. A fully dielectric fiber optic cable, suitable for ducted or direct buried applications, filled with compound to prevent axial and longitudinal ingress of water and / or soluble chemicals throughout the cable shall be provided. The cable shall have loose tubes as secondary coating of fibers. The cable length to be supplied shall be either 1,000 m or 2,000 m per drum, depending on the actual required total length.

Traction elements shall be made out of Kevlar or equivalent. The allowable tensile loading of the cable shall be 2.500 – 3.000 N, suitable for direct blowing or pulling the cable into cable ducts.

The outer cladding of the cable shall consist out of black PE. Other color coding and labeling of the particular cable components shall be according to IEC 60304. The color-coding system shall be discernible throughout the design life of the cable. Cable markings shall be printed on the outer fiber cable jacket. The markings shall be permanent, insoluble in water and be legible for the duration of cable life. The markings shall be printed at intervals of not more than 2 meters.

Optical Fiber racks:

Optical Fiber racks shall be installed in all the network and PLC panels, which shall contain pigtails and output connector. Optical fiber cores shall be spliced to join with pigtails so that the corresponding output connector can be utilized for the corresponding local panel.

8.8 Tests:

Factory Acceptance Test

Each particular cable length shall be factory acceptance tested and shall be delivered together with the respective test reports.

a. Attenuation tests of each fiber at 1.300 +30/-15 nm and at 1.550 +30/-70 nm with OTDR according to IEC 60793-1-4 double-sided shall be performed.
b. Dispersion tests of each fiber at 1.300 and 1.500 nm according to IEC 60793-1-4 shall be performed.

These measurements shall be performed on each fiber prior to cable manufacturing and on the fabricated cable. Tension and temperature test of the fiber optic cable, as homologation test and determination of resulting attenuation and variation in attenuation according to IEC 60793-1-4 shall be performed. Prior to the factory acceptance test the Agency shall provide a test procedure which is subject of approval by the owner's Engineer-in-Charge.

Receipt of Cable Test:

Each particular cable length shall be tested upon receipt on site. Attenuation tests of each fibre at 1.300 +30/-15 nm and at 1.550 +30/-70 nm with OTDR according to IEC:60793-1-4 double-sided shall be performed. Determination of optical length shall be performed.

8.9 Test protocols:

Test protocols shall be provided for all activities conducted in course of tests.

Proposal Documents:

The following documents shall be provided with the bid:

a. Delivery time schedule

b. Filled in cable data sheet

c. Additional technical data of offered cable

Delivery Documents:

The documents to be provided per cable drum shall comprise:

a. Drum number b. Manufacturer c. Cable type

d. Cable length

e. Data sheet

f. Results of FAT

Documents before FOC Installation:

Before commencement of the FOC laying works the tests to be performed after cable receipt must be available and must prove that the cable is faultless. For tests after laying and splicing reference is made to the Specification of section “Fibre Optic Cable Conduit and FOC Installation”.

9. FIBER OPTIC CABLE CONDUIT AND FOC INSTALLATION

9.1 Scope

This specification defines the general requirements for the fiber optic cable conduit to be used for the “AMARAVATI CAPITAL CITY Project". In addition the several accessories and the FOC installation, including splicing and testing is defined herein. The cable conduit shall be used for blowing in the fiber optic cable, which is defined in the Specification of section “Fiber Optic Cables”.

9.2 General

The fiber optic cable shall be laid in buried cable conduit. The conduit shall be supplied by the station Agency, and laid between the electrical buildings of the wastewater pumping station and the control building. The FOC will be installed after backfilling and removing of all heavy machinery by the cable blowing method.

9.3 Codes and Standards

The manufacturing, delivery, installation and testing of the cable Conduit shall meet the requirements established in the following codes and standards:

ISO 161-1 Thermoplastics Pipes – Nominal Diameters; Nominal Pressures

ISO/DIS 1167 Thermoplastics Pipes – Resistance to Internal Pressure – Test Method

ISO/DIS 2505-1 Thermoplastics Pipes-Longitudinal Reversion-Determination Methods ISO/DIS 2505-2 Thermoplastics Pipes-Longitudinal Reversion-Determination Parameters ISO/TR 10358 Plastics Pipes and Fittings-Combined Chemical Resistance Classification Table

DIN 8074 Polyethylene (PE) - Pipes PE 63, PE 80, PE 100, PE-HD Dimensions

DIN 8075 Polyethylene (PE) Pipes General Quality Requirements

Wherever codes, standards and recommendations are mentioned, the latest published revision or issue shall be applicable.

9.4 Transport, Unloading and Storage

All of this material shall be brought on site, unloaded and stored (if necessary) in such a way that damages are avoided. Storage supports and stacking heights must be selected in such a way that steady deformations of the cable conduits are avoided.

9.5 Cable Conduit

The cable conduits shall especially be suitable for blowing in fiber optic cables and shall reduce the friction and abrasion of the fiber optic cable during the installation process to a minimum. The inner surface of the cable conduit shall therefore provide optimum sliding characteristics achieved by longitudinal rills.

9.6 Enclosures

Direct buried splice closures shall be used for straight through splicing and branch splicing of single mode fiber cables. The splice closures (loose buffer tube with central strength member) shall be suitable for a single mode fiber optic cable according to the Specification of section "Fiber Optic Cable

In general, the enclosures will be used to splice one (1) fiber cable but shall have the capability of splicing additional branch cables whenever the need arises. The following minimum functional requirements shall be provided:

a. Mechanical protection of the splice
b. Accommodation for redundant fibres
c. Termination of the Fibre Optic Cable

The dimension of the concrete shafts shall be designed in this way that the cable loop and the enclosures at a splicing point can be laid without to under-run the minimum allowable bending radius of the fibre optic cable.

9.7 Optical Distribution Frame

The termination of each fiber in transmit and receive direction shall be provided on an optical distribution frame (ODF) for access to the transmission equipment. The ODF for receive and transmit direction shall be dimensioned in accordance to the specified number of fibers referring to the Specification of "Fiber Optic Cable" plus additionally 20% of spare capacity. The ODF are to be installed in termination cabinets, which may be combined with the communication system.

9.8 Marker

Buried passive markers (Ball EMS) shall be used.

9.9 Warning Tape

A detectable reinforced underground marking and warning tape shall be laid in the ground approx. 30 cm above the protection conduit.

9.10 Patch Cords, Pigtails, Optical Plug Connection

The patch cord consists of a single phase fibre optic cable with plug connections on both ends. Pigtails are fibre cables pre-assembled with a connector at one end. The optical plug connection consists of a plug and an adapter for the connection with a further plug. All connectors must be from the same type as the connectors of the tele-communication system. The fibres of the patch cords and pigtails shall be according the specified fibres in the Specification of section "Fibre Optic Cable". All Component shall have a service life of more than 15 years with a minimum of contact durability of 1000.

9.11 General

The cable shall be laid with a minimum of splicing joints, if possible without any joint. The cable laying shall be started after the cable conduit has been installed and tested (calibration and pressure test) successfully between two points of cable termination. After the cable conduit has successfully been tested and the trench surfaces have been reinstated, the fibre optic cable will be blown in, respectively pulled in at difficult sections.

9.12 Laying Procedure

The cable shall be laid in buried conduits. The laying process has to be in compliance with cable manufacturer's recommendation (tensile load rating, pulling force, crushing force, minimum allowed bending ratings, minimum outdoor laying temperature, etc.). The use of additional lubricants during the cable installation shall be avoided. At difficult sections (e.g. road crossings) is will be allowed to pull the cable, if the requirements mentioned above are considered. At cable joint points a surplus cable of approx. 10 m shall be provided for splicing. After splicing the surplus cable shall be coiled up. The surplus cable and the enclosure shall be installed in a prefabricated concrete shaft. Markers shall be used to locate the position of the concrete shafts.

9.13 Cable Laying Inside Buildings

Inside buildings the fiber optic cable shall be laid on cable trays or ducts. The fiber optic cable shall be tied-in, laid, terminated and relieved from strain applying all applicable regulations. Grommets through walls and floors required in course of the cable laying shall be opened and closed under consideration of fire safety regulations.

9.14 Cable Splicing

The splices shall be produced by use of fully automatic splicing devices applying fusion splicing technology.

The splicing shall be conducted with the procedure outlined by the manufacturer of the equipment with a particular emphasis on cleanliness.

For fiber optic cable connection only electric-arc fusion splicing is acceptable. Only for test purposes (e.g. receipt of cable testing) mechanical splicing is allowed. Each single splice shall not introduce to the fiber an attenuation exceeding 0.1 dB. The splices shall be accommodated in splicing enclosures. At cable joint points all fibers of the fiber optic cable shall be connected through by splices. All fibers of the cable tied-in to a station shall be spliced in a fiber optic terminal box with splicing modules. All fibers shall be spliced to pigtails which shall be terminated on an optical distribution frame with optical connectors providing access for a data transmission system to the optical fibers. The fiber optic terminal box and the optical distribution frame shall be housed in the cabinet for the data transmission system. All spare and standby fibers terminated at the optical distribution frame shall be connected through by patch cords.

9.15 Connectors

The connecter loss shall not exceed 0.5 dB per connecter.

9.16 Tests

- **Installation Test**

The SubAgency has to perform immediately after a cable is installed a rough optical time domain reflectrometer (OTDR) test just to verify if a cable damage has occurred during the installation.

- **Splice Test**

A unidirectional OTDR-testing shall be performed after a splice is done.

- **Acceptance Test**

After laying, installation, splicing and termination of each cable section the following tests shall be performed on each fibre:

a. Attenuation tests of each fibre at 1.300 +30/-15 nm and at 1.550 +30/-70 nm with(OTDR) IEC 60793 double-sided.
b. Attenuation tests of each fibre at 1.300 nm and at 1.550 nm with optical power meters single-sided.

Having identified which splices have a loss exceeding the criteria, the next step is to re- burn these splices to reduce the loss. Only if the measurements confirm that all splices, terminations and attenuations of the several cable sections are according to the cable/termination specification of manufacture and to this specification a cable section can be completed.

- **Test Protocols**

Test protocols shall be provided for all activities conducted in course of tests.

9.17 Proposal Documents

The following documents shall be provided with the bid:

a. Technical data of offered conduit
b. Requirement for the laying of offered conduit
c. Examples/data sheets for enclosures, concrete shafts, ODFs and markers

9.18 Design Documents

Following approved design documents are necessary for the installation of the cable conduit and the fiber optic cable:

- General documents
- Cable laying method statement
- Cable installation procedure
- Cable splicing method statement
- Drawing and document schedule (or part of an overall schedule)
- Time schedule (or part of an overall schedule)
- Power budget calculation
- Data sheets and sketches
- Enclosures data sheet

- Concrete shaft data and sketch
- ODF data sheet
- Marker data sheet and sketch
- Pigtails and patch cord data sheets
- Optical plug connection data sheet
- Drawings
- Interconnection diagram, terminal block diagram, distribution board schedule (ODF)
- Splicing location sheet

9.19 Documents for FOC Installation

Following documents are necessary for the Laying of the FOC:

a. Results of the test after receipt of FOC
b. Results of the calibration test

9.20 As-built Documents

The as-built documents to be provided Comprise:

a. Latest revision of all design Documents
b. Laying records
c. Splicing table and drawings with the coordinates of the splices
d. Test reports

Overall system architecture shown below of Amravati Capital city depicts complete system flow right from Intake pumping station to consumer level. It displays complete data of all pumping station and Distribution network in the center. Network including Raw Water, WTP, Clear Water Pumping Station and Water Distribution Centre are interconnected using Optical Fibre as primary communication media while wireless communication shall be secondary. This provides quick action over interdependency between Pumping station, WTP and WDC's. Data from all the Stations and Distribution outlets shall be available at Central Control Room.

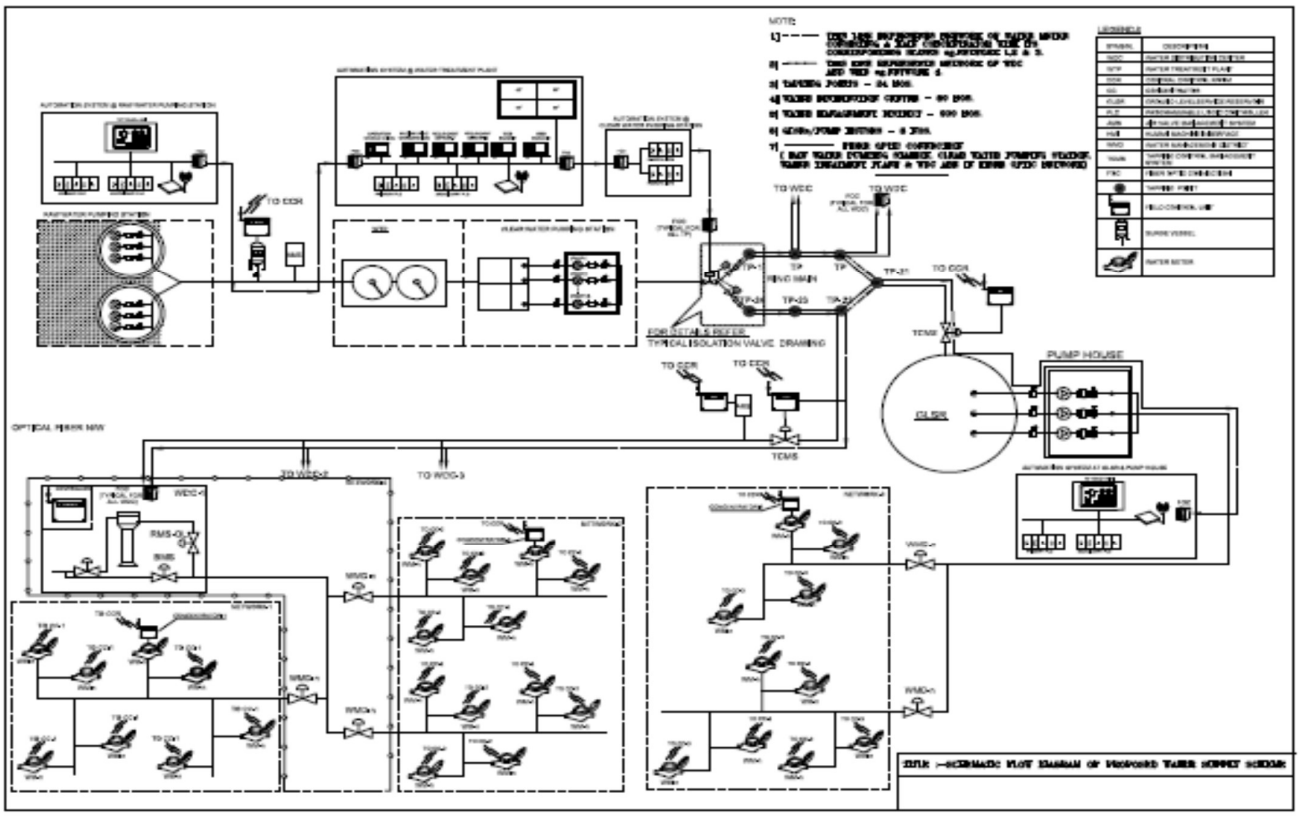

Figure 3: System Architecture: (Drawing to be separate for P& ID, System Architecture)

9.21 Detailed Specifications for Instruments:

Pressure Indicators:

Direct reading, pipe mounted Pressure gauges of Stainless Steel with 6-inch phenolic dial (white dial with black numerals), 316 SS Bourdon tube, nylon movements and micrometer type adjustable aluminium pointer with accuracy of +/-1% of span including accessories like siphons for steam services, snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services and name plate, etc. Material of accessories shall be SS. IP65 degree of protection for enclosure. Over range protection shall be 50% above maximum pressure. Armoured capillary of 15 M shall be provided as required.

Pressure Switches/ DP Switches

Non-indicating type, field mounted Pressure Switches of aluminium casing (epoxy coated), and 316 SS element and accuracy of +/-1% of span, including accessories

like snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services, name plate & mounting brackets. Material of accessories shall be Auto reset micro switch with internal adjustment for set values with 2 SPDT contacts rated for 0.2 A at 220 V DC. IP 65 degree of protection for enclosure. Over range protection 50% above maximum pressure. Scale for setting shall be provided.

Temperature Indicators (Thermometers)

Thermometers shall be Industrial type, Bi-metallic for low temperature applications (<80^{O} C), inert gas actuated vapour pressure type for above 80^{O} C of SS bulb and capillary. Body material-Die-cast aluminium. Dial size-150 mm with white dial and black numerals and process connection-1/2''NPT (M). Accuracy-+/- 1% of span. IP65 protection class. Accessories include nameplate, mounting brackets and SS Thermowell. Thermowell process connection- M33X2 and 1/2''NPT (F) on thermowell for thermometer.

Thermowells

Pipe/ equipment mounted temperature test wells of 316 SS with a process connection of M33x2 thread and instrument connection of ½" NPT (F) in general or 150 RF flanged. Accessories like name plate, plug with chain, etc. shall be provided. Material of accessories shall be SS. Thermowell shall be hex head of barstock assembly. In case flanged wells are required for any specific application, the same shall be supplied as required. The thermowell construction shall meet the ANSI 19.3 (latest) requirements. Thermowell shall be designed such that the resonant frequency is above the exciting frequencies generated by vortex shedding in the process fluid. All Test thermowell shall have the plug of SS316. IBR certification as applicable shall be provided.

Temperature Elements (RTD)

Duplex type, PT – 100, with accuracy of +/-0.5% of span, response time 1-2 seconds; Spring loaded mineral insulated three (3) wire RTD assembly with 316 SS Thermowell housed in aluminium casing (epoxy coated) having a process connection of M33 x 2 thread and instrument connection of ½" NPT (F) in general or 150 RF flanged. IP 65 or equivalent degree of protection for enclosure. Material of accessories (name plate, etc.) shall be SS. Thermowell with hex head with screwed cover & SS chain, barstock assembly. Element lead size shall be 18 AWG. The insulation resistance at

540 Deg C shall not be less than 5M ohms. Repeatability over full range shall be better than 0.02%. RTDs shall be ungrounded. RTD shall be supplied as an assembly complete with thermowells meeting ANSI 19.3 (latest) requirements.

Level Gauges

Tubular/ float type level gauges with brass guard rods & brass holders shall be provided. Material of float & float chord shall be 316 SS & cage materials shall be fabricated steel and the material of accessories (name plate, etc.) shall be SS. IP65 degree of protection for enclosure. Connection shall be screwed or flanged (ANSI class 150 RF).

Level Switches

Top mounted float type level switches for water tanks/ sumps shall be supplied with still tubes to suit the requirement. Micro switch with 2 SPDT contacts rated for 0.2 A, 220 V DC. Material of float & float chord shall be 316 SS & cage materials shall be fabricated steel and the material of accessories shall be SS. IP65 degree of protection for enclosure.

Accessories like name plate, drain valve for external case type level switches, mating flange, gaskets (asbestos), fasteners, bolts & nuts, etc. shall be supplied.

System/ Marshalling Cabinets

These cabinets shall house signal-conditioning cards, input/ output cards, processor cards & associated power supply units. Indoor located, free standing vertical type system cabinets with IP-42 enclosure and with 3 mm thick sheet metal of cold rolled steel; double doors with neoprene gaskets; anti-vibration pads of 15 mm thick; blower louvers in each cabinet with brass mesh; fire proof compound (50 mm thickness) for sealing cable entry (bottom); fire detector for each cabinet. Beacon lamp shall be provided in each cabinet to indicate the cabinet having fault condition. The colour of the cabinets shall be indicated at detailed Engineer-in-Charge stage. Doors shall have concealed type of hinges and swing of 100^{O}. The doors shall be provided both at the front and rear. Power supply distribution shall be provided on per cabinet basis with all associated MCBs, protections, etc. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless-steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots details of the card type/ service shall be inscribed on this metal tag.

Each cabinet shall be provided with one each 3 pin receptacles for 220 V AC, 1¢, 50 HZ and for +24V DC. Cabinet shall be delivered totally wired. All electronics shall be mounted & wiring connections at these hardwares shall be terminated by Bidder. Quantity shall be as required. All cabinets shall have common key for the locks. In each cabinet, a 24 V DC Voltmeter shall be provided to check the Field Interrogation voltage.

9.22 Flow Meter:

Electromagnetic Flow Meter of appropriate size shall be installed at the end of the manifold to measure the quantity of water discharged in to the Distribution Chamber. Full bore electromagnetic flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter and flow indicator and integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer and in line with the applicable standards. Agency shall finalize the exact location of flow meter in consultation with Representative of Authority.

Flow measurement shall not be affected by physical properties of water viz., temperature, pressure turbidity etc., within given limits. Agency shall provide compensating Electronic circuits, if required.

A lockable enclosure shall be provided for the flow transmitter cum computing unit, if required.

Flow meters shall be suitable for the water turbidity at site during various seasons. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow tube shall have waterproof construction and shall be suitable for installation on underground /above ground pipe lines.

The flow computer and transmitter shall be a single unit suitable for panel mounting. It shall accept inputs from flow tube, process the signals and shall provide an output proportional to the flow rate. The distance between transmitter and flow tube shall be maximum 250 mtrs. Taper pieces required for installation of flow meter shall not exceed an angle of 8° in order to avoid disturbance in flow profile.

a. General:

i. Accuracy of flow measurement during FAT ±0.5% of measured value

ii. (ii) Overall accuracy of flow measurement loop ±1.0 % of measured flow

b. Flow tube

i.	Application	:	The water pumping mains
ii.	Type	:	In line full bore electromagnetic
iii.	Size of flow tube	:	As approved by the Authority.
iv.	Process connection	:	Flanges as per BS 4504
v.	Weather Protection Class:		IP 68 as per IS 13947
vi.	Surge protection devices (SPD) between flow tube and flow transmitter	:	Required for protection from lightning surges

vii. Material of Construction:

Electrodes	:	SS 316, self-cleaning pipe
Coil Housing	:	carbon steel coil housing
Flanges	:	Carbon steel
Grounding ring	:	SS 316

viii. Flow tube Lining: EPDM/Neoprene/PTFE.

c. Flow Transmitter Unit

i.	Type	:	Microprocessor based with facility to configure the ranges.
ii.	Type of display	:	4-digit backlit LCD/ LCD, for flow rate in m3/hr.
	8 digit		Backlit LCD/ LCD for totalized flow in ML
iii.	Units of display	:	Flow rate -m3 / hr Totalized flow – ML
iv.	Input	:	From flow tube
v.	Output	:	4-20 mA DC (isolated) proportional to flow rate
vi.	Power Supply	:	230 VAC
vii.	Zero and Span Adjustment:		Required
viii.	Weather Protection Class:		IP 68 as per IS 13947

ix. Battery backup for totalized

Flow Type	:	Online
Capacity	:	2.5 mVA
Backup Time	:	8 hours.

x. Facility for on line diagnosis : Required

9.23 Calibration:

The Electromagnetic flow meter shall be wet calibrated for the full flow range specified as per BS EN 29104/International Standard (Methods of evaluation of electromagnetic flow meters).

The calibration method shall be either gravimetric method as per ISO 4185/International Standard (Measurement of fluid flow in closed conduits – weighing method) or volumetric method as per ISO 8316 (Calibration by Volumetric Method). The 'test bed' shall be accredited by appropriate National / International certifying authority. The Agency shall produce accreditation certificates for the test facility and calibration certificate for the flow meter for the review by representative of the Authority. The Agency shall also demonstrate complete wet calibration on the test bed in the flow meter laboratory. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

Flow Indicator and Integrator

Flow indicator and integrators shall be modular in design. It shall consist of two separate dedicated displays for flow rate indication and total flow indication. It shall accept 4-20 mA DC isolated input. The flow integration shall be carried out in the Programmable Logic Controller (PLC). The flow indicator cum flow integrator shall provide 4-20 mA retransmission output proportional to flow rate.

Sl. No.	Details	Description
1	Type	Microprocessor based
2	Mounting	Front facia of Control Panel
3	Display	Digital, seven segment back lit LCD / LED display
4	Digit Height	14 mm or Higher
5	No. of Digits for Flow indicator Flow integrator	 4 Digits 6 Digits
6	Input	4-20 mA DC (Isolated) from flow transmitter through analogue signal multiplier (Refer Note 2)
7	Zero and span adjustment	Required

8	Manual Reset Facility for flow integrator	Required (shall be password protected)
9	Engineer-in-Charge units: - Flow rate indicator - Flow integrator	 Cum/hr ML
10	Battery backup for integrator	Required
11	Retransmitted output	4-20 mA proportional to flow rate
12	Alarm outputs	1 NO + 1 NC for high and low alarms (adjustable)
13	Communication port	RS-485 (With Mod bus protocol) for interfacing with PLC
14	Weather Protection	Class IP-52 of IS 13947 Part I
15	Accuracy	± 0.25% of span or better.

Note:

Digital flow indicator and flow integrator shall be a combined unit.

Facility shall be available in the analog signal multipliers and in the flow indicator and integrator for providing excitation voltage for the flow transmitter in case of 2-wire flow transmitters.

9.24 Installation

The installation of the Electromagnetic Flow meters shall be done at the locations decided by the Engineer-in-Charge. The job covers supply of the Electromagnetic Flow meters at work site with cost of all the required material and all types of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job also covers field hydraulic testing of the Electromagnetic Flow meters after installation for the specified test pressure for the respective pipeline section.

10. PRESSURE TRANSMITTERS.

Transmitters shall be manufactured from material suitable for use with the process medium and for the site ambient conditions.

The transmitter shall be of suitable IP or as per data sheet, yoke mounting, provided with mounting arrangements suitable for minimum 2” pipe mounting. The materials of

construction shall be suitable for the local climatic conditions and where necessary suitable, weather proof enclosure with viewing windows shall be provided. Pressure sensors shall be fully temperature compensated Transmitters shall be powered by 10-30V DC with 4 to 20 mA output and SS-316L wetted parts.

11. LEVEL TRANSMITTERS/ Switches.

Suitable Level Transmitters/ Level Switches shall be supplied to measure liquid level of tanks/sump like treated water / backwash service water sump, backwash water over head tank (ESR), dirty water sump, and all alum/PAC solution preparation& dosing tanks. The purpose is to monitor tanks/sump levels locally and at ICP at main control room as well as provide low level trip for safety of pumps against dry running, start/stop of pumps in auto mode through suitable logic to be decided during detailed Engineer-in-Charge, low/high level alarm annunciation at HMI/SCADA at control room, etc. Ultrasonic level measurement shall be provided wherever necessary and based on site feasibility. The measurement shall be accomplished by using non-contact, echo time measuring equipment operating at ultra-sonic frequency.

Level transmitter shall consist of a sensor incorporating both transmitter and receiver along with integral controller or a separate control unit. Control unit shall be programmable and shall have as per data sheet.

The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be with environmental protection as per data sheet.

The transmitter shall provide 4 to 20 mA with relevant IP 65 Class protection.

Ultrasonic Transmitter for Open Channel/Rectangular Flow Measurement:

Ultrasonic transmitter shall be provided to measure each open channel/weir flow as provided for the treatment plant in Outlet of the Plant. The brief specifications in addition to above specifications shall be as under:

Type	:	Ultrasonic, fully user Programmable, microproc. based
Mode of Operation	:	Flow
Accuracy	:	± 0.25% of range OR 6 mm, whichever is greater
Resolution	:	0.1 % of range OR 2 mm, whichever is greater
Outputs	:	4-20 mA analog output proportional to flow

Programming Device In-Built in controller or Hand-held

Local Digital Display Flow in Engg. Units

Power	:	230 V ac ± 15%, 50Hz OR 24 V DC
Control Unit Protection:		IP-65 as a minimum
Operating Temp	:	0 to 50 deg C
Proc. Temp. Compensation:		Required, Built-in temp. sensor in transducer
Sensor MOC	:	PVDF or equi. suitable
Transducer Protection	:	IP-68
Transducer Cable Length:		10 m minimum
Communication Port	:	As given by manufacturer

Erection As per site requirement and directed by Engineer-in-Charge

Flume Flow (Instantaneous and Totalised) readings shall be continuously displayed locally and at PLC HMI at main control room and also at ICP (Control Panel) in main control room on panel mounted indicators/totalizers. The instrument shall be competent to perform open channel measurements for all kind of flumes & weirs.

12. ON-LINE RESIDUAL (FREE) CHLORINE MEASUREMENT SYSTEM:

Free Chlorine readings shall be continuously displayed locally and remotely at ICP at main control room.

On-line type Free Residual Chlorine analyzer shall be provided to measure free residual chlorine values in Clarified Water Outlet (Common channel to filter inlet) and for treated water at Backwash Sump / Treated Outlet Chamber after required chlorination. The specifications shall be as under:

Type	:	Microprocessor based, programmable
Measurement type	:	DPD Colorometric type
Range	:	0-10 mg/l or suitable
All wetted parts MOC	:	Non-corrosive material
AnalogOutput	:	4-20 mA proportional to residual chlorine
Contact Output	:	Min. 2 potential free changeover contacts
Local Display	:	Free Chlorine value
Accuracy	:	+ 5% of reading or better
Mtg / Sensor Holder Type:		Flow Through assembly or suitable as required (Suitable

		sampling system shall also be provided, if required)
Sensor Cable	:	included, min. 5m length or higher as suitably required

13. Power:

230 V AC, 50 Hz

Transmitter Housing: Weather proof to IP-65 / NEMA-4X as a minimum

Electrical Connection: ½" NPT

Sensor Failure Alarm: Required

Instrument Canopy: Required

FRC reading shall be continuously displayed locally and remotely at PLC HMI / SCADA and ICP (Control Panel) in main control room on panel mounted. Low / High FRC level alarm shall be annunciated at PLC / SCADA and at alarm annunciator in main control room. Real time and historical trend shall be available as per requirement. Chlorine dosing shall be shutoff on the high level of leakage of Chlorine Gas. The same shall be incorporate in HMI/SCADA through chlorine gas detector transmitter. It shall provide necessary arrangement to control chlorine dosing (pre-chlorination) in the treatment to achieve accurate chlorine dosing level in ppm at the final outlet of treatment. To achieve this, chlorinator shall be provided with auto control the chlorine dose with required control valves based for closed loop control through feedback of either (clarifier outlet FRC or Filter outlet FRC) of the FRC analyzer feedback as selected by operator at PLC/SCADA to maintain the FRC at selected location at programmed set point.

14. CABLES:

All power & control cables for use on medium / low voltage shall be heavy duty type, aluminium/ copper conductor. PVC (XLPE may also be accepted) insulated, inner sheathed, armored and overall PVC sheathed as described below.

Cables shall be sized based on the maximum continuous load current and the voltage drop. The derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other etc. shall be taken into account. Below grade cables in paved areas shall be in concrete lined trenches with concrete covers having proper slope and suitable drainage arrangement to avoid water collection. In unpaved areas

cables shall be in lined trenches or directly buries in ground. In hazardous areas trenches shall be completely filled up with sand. Concrete lined cable trenches shall be sealed against ingress of liquids or gases wherever the trenches leave a hazardous area or enter control room or substation.

The cable trenches shall be sized depending upon the number and voltage grade of cables. Where underground cables cross roadways, pipe sleepers at grade, etc., they shall be protected by being drawn through PVC sleeves/ducts or suitable RCC Pipes to provide a permanent crossing. Pipes laid for mechanical protection shall be sealed at both ends. High voltage, medium/low voltage, control and signal cables shall be separated from each other by adequate spacing or running through independent pipes, trenches or cable trays as applicable. Cable trays, racks and trenches shall be sized to allow for 20% future cables.

Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer. Cable route markers shall be installed at every 30m interval all along the routes of directly buried cable trench and also at locations where the direction of cable trench changes. All power and control cables shall be of continuous lengths without intermediate joints. Where joints are unavoidable, these shall be provided with the permission of Engineer-in-Charge. All cables shall carry tag numbers for easy identification.

In case of control cables all cores shall be identified at both sides by their terminal numbers using PVC ferrules as per interconnection diagrams.

Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every one meter. The embossing/engraving shall be legible and indelible. Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the colour of insulation with a spacing of maximum 50mm between two consecutive numbers. Colour coding for cables up to 5 cores shall be as per IS.

14.1 Laying of Cables:

Cables shall be laid on trays, in trenches, conduits, ducts as necessary. Instrument cables shall not be buried in ground as far as possible. Cable joints in instruments signal and power supply cables shall not be permitted. In case if some of the instrument cables are

to be buried in the ground, it shall be as per standard/good Engineer-in-Charge practice and shall be subject to client's/consultant's approval.

It shall also supply necessary materials such as junction boxes, glands, lugs etc. required for termination of cables. Each cable shall be terminated to individual panel/terminals box. Cable glands shall be of Nickel plated Brass and of Double Compression Weather proof type. Flame proof gland wherever required shall be with Ex (d) certification. A distance of minimum 300 mm shall be maintained between the cables carrying low voltage AC & DC signals and a distance of minimum 600 mm shall be maintained between cables carrying HT & LT cables.

Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared. All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedule. Identification tags shall be securely fastened to the cables at both ends.

Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared. All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedule. Identification tags shall be securely fastened to the cables at both ends.

14.2 Communication Cable

Suitable for supporting communication over Profibus, Serial (Modbus Protocol), Ethernet etc. as per the communication option selected for various proposed analysers, instruments, VFDs, power analysers, relays and instrument, as applicable (existing instrument / equipment where applicable shall normally be without communication port or if available shall be with Modbus, Profibus or Ethernet communication). Communication cables shall be shielded and shall be laid in PVC ducts of minimum 1" size (for buried cables) / on ducts / trays (for in air / overhead cables). It shall offer the price for various communication cable options as specified in the price bid and in case it is opting for any other communication option not mentioned there in, he shall quote the price in "Other Communication" option providing all necessary details in the technical bid. However, it shall note that selection of communication option other than those specified in the price bid are subject to review of client / consultant and client reserves to reject

the proposal without assigning 258 any reason there of in which case it shall offer instrument / equipment with communication options mentioned in the bid (Profibus, Modbus, Ethernet,). Necessary repeaters, couplers, termination kits, converters, connectors / plugs, etc. as applicable for connecting with necessary instrument / equipment shall be included appropriately based on the quantity (BOM) furnished for all instrument / equipment for proposed as well as existing instrument / equipment for necessary connection to communication network and communicate with PLC/SCADA system In general, cables for Ethernet shall be twisted pair with RJ45 connector (Specify the repeater requirement for more than 90 Mtr. Length or as per manufacturer guideline), for Modbus it shall be twisted pair, shielded cable with terminators, for Profibus-DP it shall be shielded twisted-pair line or a fiber optic cable (with transmission standard EIA RS485).

Network Cable – CAT6 UTP Cable: -

The copper cable shall either be 4-pair 100 ohms Balanced Twisted Pair cable (UTP) with rip cord and dielectric central isolation member:

The 4-pair UTP cable shall meet and exceed the following specifications:

- ✓ Shall comply to the following standards:
- ✓ ANSI/TIA/EIA-568B.2-1
- ✓ ISO/IEC 11801:2002 2nd Edition (Category 6)-IEC 61156-5 1st Edition
- ✓ LSOH: IEC 332: Part 1, IEC 754 and IEC 1034
- ✓ UL CM
- ✓ Minimum bend radius 1.00”
- ✓ 100 % of final production reels are tested to 550 MHz
- ✓ be 0.57mm (0.23 in) (24AWG) solid bare copper
- ✓ The maximum jacket diameter (for 4-pair UTP cable) shall not exceed 6.35 mm (0.25 in).
- ✓ sequential meter markings on jacket
- ✓ be appropriate for the environment in which it is installed.

14.3 Instrument Earthing:

All the non-current carrying metal parts of the electrical installation and mechanical equipment shall be earthed properly. The cables armour and sheath, electric panel boards, lighting fixtures, ceiling and exhaust fan and all other parts made of metal shall be bonded together and connected by means of specific earthing system. An earth continuity conductor shall be installed with all the feeders and circuit shall be connected from the earth bar of the panel boards to the conduit

system, earth stud of the switch box, lighting fixtures, earth pin of the socket outlets and to any metallic wall plates used. All the enclousers of the motors shall be also connected to the earthing system.

14.4 SCOPE OF WORK

The scope of work shall cover supply, laying, installation, connecting, testing and commissioning of:

- ✓ Earthing station.
- ✓ Earthing G.I/Copper strips from earthing station to equipotential bar.
- ✓ Earthing G.I/Copper strips/ wires from equipotential bar to lay feeder mains and circuit to
- ✓ connect power panels, DBs, switchboards etc.
- ✓ Bonding of Non-current carrying parts and metallic parts of the electrical installation

14.5 STANDARDS

The following standards and the rules shall be applicable.

1) IS; 3043 – 1966 Code of practice for earthing.

2) Indian Electricity Act and Rules

All codes and standards mean the latest. Where not specified otherwise the installation shall generally, follow the Indian Standard Code of Practice or the British Standard Code of Practice in absence of Indian standards.

14.6 CABLE TRAYS:

All branch cables/tubes, cables on various civil units/structures shall run on cable trays only. Cable trays shall be made out of galvanized mild steel sheets of 2.5 mm thickness. The width shall be so selected that 40-50% space is available for future use. Suitable cable clamps shall be supplied for binding cables / tubes at every 500mm.

14.7 JUNCTION BOX:

Junction Box material shall be Cast Aluminium (LM-6) only and shall be weather proof to IP- 65. Flame proof junction boxes shall be supplied with ex (d) certification in addition. The boxes shall have terminals suitable for a minimum of 4 mm2 cable termination mounted on rails. 20% spare terminals shall be supplied in junction boxes. Each

junction box shall have 10% or minimum 2nos. whichever is is a higher, spare entry of each size. Spare entries shall be provided with plugs.

14.8 Air-conditioners

All control room, SCADA Panel room, Control command Centre, VFD panel room shall provide air conditioning as per the approved heat load calculation and approved lay out.

14.9 SPARES:

Start-up spares shall be as required

Essential spares shall be supplied as detailed below:

For field instruments, air filter regulators, E/P converter and junction box and drive modules a minimum of one (1) No., or 10% of the quantity of each type and range, whichever is higher, shall be provided.

PLC System

All modules like Signal distribution modules, signal conditioning modules, I/O modules, Processor modules, Power supply modules, Network cards etc., – 10% of each type, or minimum one (1) No. whichever is higher.

Each type of fuse – 5 Nos., or 30% of each, whichever is higher.

Local Panels, System Cabinets 10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following

Fuses of each type and rating.

MCB of each type.

Terminals of each type

Male & female parts of pre-fabricates Cables – 6 Nos., of each type.

Solenoid valves (for each valve):

Coil – 2 Nos., of each rating and insulation.

Plunger – 1 No. of each type and size.

Seat – 1 No. of each type and size

Gaskets – 2 sets of each type and size.

O-rings – 5 sets of each type and size.

Diaphragm – 2 Nos., of each type and size.

Wiring, Termination & Accessories.

10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following

Fuses of each type & rating.

Miniature circuit breaker of each type & rating

Terminals of each type.

Space heater with thermostatic controls.

Fire detectors.

Blower.

Blank CD's for software back-up: 30 Nos.

Cable clamps each type.

Male & female pre-fabricated cables – 6 Nos., each type.

Spare terminal in each terminal block in all cabinets.

Spare space for counting additional terminal blocks in all cabinets.

Wiring raceways to accommodate additional 30% space of total quantity.

15. APPLICATION STANDARDS

All equipment shall comply with all applicable national and local laws regulations and standards, in addition to those listed below:

A.	ISO 9000 and 09004:		Quality Systems
B.	IEEE 587	:	Power Supply Surge Protection
C.	IEC 61131-3	:	Programming Languages for Programmable Controllers.
D.	IEC 61158-2	:	Communication Protocols
E.	ISO 9075 (BS 6964):		Structured Query Language (SQL)
F.	BS 5515	:	Documentation of Computer Based Systems
G.	BS 7165	:	Recommendation for Achievement of Quality in Software
H.	BS EN 50081	:	Electromagnetic Compatibility
I.	ISO 3511	:	Process measurement control functions instrumentation symbolic representation.
J.	ISO-OSI	:	7 Layer Communication Model
K.	IEEE 472-1974	:	Surge protection.
L.	IEC 61850	:	PLC sub-station automation protocol.

M. IEC 8705101 : Modbus protocol conversion

N. ISO 9000 and 09004: Quality Systems

15.1 Submittals

Functional Design Specification (FDS):

The Functional Design Specification (FDS) shall be submitted to the Engineer-in-Charge within 3 months on the award of the contract and approved before manufacture and purchasing commences. FDS document for STP shall be submitted within the time period indicated above. The system vendor and/or it shall include the following material as a minimum:

a. Project Overview, design concept, criteria and system architecture
b. Description of the design and design criteria.
c. Details of associated equipment.
d. Datasheets of the proposed equipment.
e. Electrical Design Specifications
f. Quality Plan.
g. Outline of acceptance test procedures (FAT & SAT).
h. Implementation program for manufacture, installation and commissioning.
i. Manufacturer's literature for each item of equipment supplied/proposed.
j. Detailed Plant screens (SCADA screens)
k. Software architecture, etc.

Note: It shall be noted that no part approval of FDS will be accorded. FDS shall be submitted in full with all details as detailed above.

15.2 Drawings and Documentation:

- Clear indication of all instruments addressed P&ID shall submit for Engineer-in-Charge approval.
- System write up architecture indicate all process shall submit for Engineer-in-Charge approval.
- Control philosophy explaining entire process from intake well to WDC shall submit for Engineer-in-Charge approval.
- PLC system configuration With Technical Literature & PLC Requirements (Refer TABLE-3)
- PLC I/O List
- G.A. Drawing for PLC cabinets

- List of Feeders with Feeder Loads for 110 V AC (UPS) power supply
- Time stamping protocol required for PLC system from GPS master clock supplied by Purchaser.
- Data sheet along with catalogues of manufacturers for all field instruments and equipment supplied by vendor.
- Junction Box Grouping Details
- Cable Schedule
- Interconnection Schedule
- Data sheet along with catalogues of manufacturers for all field instruments and equipment supplied by vendor
- QA Plan For I&C Equipment Final List of Essential Spares
- Earthing requirement for PLC system cabinets.
- All drawings of telemetry and instrumentation control and Automation (ICA) equipment shall be on A3 size sheets, with title blocks approved by the Engineer-in-Charge. Signature of the authorized representative to indicate the drawings have been checked prior to submission.
- The text of all drawings and documentation provided shall be in the English Language.
- All modifications or revisions to drawings shall be clearly indicated and the revision reference changed.

15.3 Training Plan and Manuals:

As part of the Works and before beginning training, it shall submit to the Engineer-in-Charge, 6 copies of complete operating and maintenance instructions for the system, referring specifically to the Plant. The documents will also be presented on computer disk in Microsoft Office 2003/2007 Word or latest version available for Windows soft-ware format. Each copy of the instructions shall be contained in a substantial binder. These manuals shall include but not be limited to the following information:

a. Detailed descriptions of the Plant operation and control scheme.
b. Manufacturer's original operation and maintenance procedures.
c. Complete parts list for all items of the Plant.
d. Recommended spare parts list.

e. Detailed maintenance instructions for all items as necessary to maintain the items in good working order, including all step-by-step procedures for troubleshooting and fault correction.
f. Detailed descriptions of the Plant operation and control scheme.
g. Manufacturer's original operation and maintenance procedures.
h. Complete parts list for all items of the Plant.
i. Recommended spare parts list.
j. Detailed maintenance instructions for all items as necessary to maintain the items in good working order, including all step-by-step procedures for troubleshooting and fault correction.
k. Configuration of data base, reports, logs and screen displays.
l. Data communication interface standards and protocols.
m. FBD/Ladder and control loop flow diagrams.
n. Programme user instruction for all software
o. The system shall provide on line, complete user documentation, including examples of how to operate the various modules within the system.

15.4 Commissioning

The Executor, the Engineer-in-Charge and any appropriate personnel of the Authority shall be present when the equipment or installation is tested & commissioned. Commissioning shall include operating the equipment in a variety of modes and sequences to prove its satisfactory operation, prior to commencing the formal site inspection and testing.

15.5 Instrumentation, Control & Automation Training requirements

The Executor/ system supplier shall conduct training courses for personnel selected by department. Training shall be conducted by personnel employed by the Executor/ system supplier familiar with the system supplied and who have experience and training in developing and implementing instructional courses.The executor shall arrange training for the department personnel for 5 days before the conduction of FAT. This training shall be separate from the training for department (2 sessions of 5 days each) which shall be conducted during SAT.

The entire cost of the complete training program, including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all personnel and the consultants attending the training program, shall be the responsibility of the Executor/ system supplier and shall be included in the contract price. The Executor/ system supplier shall submit information on the training program for approval, prior to shipment of the equipment. This submittal shall include a course outline; time required, course schedule, sample workbook and instructor qualification information for each level. The Executor/ system supplier shall make a workbook on each course available to every person taking the courses listed herein. The workbook shall be of sufficient detail so that, at a later date, a trainee could review in detail the major topics of the course. The training times shall be scheduled by the department in advance with the Executor/system supplier so as not to disrupt the department's ability to operate the plant.

15.6 Operations and Maintenance Training

Training shall be provided for ten (10) of the department personnel at the Executor/ system supplier facility on operations and maintenance of all system components. The training program shall be divided into two segments and shall consist of at least 5 (five) working days, each of 8 (eight) hours duration.The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished.

As a minimum, the following subjects shall be covered:

- System Architecture and Layout
- Hardware Components
- Module Switch Settings (Configuration Switches)
- I/O Modules
- Power Supplies
- Data Highway:
- Programmer connection
- IOP programming and diagnostic techniques
- Battery replacement and recharging
- PC and workstation familiarization and maintenance:

- Troubleshooting
- Disassembly
- Cleaning
- Component Replacement
- Re-assembly

The operation training program shall include the following topics:

- Power-up, bootstrapping and shutdown of all hardware devices
- Interpretation of all standard displays
- Appropriate actions for software and hardware error occurrences
- Use of operator interface displays and keyboards
- Use of printer including replenishment of supplies
- Manual data entries
- Creation and editing of graphic operator display screens.
- Loading of any required software into the system
- Data base creation and editing.

16. CONTROL SYTEMS

16.1 RESERVOIR MANAGEMENT SYSTEM

Design, Supply, Erection and Commissioning of Reservoir Management System(RMS) to enable to avoid the overflow of Reservoirs/Sumps, Uniform Distribution of Water to the Reservoirs /Sumps irrespective of its location and distance from the source of supply. Also, the RMS shall have the outlet management valve / system. The system shall be enabled to record, monitoring and control of the cumulative flow Delivered to the Reservoirs/Sumps without any external Electric Energy and no high recovery cost for Energy/Communication Cost such as GSM/GPRS/RADIO etc.

SPECIFICATION OF RESERVOIR MANANGEMENT SYSTEM (RMS)

- The System shall be able to operate without any External Electric Energy. The System shall be capable to achieve the Uniform Distribution of Water to all the

reservoirs/Sumps in the Network irrespective its Elevation and Distance from the Source of Supply.

- The System shall be capable to avoid the overflow of Reservoirs/Sumps in the Networks.
- The System shall be able to Operate/Isolate remotely without any Electrical Energy.
- The System shall be able to record and generate the report of the Cumulative Flow Delivered to Every Reservoirs/Sumps in the Network.
- The System shall be able to allow the flow to Reservoirs/ Sumps as per the Demand.
- The System shall be able to Operate, Monitor, Control and Manage the Water to Reservoirs/ Sumps in Complete Distribution Network without any External Electric Energy.
- The System shall not have any high recurring cost for Energy/Communication Cost such as GSM/GPRS/RADIO etc.
- The System shall be kept in Protective Cover Box capable of giving Vandalism Alert messages such as door open and site GPS co-ordinates.
- The System shall update battery status and atmospheric temp to control centre. Low battery & High temp Alert messages shall be generated to avoid the faults.
- The System shall be capable of water quality monitoring and close in the event of water security issues.
- RMS shall consist of PFCMD, Air valve, inlet and outlet isolation valves, solar power panel of suitable capacity with 12 V battery having 04 days back up capacity for communication, protective enclosure.

16.2 COMPONENTS OF RESERVOIR MANAGEMENT SYSTEM WITH OUTLET MANGEMENT SYTEM (RMS)

Pressure Flow Control Monitoring Device (PFCMD)

- The Pressure & Flow Control and Monitoring Device (PFCMD) shall automatically performs one, two or more independent functions as per the requirements, such as Anti Draining of System, reducing higher upstream pressure to a constant maximal downstream pressure or sustaining maximum set Flow. All functions are performed irrespective of change in upstream pressure and/or demand. Functions can easily be

added or removed in a modular way. The valve shall be compatible with Automation System.

- Valve Shall be with Rapid-action piston for Fast Opening/Closing action to facilitate stable and accurate control of pressure, flow and level.
- Valve shall have Low head loss at high flow rates,
- Valve Shall have Precision molded composite construction (Nylon12 + 50% glass fiber reinforced)
- Valve shall be strong, lightweight and corrosion proof surfaces, which resist cavitation
- damage, thus increasing service life and reducing operation & maintenance cost.
- Valve shall have Linear flow, Low turbulence to minimize cavitation, and allow high flow velocities with low noise and vibration.
- Valve shall have Double-chambered piston actuation for Drip-tight closure, even when command pressure is lower than line pressure.
- Valve shall have "Soft closure" feature to prevent water hammer.
- Multi-Valve modular configuration Full redundancy enabled. Individual valves can be possible to separately removed for maintenance or replacement which reduces downtime and maintenance costs & allows maintenance work to be done without halting water flow.

MATERIAL OF CONSTRUCTION:

Valve Body	:	Reinforced fiberglass nylon or Polypropylene
Pistons, Bushing, Front and Rear Cups:		Reinforced fiberglass nylon or Polypropylene
Main seal	:	NBR, VITON or EPDM rubber, Shore index: 80
O-rings	:	NBR or EPDM rubber, Shore index: 70
Inlets, outlets	:	Stainless steel/ Reinforced fiberglass nylon
Clamps, bolts	:	Stainless steel
Multi-Valve manifolds:		Spheroid iron with polyester or epoxy coating/ Coated Steel
Pressure Rating	:	PN 16

16.3 SPECIAL COMBINATION AIR VALVES (FOR RMS)

- Working pressure range : 0.1 to 10 bar
- Testing pressure : 16 bar
- Working temperature : 60 0C maximum
- Shall be suitable to prevent premature closing.
- Shall be suitable for low pressure sealing.
- **Kinetic components** : Valve shall discharge air at high velocity during filling of system and admit air during draining of water.
- **Automatic components** : Vacuum orifice making it less prone to obstruction by debris.
- **Body material** : Reinforced Nylon.
- **Installation** : It shall be installed before the PFCMD in the RMS System and has the features of an Air-release valve and Air / vacuum valve.

16.4 AUTOMATION SYSTEM FOR REMOTE CONTROL AND MONITORING

The proposed Automation System for RMS shall be able to control and monitor the required parameters from Control Centre with the help of licence free radio frequency and GPRS system.

A: Remote Control Centre

The Remote-Control Centre shall provide a management tool for controlling the all Reservoir Inlets in the water network. Remote control station will be web based application so that user can monitor and control each Reservoir from any place with the help of internet connection.

System configuration:

- The Remote-Control Centre shall be able to configure system's parameters for optimal operation.
- The user shall be able to define all field Units and their associated configurations,
- The user shall be able to define all software application functionality and download (send) the data to the field units, in order for them to perform the on-site function.

- The user will be able to upload the existing data from the field units in order to monitor the entire system.
- The Control Centre shall provide the ability for the user to "zoom in" to the level of single element characteristics (i.e. Input/Sensor, Output/Pump etc.) at each site.
- The user can able to monitor site conditions like inside panel temperature, Battery Voltages, GSM/Radio signal strength.
- The user can able to monitor the Panel door status at central

Management tools:

- Accumulation reporting, historical trends views and Events/Alarms logging.
- Interface to third party database and communication systems such as SMS, paging alarms and weather stations.
- Time based and/or Volume based Weekly Auto schedule will be stored into the controllers.
- Onsite Critical alarms and events are sent by email /SMS to user given email ID or mobile nos.

Edit Mode:

The same Remote-Control Centre SW package shall provide both functionality of what is known as Runtime Mode and Edit Mode (when changes to the runtime screens are needed).

Part of the Remote-Control Centre a Zonal Field Control Unit (ZFCU).

- The ZFCU shall provide communication capabilities and interface between the Remote-Control Centre and Field Control unit which is on the site.
- The ZFCU shall have the ability to perform "regular" Field Control Unit's functionalities, such as monitoring sensors or activating pumps, in addition to its ZFCU functionalities.
- As part of the Control Centre a front end (FEP) is requested (HW and/or SW) enabling the communication between the Control Centre and the Field Control Units.
- The Control Centre shall be able to interface with various software applications (third party), such as weather stations, and other management SW packages.

The Remote-Control Centre shall be able to execute and support the following features*:*

- Displaying the entire data of Field Control Unit such as, flow rate/accumulated flow, and total time of operation, balance time in the form of tables and graphical screens
- Displaying Field Control Unit's events and alarms and ability to report them utilizing SMS technology.
- Display the communication healthiness of field units.
- The user shall be able to change valve operation timings, from the graphical screens
- The user shall be able to operate valve from the graphical screens
- Shall be able to call the Downloading and Uploading data from the Field Control Units
- Shall allow the quantity of water as per the Demand set by the operator.
- Shall have a program to design and display an event report for each Reservoir in the water network.
- Shall have a program to calculate the predicted flow load, over the hydraulic system.
- Shall have a program for displaying sensors data historical trends and alarms.
- Shall have an Off-Line program for the Field Units in addition to the current run-time unit's program.

B: Field Control Units

- Shall have Logic board incorporating microcontroller/microprocessor and data storage components.
- Shall run on solar power or long-life lithium battery.
- Shall be with I/O port required for on-site sensor connection. I/O boards may be expanded/ replaced on-site. These may be inputs such as water meters, reservoir level, pressure meters, or general digital inputs, or outputs such as valves, pump starts, general relays, etc.
- Communication Ports - enabling the Field Unit to communicate with the Remote-Control Centre, and/or each other, and on-site programming/diagnostic tool (such as laptop).
- Shall be able to operate not only the local I/Os (on board I/O connections), but remote I/Os as well.
- Shall be able to update the Remote-Control Centre database upon request (by the remote-Control Centre) or by exception. The Field Unit shall be able to report to the Remote-Control Centre every defined alarm which occurs in the field.

- Shall be capable of functioning in a stand-alone mode (no Remote-Control Centre), as well as a part of a system with a Remote-Control Centre.
- Shall be able to perform Store & Forward functionality - receive information from other sites, store it in memory, and then transmit (forward) the data to another site.
- Shall be able to support both local I/O's and Remote I/O's modules. The remote I/O modules shall be equipped with radio technology, allowing the Field Unit full access and control, as if they are locally connected.
- Shall be able to report by exception (known as burst) to the Control Centre upon any Change-of-State (COS)
- Shall be equipped with a multi-tasking Operating System, specially designed for a real-time environment.

C: Radio/GPRS communication Network

The Radio/GPRS communication network shall be able to make the communication link between the Remote-Control Centre and Reservoir with conventional (865-867MHz licenses free) frequency or using GPRS network.

The communication protocol shall be able to support multiple logical channels per physical port, enabling simultaneous Central-to-Field Control Unit and Field Control Unit -to-Field Control Unit sessions.

The communication protocol shall be able to support the following messaging methods:

Burst (also known as Contention) - this is transmission upon change of state.

Polling (also known as Interrogation) - automatically or manually request for data updating.

Report by Exception - the unit shall only report data that have changed since the last poll.

16.5 ISOLATION WAFER TYPE BUTTERFLY VALVE

Wafer Type BFV shall be provided to Inlet and outlet of PFCMD

Material of Construction

Body	:	Ductile Iron GGG 40
Disc	:	Ductile Iron GGG 40/50

Shaft	:	Stainless Steel 410
O-Ring	:	NBR
Plug	:	Stainless Steel 410
Bushing	:	Bronze
Washer :	Stainless Steel 410	
Bolts	:	Galvanized Steel

TEST PRESSURE:

a) SEAT TEST : 16 Kg/cm^2

b) BODY TEST: 24 Kg/cm^2

16.6 ENCLOSURE

Enclosure to be made up of Reinforced Polyester with Door having vandalism alert.

16.7 BYPASS MANAGEMENT SYSTEM

Scope:

Supply, Erection and Commissioning of BMS System which shall be able to control the flow as per demand to facilitate Uniform Distribution of Water to the Bypass s irrespective of its location, elevation and distance from the water source.

The system shall be able to record, monitor and control the cumulative quantity delivered to the Bypass s without any external Electric Energy and with no high recurring cost for Communication with GSM/GPRS/RADIO etc.

General specifications:

- The System shall be able to Operate, Monitor, Control and Manage the Water to Bypass in Complete Distribution Network without any External Electric Energy.
- The System shall be capable to achieve the Uniform Distribution of Water to all the Bypass in the Network irrespective of its Elevation and Distance from the Source of Supply.
- The System shall be able to record and generate the report of the Cumulative Quantity delivered to every Bypass in the Network.
- The System shall be able to allow the quantity to Bypass as per the Demand / Quota.
- The System shall have minimum recurring cost for Communication by using GSM/GPRS/RADIO etc.
- The System shall be kept in Protective Enclosure capable of giving Vandalism Alert.

- The System shall be capable of water quality monitoring and close in the event of water security issues
- BMS shall consist of PFCMD, Air valve, inlet and outlet isolation valves, solar power panel of suitable capacity with 12 V battery having 04 days back up capacity for communication, protective enclosure.

16.8 COMPONENTS OF BYPASS CONTROL MANAGEMENT SYSTEM (BMS)

Pressure Flow Control Monitoring Device (PFCMD)

- The Pressure & Flow Control and Monitoring Device (PFCMD) shall automatically performs one, two or more independent functions as per the requirements, such as Anti Draining of System, reducing higher upstream pressure to a constant maximal downstream pressure or sustaining maximum set Flow. All functions are performed irrespective of change in upstream pressure and/or demand. Functions can easily be added or removed in a modular way. The valve shall be compatible with Automation System.
- Valve Shall be with Rapid-action piston for Fast Opening/Closing action to facilitate stable and accurate control of pressure, flow and level.
- Valve shall have Low head loss at high flow rates,
- Valve Shall have Precision molded composite construction (Nylon12 + 50% glass fiber reinforced)
- Valve shall be strong, lightweight and corrosion proof surfaces, which resist cavitation damage, thus increasing service life and reducing operation & maintenance cost.
- Valve shall have Linear flow, Low turbulence to minimize cavitation, and allow high flow velocities with low noise and vibration.
- Valve shall have Double-chambered piston actuation for Drip-tight closure, even when command pressure is lower than line pressure.
- Valve shall have “Soft closure” feature to prevent water hammer.
- Multi-Valve modular configuration Full redundancy enabled. Individual valves can be possible to separately removed for maintenance or replacement which reduces downtime and maintenance costs & allows maintenance work to be done without halting water flow.

MATERIAL OF CONSTRUCTION:

Valve Body	:	Reinforced fiberglass nylon or Polypropylene
Pistons, Bushing, Front and Rear Cups	:	Reinforced fiberglass nylon or Polypropylene
Main seal	:	NBR, VITON or EPDM rubber, Shore index: 80
O-rings	:	NBR or EPDM rubber, Shore index: 70
Inlets, outlets	:	Stainless steel/ Reinforced fiberglass nylon
Clamps, bolts	:	Stainless steel
Multi-Valve manifolds:		Spheroid iron with polyester or epoxy coating/ coated Steel
Pressure Rating	:	PN 16

16.9 SPECIAL COMBINATION AIR VALVES (FOR BMS)

- Working pressure range: 0.1 to 10 bar
- Testing pressure: 16 bar
- Working temperature: 60 0C maximum
- Shall be suitable to prevent premature closing.
- Shall be suitable for low pressure sealing.
- **Kinetic components:** Valve shall discharge air at high velocity during filling of system and admit air during draining of water.
- **Automatic components:** Vacuum orifice making it less prone to obstruction by debris.
- **Body material:** Reinforced Nylon.
- **Installation:** It shall be installed before the PFCMD in the BMS System and has the features of an Air-release valve and Air / vacuum valve.

16.10 TECHNICAL SPECIFICATIONS OF AUTOMATION SYSTEM FOR REMOTE CONTROL AND MONITORING

The proposed Automation System for BMS shall be able to control and monitor the required parameters from Control Centre with the help of license free radio frequency and GPRS system.

A: Remote Control Centre

The Remote-Control Centre shall provide a management tool for controlling the all Bypass s in the water network. Remote control station will be web based application so

that user can monitor and control each Bypass from any place with the help of internet connection.

System configuration:

- The Remote-Control Centre shall be able to configure system's parameters for optimal operation.
- The user shall be able to define all field Units and their associated configurations,
- The user shall be able to define all software application functionality and download (send) the data to the field units, in order for them to perform the on-site function.
- The user will be able to upload the existing data from the field units in order to monitor the entire system.
- The Control Centre shall provide the ability for the user to "zoom in" to the level of single element characteristics (i.e. Input/Sensor, Output/Pump etc.) at each site.
- The user can able to monitor site conditions like inside panel temperature, Battery Voltages, GSM/Radio signal strength.
- The user can able to monitor the Panel door status at central

Management tools:

- Accumulation reporting, historical trends views and Events/Alarms logging.
- Interface to third party database and communication systems such as SMS, paging alarms and weather stations
- Time based and/or Volume based Weekly Auto schedule will be stored into the controllers
- Onsite Critical alarms and events are sent by email /SMS to user given email ID or mobile nos.

Edit Mode:

The same Remote-Control Centre SW package shall provide both functionality of what is known as Runtime Mode and Edit Mode (when changes to the runtime screens are needed).

Part of the Remote-Control Centre a Zonal Field Control Unit (ZFCU).

- The ZFCU shall provide communication capabilities and interface between the Remote-Control Centre and Field Control unit which is on the site.

- The ZFCU shall have the ability to perform "regular" Field Control Unit's functionalities, such as monitoring sensors or activating pumps, in addition to its ZFCU functionalities.
- As part of the Control Centre a front end (FEP) is requested (HW and/or SW) enabling the communication between the Control Centre and the Field Control Units.
- The Control Centre shall be able to interface with various software applications (third party), such as weather stations, and other management SW packages.

The Remote-Control Centre shall be able to execute and support the following features:

- Displaying the entire data of Field Control Unit such as, flow rate/accumulated flow, and total time of operation, balance time in the form of tables and graphical screens
- Displaying Field Control Unit's events and alarms and ability to report them utilizing SMS technology.
- Display the communication healthiness of field units.
- The user shall be able to change valve operation timings, from the graphical screens
- The user shall be able to operate valve from the graphical screens
- Shall be able to call the Downloading and Uploading data from the Field Control Units
- Shall allow the quantity of water as per the Demand set by the operator.
- Shall have a program to design and display an event report for each Bypass in the water network.
- Shall have a program to calculate the predicted flow load, over the hydraulic system.
- Shall have a program for displaying sensors data historical trends and alarms.
- Shall have an Off-Line program for the Field Units in addition to the current run-time unit's program.

B: Field Control Units

- Shall have Logic board incorporating microcontroller/microprocessor and data storage components.
- Shall run on solar power or long-life lithium battery.
- Shall be with I/O port required for on-site sensor connection. I/O boards may be expanded/ replaced on-site. These may be inputs such as water meters, reservoir level, pressure meters, or general digital inputs, or outputs such as valves, pump starts, general relays, etc.

- Communication Ports - enabling the Field Unit to communicate with the Remote-Control Centre, and/or each other, and on-site programming/diagnostic tool (such as laptop).
- Shall be able to operate not only the local I/O (on board I/O connections), but remote I/O as well.
- Shall be able to update the Remote-Control Centre database upon request (by the Remote-Control Centre) or by exception. The Field Unit shall be able to report to the Remote-Control Centre every defined alarm which occurs in the field.
- Shall be capable of functioning in a stand-alone mode (no Remote-Control Centre), as well as a part of a system with a Remote-Control Centre.
- Shall be able to perform Store & Forward functionality - receive information from other sites, store it in memory, and then transmit (forward) the data to another site.
- Shall be able to support both local I/O's and Remote I/O's modules. The remote I/O modules shall be equipped with radio technology, allowing the Field Unit full access and control, as if they are locally connected.
- Shall be able to report by exception (known as burst) to the Control Centre upon any Change-Of-State (COS)
- Shall be equipped with a multi-tasking Operating System, specially designed for a real-time environment.

C: Radio/GPRS communication Network

The Radio/GPRS communication network shall be able to make the communication link between the Remote-Control Centre and Bypass with conventional (865-867MHz licenses free) frequency or using GPRS network.

The communication protocol shall be able to support multiple logical channels per physical port, enabling simultaneous Central-to-Field Control Unit and Field Control Unit -to-Field Control Unit sessions.

The communication protocol shall be able to support the following messaging methods:

Burst (also known as Contention) - this is transmission upon change of state.

Polling (also known as Interrogation)- automatically or manually request for data updating.

Report by Exception- the unit shall only report data that have changed since the last poll.

16.11 ISOLATION WAFER TYPE BUTTERFLY VALVE

Wafer Type BFV shall be provided to Inlet and outlet of PFCMD

Material of Construction

Body	:	Ductile Iron GGG 40
Disc	:	Ductile Iron GGG 40/50
Shaft	:	Stainless Steel 410
O-Ring	:	NBR
Plug	:	Stainless Steel 410
Bushing	:	Bronze
Washer	:	Stainless Steel 410
Bolts	:	Galvanized Steel

EST PRESSURE:

a) SEAT TEST	:	16 Kg/cm^2
b) BODY TEST	:	24 Kg/cm^2

16.12 ENCLOSURE

Enclosure to be made up of Reinforced Polyester with Door having vandalism alert.

Note: Please refer the Schematic Flow Drawing and WDC installation drawings.

17.0 Closed Circuit Television System (CCTV)

The Contractor shall provide a CCTV System that shall include, but not be limited to, the provision of CCTV Day/Night cameras, CCTV infra-red floodlights and control panel, video signals data servers and panel enclosure complete with router/hub, digital video recorders, surge and lightning protection devices, made necessary configuration, user licenses of any software for the System and associated equipment fittings and cabling necessary for the completion of the works. The CCTV shall be configured on Operator Workstation essential software's shall consider on the same.

Following areas shall be considered under CCTV surveillance.

- Raw Water Pumping station
- Raw Water Control Room

- WTP area
- Clear Water Pumping Station
- Clear Water Control Room
- Water Distribution Centers
- Central Control Room
- Panel rooms.
- Substations and Transformer yards
- Entrance gates
- Security cabins
- Major equipment areas

The CCTV camera shall be inside and outside the buildings mentioned above.

Exact Locations and final quantities shall be decided during detail engineering.

17.1 Voice Communication

Communication system shall be between control room, machine hall floor, Powerhouse security room & switchyard through EPABX system with spare outlet. The main controller should be compatible with P&T system with a capacity for 2 P&T lines. The following should be provided along with:

- EPABX system
- Telephone instrument sets
- UPS for above system

17.2 Site Acceptance Tests (SAT)

- After installation and commissioning, the contractor shall demonstrate, by tests in the field, compliance of the values, functionalities, quality and reliability of the complete system and its components, both hardware and software, as specified and as per guarantees.
- Contractor shall fully participate in interfacing to the equipment of others. It shall be Contractor's responsibility to ensure satisfactory functioning of the system in conjunction with related equipment like exchanges, data equipment and other communication equipment of the Owner. Problems relating to such interconnections shall be mutually resolved.

- After tests as above, the complete system shall be on continuous uninterrupted service with all functionalities and interconnections to Owner's equipment for 4 weeks without any failures or manual interventions for correction, modification.

SECTION – VII

Technical Specification for Erection, Testing & Commissioning

1. UNLOADING, HANDLING & STORAGE

1.1. The Agency shall be responsible for the delivery at site/sites of all equipment, material and supplies required for the fulfillment of the contract up to handing over of the proposed water supply to the Authority.

1.2 The Agency shall at his own expense and responsibility transport or shift to plant site, all materials, equipment and supplies furnished for this contract. All movement of materials and equipment to and from storage shall be at the expense of the Agency. Space for storage facilities shall be provided by the Authority at the site of the work as available. If the Agency does not promptly shift and place for use in the premises, where the work is to be done, any material, equipment or supplies delivered, the Authority may do so, and charge all the costs thereof to the Agency and in any event the Authority shall not be responsible for any damages, arising out of, or in any way connected with such shifting or placing of the same. The Agency shall further after shifting, unpack the materials, verify contents against invoices and notify shortages or breakages to the Engineer-in-Charge within one week of the receipt of materials and equipment at site, failing which the Agency shall be held responsible for any consequences.

1.3 If requested by the Engineer-in-Charge, the planned method of transport of equipment shall be submitted to the Engineer-in-Charge for approval. This approval shall not relieve the Agency of any responsibility for the safety of the equipment and personnel.

2. AGENCY REMAINING INFORMED AS TO CONDITIONS

2.1 The Agency shall inspect, examine, obtain all information and satisfy himself regarding all matters relating to the execution and maintenance of the works to be carried out under the contract or any hindrances or interferences to or with the construction or maintenances of the works from any cause whatsoever including any other operations of works which may or shall be carried out on or adjacent to the site of the works before or during the construction or maintenance of the works under the contract and shall make allowance for all such contingencies in the contract price and shall not raise any claims or objections against the Authority in respect of any of the matters mentioned above.

2.2 The Agency shall take field measurements when or where necessary before detailing, ordering or fabricating any material.

2.3 The acceptance of the order or making of a contract shall be construed as evidence that such an examination was made and later claims for labour, equipment or materials required or for difficulties encountered, which could have been foreseen, shall not be allowed.

3. PROSECUTION OF THE WORK

3.1 The Agency shall furnish adequate, courteous and competent labour, supervisors and Engineer-in-Charges of all classes for the duration of the work to maintain progress of erection in accordance with the requirement of the scheduled completion date, and shall begin the work included in the contract at such time as well ensure its completion as specified and shall complete the same, free of all liens and charges, at or before the time specified for completion. The Agency shall make available qualified Engineer-in-Charges for placing the equipment in operation, carrying out the necessary tests and trials and the training of Authority's operating staff, as directed by the Engineer-in-Charge.

3.2 The Agency shall be completely responsible for the satisfactory construction, erection, testing and commissioning of the works notwithstanding that he may have been assisted by the Engineer-in-Charge in doing so.

4. WORK PERFORMED AT AGENCY RISK

4.1 The Agency shall take all precautions necessary and shall be responsible for the safety of the work to be performed by him, and shall maintain all lights, guards, signs, temporary passages, or other protections necessary for the purpose. The Agency shall be responsible for any loss or damages to his personnel, materials, tools or other articles used or held for use in such work. Such work shall be carried on to completion without damage to any work or property of the Authority or of others and without interference with the operation of existing machinery or equipment.

5. CONSTRUCTIONS TOOLS, EQUIPMENT AND SITE FACILITIES

5.1 The Agency shall, at his own expense, furnish all necessary false work, erection tools, hoist, cranes, air compressors, rigging, skids, cribbing, blocking, scaffolding, sheet piles,

equipment, appliances, materials and supplies required for erection and/or testing for performances and start up (hereinafter in this section called 'construction tools and equipment') that may be required to accomplish the work under contract unless otherwise provided for. Adequacy of such shall be to the entire satisfaction of the Engineer-in-Charge.

5.2 All piping for service, and drinking water to work area shall be furnished, installed and maintained by the Agency at his own cost. He shall also furnish, install and maintain at his own cost the power lines, junction boxes or any other electrical receptacles, apparatus or equipment from starting points, to his area.

5.3 The Authority shall not be responsible or held liable for any damage to person or property consequent upon the use, misuses or failure of any construction tools and equipment used by the Agency or any of his sub-contracts, even though such construction tools and equipment may have been furnished, rented or loaned to the Agency or any of his agents by the Authority. The acceptance and/or use of any such construction tools and equipment by the Agency or his agents shall be construed to mean that the Agency accepts all responsibility for and agrees to indemnify and save harmless the Authority from said use, misuse or failure of such construction tools and equipment for which the Authority may be liable.

5.4 The Agency shall bear and pay all charges including freight, clearing, insurance, duty on all construction tools and equipment furnished by him.

6. TRAVELLING AND LIVING EXPENSES

6.1 The contract price shall include all salaries and wages, all travelling time and expenses and boarding and lodging allowances for all personnel furnished by the Agency and all payments which the Agency may have to make in relation to the work of the labourers and other personnel employed for complete installation.

7. SIMULTANEOUS WORK BY OTHERS

7.1 The Authority reserves the right to perform or have performed in and about the works during the time when the Agency is performing his work hereunder such other work as the Authority desires and the Agency shall make all reasonable effort to perform his work

hereunder in such manner as shall enable such other work to be performed without hindrance from the Agency and shall make no claim for damages against the Authority arising out of such other work or interference therefrom. The Agency shall work in harmony with such other Agencies regardless of race, religion, colour or national origin and any dispute between Agencies shall be arbitrated by the Authority, if necessary.

8. START-UP AND GUARANTEES

8.1 Until such time as the equipment or material installed and erected under the contract is finally accepted by the Authority in keeping with the terms and conditions of this contract and associated specifications the responsibility for proper testing, maintenance and efficient operation of the same shall be that of the Agency. Prior to start-up, the Agency shall be required to service the equipment and during start-up render such assistance as may be necessary or requested for by the Authority.

8.2 Where the equipment has not been manufactured by the Agency, the manufacturer's recommendations for installation of the same shall be strictly adhered to and any defects developing due to faulty installation and/or erection during start-up or during a trial run and period of one year from the date of commissioning shall be rectified, remedied or made good by the Agency through the manufacturer if considered necessary by the Authority at his own expense. When the equipment has been manufactured by the Agency himself, rectification within similar period is compulsory.

9. AUTHORITY USE OF EQUIPMENT

The Authority shall have the right to use the materials and the equipment as he requires, even prior to final acceptance.

10. Removal of Debris

10.1 The Agency shall always keep the site free of rubbish, debris and surplus materials so as to render the place of work clean and safe for all personnel working in that area and upon completion of the work shall remove all rubbish and waste materials resulting from his work and leave the works and work site on a clean and finished condition. If the Agency fails to comply, such work shall be performed by the Authority at Agency expense.

10.2 Whenever demolition or other work of any kind creates harmful dust or fumes, equipment for the complete protection of all personnel and property against dust fumes shall be installed, maintained and effectively operated by the Agency as required by statute. All such equipment shall be of a type approved by the State govt. / Central Govt. / or municipal or any other regulatory body and the expression harmful dust or fumes shall have the meaning assigned to it be such appropriate regulatory body.

11. Agency Obligations

11.1 Over and above the responsibilities of the Agency stipulated in this document, the following obligations shall be fulfilled by the Agency.

11.1.1 The Agency shall satisfy the Engineer-in-Charge that adequate provision has been made.

a) to carry out his instructions fully and with promptitude;

b) to ensure that parts required to be inspected before use are not used before inspection; and

c) to ensure that adequate supervision is provided at all stages of the work and each portion of the work is checked for accuracy before erection.

11.1.2 The Agency shall make necessary arrangements including provision of suitable spaces and facilities for testing, for inspection at any stage of manufacture of plant and equipment by the Engineer-in-Charge or his agents, as and when deemed necessary by the Engineer-in-Charge; the time schedule for any inspection shall, however, follow the inspection schedule suggested by the Agency and agreed upon by the Engineer-in-Charge during scrutiny of delivery plan. Irrespective of any inspection and tests made by the Engineer-in-Charge, the Agency shall be entirely responsible for the proper execution of the Contract notwithstanding any approval which may have been given by the Engineer-in-Charge or the work or of tests carried out either by the Engineer-in-Charge or the Agency. At least 15 days' notice shall be required for inspection to be carried outside the State.

11.1.3 The Agency shall at his own cost,

a. establish and maintain the area placed at his disposal for office/storage purposes.
b. provide the necessary power and water connection from the supply mains and install and maintain the temporary distribution lines within the working area;
c. erect and maintain necessary offices and storage space;

d. provide temporary lighting at erection site required for erection;
e. arrange for personnel accident insurance for his own personnel at site;
f. arrange adequate security lighting and watch system to safeguard the equipment from any type of mishandling, theft, fire hazards etc. during the construction period, period of Trial Run and period of maintenance;
g. Gardening and landscaping and beautification of the site before commissioning;
h. Curved Glow Signboard on each gate covering entire width of gate including supporting frame structures and all electrical accessories. The details of the signboard and its writings shall be as per instruction of the Engineer-in-Charge.
i. Identification metallic signboard for each units of the plant including supporting frame structures and all electrical spotlight arrangements. The details of the signboard and its writings shall be as per instruction of the Engineer-in-Charge.

11.1.4 The Agency shall design, manufacture, erect and dismantle any false work, staging temporary support, etc. required for safe and accurate plant and equipment erection and structural steelwork and shall be fully responsible for the adequacy of the same. The cost of such work shall be deemed to have been included in the raise quoted in the Schedule of prices.

11.1.5 The Agency shall, if so required by the Engineer-in-Charge, furnish drawings and design of such false work, staging etc.

11.1.6 The Agency shall provide for the convenience of inspection/testing adequate temporary and sufficiently strong and stable stairs and access ladders, gangways, etc. wherever necessary at his own cost.

11.1.7 The Agency shall abide by the instructions and decisions of the Engineer-in-Charge at any stage of execution of the job unless he can convince that the same goes against the interest of satisfactory progress and completion of this work as per agreed schedule.

12. SHOP TESTS

12.1 Shop tests shall include all tests to be carried out at Agency works, works of his agents at manufacturer's works and at works where raw materials supplied for manufacture of equipment.

12.2 The tests to be carried out shall include but not be limited to the tests mentioned below:

i. Composition of all materials, castings, forgings, etc.

ii. Hydraulic test for pressure vessels, tanks, pump castings etc.

iii. Hydraulic tests for valves, specials etc.

iv. Test to check faults in rubber lining (as per IS: 4682) or its equivalent and painting.

v. Static and dynamic balancing test on all impellers.

vi. Static balancing test on agitators, stirrers, paddles etc.

vii. Performance test (Head, Capacity, BHP) on pump and blowers.

viii. Tests on motor as per IS: 4029.

ix. Any other test that may be provided in I. S. Specification and as required by the Engineer-in-Charge.

12.3 All test certificates and reports shall be submitted to the superintending Engineer-in-Charge for approval. All tests are normally to be carried out in presence of the Engineer-in-Charge or his representative. However, waiver may be allowed in specific cases by the Authority at his discretion.

12.4 The Authority's representatives or his appointed agents shall be given full access to all tests, The Agency shall inform the Superintending Engineer-in-Charge allowing adequate time so that the Engineer-in-Charge or his appointed agents can witness the test, if it is so desired by the Engineer-in-Charge.

12.5 No component or equipment shall be dispatched unless accompanied by approved test certificates and reports. The approval shall be given provided the corresponding drawings /technical particulars are already approved the Authority's representatives or his appointed agents have witnessed the tests or a letter of inspection waiver is issued by the Engineer-in-Charge.

13. SITE TESTS

13.1 General

After erection at site, all components, equipment as Described below shall be tested to prove satisfactory performance and/or fulfilment of functional requirement without showing any sign of defect as individual equipment and as well as systems, The Agency shall make all arrangements for testing and inform the Engineer-in-Charge for witnessing the tests.

i. All pipes, fittings and valves, after installation shall be tested hydraulically at a pressure, at least 1.5 times the maximum attainable pressure in the system, to check

against leak tightness. A higher factor shall have to be adopted in specific cases if so specified by the I.S./B.S.

ii. All manually operated valves / gates shall be operated throughout 100% of the travel and these shall function without any trouble.

iii. All pumps shall be run with the specified fluid form shut off conditions to valve wide open condition. During the test, the pumps and drive motors shall run without any undue vibration, leakage through gland, temperature rise in bearing parts, noise, flow pulsation etc.

iv. Visual check on all structural components, welding, riveting, rubber lining, FRP lining, painting etc. and if doubt arises shall be tested again.

v. All EOT and HOT hoists and its components shall be subjected to double the full working load during all motions without showing any sign of defect.

vi. Water leakage test of all liquid retaining structures as per IS specifications.

vii. Load tests and integrity tests of piles.

viii. Load test of civil structures if desired by the Engineer-in-Charge.

ix. All test instruments and equipment shall be furnished by the Agency to the satisfaction of the Engineer-in-Charge.

13.2 Mechanical Tests

All the rotating / moving components like agitators, paddles etc. shall be run at the rated speed with water /chemicals up to the normal water /liquid level continuously for a period of twenty-four (24) hours. During this period, all the components shall function smoothly without any unbalance vibration, overheating at bearing parts, etc.

14. ERECTION SCHEDULE

14.1 The Agency shall prepare a time table for erection schedule of requirements of men and material and tools & tackles or erections and outlines of erection methods together with erection drawings and specifications and submit those for approval of the Engineer-in-Charge. Such schedules shall be submitted well in advance. Any revisions to such schedules shall only be effected after prior approval of the Engineer-in-Charge giving specific reasons for such revisions.

15. BLOCK GROUTINGS

15.1 All equipment after erection shall be properly grouted without charging extra.

16. SETTING OUT AND FOUNDATIONS

16.1 Where setting out and preparation of foundations are carried out by others, the Agency shall approve the accuracy of the setting out before execution of foundation work. The Agency shall be responsible also for the adequacy of such setting out a preparation of foundations.

17. PROTECTION OF PLANT

17.1 All plant shall be afforded adequate protection against corrosion, mechanical damage, deterioration etc. until the plant is taken over, The Agency shall submit his proposals for achieving this protection for the approval of the Engineer-in-Charge.

17.2 The Agency shall make good to be satisfaction of the Engineer-in-Charge any deuteri-ation of the protective coatings, paintwork, etc. which may occur during transportation, erection, commissioning etc. until the plant is taken over.

17.3 Finish painting of the plant at site, as specified shall be carried out before the plant is taken over.

17.4 Items of plant which are finished painted at the manufacturer's works, such as switch boards, etc. shall be suitably encased in crate or their protection before dispatch. This plant may require to be returned to the works for making good of any deterioration of the paintwork etc. at the Agency expense, which may have occurred during the period until the plant is taken over.

18. TOOLS AND TACKLES

18.1 All tools and tackles, measuring and testing equipment etc. required for the successful execution of all contract shall be provided by the Agency as part of his responsibility with respect to erection and commissioning of the plant as per the terms of contract.

18.2 All tools and tackles supplied by him shall be taken back by him after completion of works excepting special maintenance tools which shall be retained by the Authority till the plant is taken over by him.

19. DELIVERY AND ERECTION SCHEDULE

The tenderer shall quote his best schedules for delivery of equipment and plant, erection and commissioning, and shall indicate the expected delivery schedule required for components to suit the erection schedule of the plant.

20. COMPLIANCE WITH SATUTES, REGULATION ETC.

20.1. The Agency shall conform in all respect with the provision of any such state Ordinance or Law as aforesaid and the regulations or Bye Laws of any local or other duly constituted Authority which may be applicable to the work or to any temporary work and with such rules and regulations of public bodies and companies as aforesaid and shall keep the Authority indemnified against all penalties and liability of every kind for breach of any such statute ordinance or law regulation or bye law.

21. REMOVAL OF IMPROPER WORK AND MATERIALS.

21.1 The Engineer-in-Charge shall during the progress of the work have power to order in writing from time to time.

a. The removal form the place of work of site within such time or times as may be specified in the order of any materials which in the opinion of the Engineer-in-Charge are not in accordance with the contract.

b. The substitution of in proper and the suitable materials, and

c. The removal and proper re-execution (notwithstanding any previous test thereof or interim payment therefor) of any work which in respect of materials or workmanship is not in accordance with the contract.

22 PACKING

22.1 Materials used for packing of the equipment shall be of sound timber of dimensions proportional to the size the weight of contents. The seller shall not use second hand packing materials, all package shall be steel strapped with at least two (2) straps on each package to ensure a solid package and to prevent pilferage. Bundled materials shall be rigidly steel strapped.

22.2 Fragile materials shall be securely packed within the containers or otherwise apply protected and packed to prevent shifting or rattling.

22.3 The empty containers shall be fully covered by strong and durable water proof paper inside, before putting the material, in order to protect the contents from damage, dust and corrosion due to sea or rain water creeping into the cases and, in addition, they shall be properly lined to withstand the elements while in transit or stored without cover.

22.4 Machined parts shall be thoroughly greased and amply protected against rust forming and corrosive elements.

22.5 The Agency shall not use open type crates or fiber board cartons, unless permission is received from the Authority.

22.6 The Agency shall not forward any articles without packing as specified herein, without obtaining prior approval of Authority.

22.7 Spare parts shall be packaged separately, under no circumstances they shall be included in the containers with the related commodity.

23. DAMAGE RISK AND INSURANCE

23.1 The Agency shall arrange the plant and equipment and each part thereof, to be insured against loss, damage or destruction to fire, lightening, earthquake theft and such other risks until it is handed over to the Authority after erection and trial run period as provided for in the contract and shall from time to time, when so required by the Engineer-in-Charge produce the policy and receipts for the premiums. All money received under any of such policies shall be applied in or towards the replacement and repair of the plant damaged or destroyed, but this provision shall not affect the Agency liabilities under the contract.

Separate insurance policies shall be obtained to cover

i) rail and / or road etc. transit of equipment to site; and

ii) period of storage and erection and commissioning at site.

24. COMMISSIONING AND PERFORMANCE TESTS

24.1 The Agency shall undertake the complete responsibility for successful erection and commissioning of the plant and giving successful performance tests.

24.2 The commissioning of the plant shall involve the following steps of operations

a) Testing of each unit on no load, to make complete check of its mechanical operations, alignment, clearance and rigidity and making necessary adjustments or alterations required to make such unit properly operatable mechanically.

b) After the mechanical check has been made, as stated above, the equipment shall be energized and run progressively from no load to full load.

c) Thereafter, trial operations of the units under completion shall be taken at normal full load operating conditions for which the respective units are designed, further the units shall be rechecked for operation under normal overload conditions and necessary adjustments and alterations of the units shall be carried out to prevent leakage, spillage, heating up, undue vibrations, etc. and ensure that the equipment as erected to fulfill the design requirement. For this purpose, continuous 72 hr. operation shall be demonstrated as a necessary prerequisite to commissioning vide 24.3 (d).

24.3 The initial performance tests shall involve the following steps of operations:

a) Necessary pumps shall be started and flow established through all the streams, valves shall be adjusted so as to have rated distribution of flow through all streams.

b) Various units of the plant shall be started simultaneously. Samples of water shall be drawn every hour in the presence of the Engineer-in-Charge or his authorized representative from the outlets of flash mixers, flocculators, plate/tube settler clarification units, filters and chlorinators and tested in the plant laboratory or in any other laboratory approved by the Engineer-in-Charge. The test results shall be compared against the required parameters.

c) Similarly, samples of raw water shall be collected in the presence of the Engineer-in-Charge or his authorized representative and tested in order to determine the efficiency of treatment at different stages of treatment.

d) The initial performance tests shall be carried out at least for 72 hours continuous operation.

e) The performance tests of the water treatment plant shall be deemed as a failure in case performance as specified is not met regarding quality and flow.

All cost of the initial performance tests shall be borne by the Agency.

After the initial performance tests, the plant shall be subjected to Trial Run during which performance tests shall be carried out further as specified in section F and other relevant chapters.

SECTION - VIII
General Provision for Operation & Maintenance

1. GENERAL

This section applies to carry out operation and maintenance of the facility in meeting its objective. The section pertains to the specifications of water supply system and equipment including materials to be used for operation and maintenance, the workmanship, period for routine maintenance, specifications for the satisfactory performance of the entire proposed water supply system, maintenance of records, and responsibilities during operation and maintenance period. The Agency shall be responsible for providing continuous operation of the Intake well-cum-raw water pumping station, water treatment water supply system, clear water reservoir-cum-pumping station, GLSRs in WDCs, instrumentation system, communication system, PLC/SCADA, water supply system and machineries, all ancillary buildings, campus area, for a period of eight years, and to prevent any sudden failure or breakdown through maintenance works on water supply system operation and its operation works. It is essential that Authority and Agency need to have sufficient information on operational issues under normal and emergency conditions.

Notwithstanding as to what is specifically stated under Maintenance Schedule, it shall be the responsibility of the successful bidder to attend to all the preventive & routine maintenance and repairs and breakdown services including replacement of necessary parts and components.

1.1 System Components for O & M

The system components for O&M shall comprise the following for the proposed water supply system:

1. Intake well-cum-raw water pumping station,
2. Raw water pumping machineries
3. Raw water pumping main
4. Water treatment water supply system (Plate Settler, RGF, etc)
5. Clear water reservoir

6. Clear water pumping station
7. Clear water rising main
8. Air management system
9. Tapping control system
10. Bypass management system
11. Semi-underground reservoirs in Water Distribution Centers (WDC)
12. All MEP services installed in Intake well, WTP, clear water pumping station administrative building and guest house.
13. Electrical equipment in Intake well, WTP, clear water pumping station, administrative building and guest house
    v. 33KV supply from two sources
    w. 33KV Ring main unit
    x. 33kV Switchgear Panel
    y. 6.6KV switchgear panel
    z. 33/6.6kV Oil Filled Power Transformers
    aa. 6.6/0.415kV Dry type indoor Transformers for station auxiliaries
    bb. 33/0.415KV CSS for WTP
    cc. 6.6kV Neutral Earthing Resistors
    dd. 6.6kV Pump Panels
    ee. Main LT PCC Panel
    ff. Pump Motors
    gg. Pump MCC Panels
    hh. Fresh air & Exhaust Panel
    ii. AC Panel for cabin air condition
    jj. Main Lighting & Power Panel DB
    kk. Lighting Panel for Admin Building
    ll. Variable Frequency Drive for Pumps (VFD)
    mm. Capacitor and APFCR panel to maintain Power factor greater than 0.90
    nn. UPS – 2 Nos with Battery Banks & Battery chargers
    oo. DC Distribution Board
    pp. UPS DB – 1 & UPS DB – 2
14. Fire Alarm System with Control Panel

15. Lighting system
16. SCADA/ PLC system
17. Control & Power cables
18. Earthing & Lightning Protection system
19. Fire Fighting System
20. Hand Operated Hoist & Trolleys

The list of Mechanical & Electrical equipment applicable for Operation and Periodic Maintenance activities are listed subsequently. The list of equipment is applicable for Operation and Periodic Maintenance activities of the proposed water supply system and associated systems, as listed above.

1.2 PERFORMANCE GUARANTEE

The Agency shall guarantee & maintain the design parameters of water supply on 24x7 basis as stated in Basis of Design, throughout the Operation & Maintenance Period of 8 years.

1.3 DUTIES & RESPONSIBILITIES

The Agency shall operate and maintain the proposed water supply system on regular and systematic basis, in compliance with designed /calculated operational index. The Agency shall manage water supply system operations to restrict power consumption and chemical usage within the specified functional guarantees. The Agency shall ensure satisfactory operation and maintenance of the whole works so that the water supply system operation provides reliable, consistent performance and is economical at all times.

1.4 DEFINITION OF MAINTENANCE

Maintenance covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures, predictive, condition monitoring and, in the event of problems, enable repairs to be carried out with the minimum disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of

preventive and corrective procedures. Maintenance also includes all civil structures, pipeline, approach bridge & roads, storm water drainage network, sewerage network, electrical installations, instrumentation & SCADA etc.

Preventive Maintenance

Preventive maintenance consists of all the regular work carried out in order to sustain the conditions necessary or smooth operation of the water supply system and to keep the performance of the equipment as close as possible to its original performance level. Its purpose is to reduce the probabilities of failure of deterioration of equipment of the water supply system. In simple terms, preventive maintenance involves the elementary operations such as lubrication, mechanical servicing, electrical and instrumentation servicing.

Corrective or Remedial Maintenance

Corrective or remedial maintenance consists of all works needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment. It includes the following operations:

- Dismantling or equipment,
- Replacement of parts

The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc.), or may be dictated by an unexpected breakdown.

Condition Monitoring (Predictive Maintenance)

Condition Monitoring (Predictive Maintenance) consists of all the regular work carried out in order to sustain the conditions necessary or smooth operation of the water supply system and to keep the performance of the equipment as close as possible to its original performance level. Its purpose is to reduce the probabilities of failure or deterioration of equipment of the water supply system. All equipment vibration analysis and thermal

analysis shall be monitored on continual basis; remedy action shall be planned to achieve **"zero unscheduled break down".**

Supply and maintain at WTP premises of Environment Temperature Vibration Analyzer is a Class 1 ruggedly designed device for measuring sound and vibration caused due to environmental factors, for e.g. in pumps, pump room etc. It shall boast of versatile software applications to measure and record the Environment sound and vibration monitoring and analysis on the portable rugged system. This data can be exported for post-processing and regression analysis. Contractor shall Supply the Vibration Analyzer as specified below.

Type of Product	Environmental Sound Vibration Analyzer
Speaker Amp.	1W
International Protection	IP64
USB	1 Host, 1 Device
I/O	Head-Phone, Speaker, LED, Power etc.
Input Signal Gain	2, 4, 8, 16, 32, 64
Input Channel	4 Channel (3-Vibration, 1-Sound)
Dynamic Range	134dB (50mV/Pa x 10Gain)
Sampling Frequency	3 channels with 512Hz for vibration and channels with 32,768Hz for sound
LCD	3.5 " 240 * 320 TFT or LCD + TSP
Expandable Memory	SD Card
System Memory	DDR SDRAM 128MB
Temperature	4 C to +50 C
External Memory Slot	SD/MMC Slot
A/D Converter	24 Bit

Humidity	5 % to 95 % Non-condensing
Communication	Serial, Wifi, CDMA
Operating System	WinCE 5.0
CPU	PXA320 (806MHz)
SNR	More than 100dB
Sensor Type	IEPE, AC, RPM, IR Temperature Sensor
Operating Temperature	4 C to +50 C
Storage Temperature	4 C to +70 C
More Options	3M CMOS Camera, 1D Bar-code Scanner, IR Temp Sensor, Laser Macho
Flash	NAND 128 MB
Frequency Range (Hz)	0.5 ~ 80Hz(3dB) for 3 ch. vibration and 0.5 ~ 16kHz(3dB) for 1 ch. sound
Keys	Power, Reset, Menu, Navi etc.

Maintenance work

Maintenance work consists of inspection work and maintenance work as given below:

Inspection work includes physical appearance, inspection and measurement with testing equipment to verify and survey the water supply system performance whether operation is normal or not.

The inspection work shall be daily executed by each technical specialist as a routine and/or regular inspection and shall be recorded each time. The evaluation on the collected data shall be immediately reviewed by the chief operational Engineer-in-Charge to instruct the staff member for operation on the same day and/or make a plan of detail inspection and/or make repair schedule to make sure continuous water supply system operation without any problem.

Maintenance work shall include activities, such as lubrication, overhaul, replacement of parts, repair, adjustment, detail examination and test, cleaning, to maintain the water supply system in a good condition, performance consistent and low-cost operation based on a regular and preventive maintenance schedule including attending sudden Equipment breakdown and to achieve high operational efficiency, damage of civil structures, instrumentation and control etc.

Operation work

This work consists of operation work and monitoring work:

Operation work is executing the water supply system operation based on the scheduled process and procedure to meet designed criteria including set-up or adjust the operational index or data according to the required characteristics of 24x7 water supply at the Building Distribution Network.

Monitoring work is to confirm the operation data, and readout it's measurement value on panels, and check-up the working performance of water supply system appropriately, as well as keep the records of the out-put.

2.0 SPECIFICATIONS

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer-in-Charge prior to commencement of the operation and maintenance period and must be incorporated in the O&M Register. Without being limited by this clause, during O&M period, the Agency shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation.

Table 1: List of Execution Schedule

Items	Description
Water supply maintenance of system/facilities	List of unit process, Capacity of equipment, Method/Frequency of maintenance.
Operation of water supply system/facilities	List of water supply system/equipment, Items to be monitoring/operation. Preparation of chemical, Method of system control and its note, how to input data into computer,

	operation of backup, Period of Power failure and communication method
Monitoring of water quality at water supply system & WDC Distribution Network	Scope of monitoring, Method of Measurement and analysis, Place of monitoring and name of authorized personnel
Counter measure against accident and risk management	Damage prediction, Simulation of public relations, Method of recovery, Contact address, Rescue activity and emergency team
Renewal	Replace of pipes, Replace of equipment & Facilities
Sub-contracting	Method of contract out, Scope of works, limit of responsibility
Evaluation & Report	Method of data analysis, Evaluation of collected data, Improvement program, Reporting.
Organization and administration	Executive organization chart, Segregation of duties, List of staff members, Experience, Health certificate of staff members, type of insurance, Criminal record, Personnel name of taking record and make soft data, method of data control, Operation and maintenance cost.

The Agency shall deploy Qualified Staff having knowledge of entire water treatment Water supply system and its Distribution Network.

3.0 WORKS COVERED UNDER O & M SCOPE

3.1 General

The Agency shall be responsible for, but not limited to, the following operation & maintenance works:

- Providing & Maintaining water as per specified characteristics on 24x7 basis up to WDC end as specified in the Basis of Design or as directed by the Engineer-in-Charge.
- Providing the required staffs, but not less than the minimum specified numbers/ level, during operation and maintenance period and additional staffs as per requirement during periodic maintenance and in emergencies.
- Providing all required consumables such as spares, tools, tackles & equipment and consumables required for functioning of all water supply systems and equipment.
- O & M of all functional and utility buildings, infrastructure and common areas within the water-work campuses as listed in 1.1 above.

- Entering into AMC contracts, if required, with system / equipment suppliers such as treatment water supply system, Firefighting system, Ventilation Fans, Centrifuges, Air Blowers, Hoists and cranes, Valves and actuators, Sluice Gates and actuators, pumps and mixers, and all proprietary equipment and others as necessary. It is mandatory to enter into an agreement for 8-year maintenance contract with the Controls & Instrumentation System, PLC and SCADA system supplier or the authorized system integrator, whosoever has executed the work for this project. The AMC contract shall include preventive maintenance and emergency corrective maintenance programmers, so that breakdowns can be kept to absolute minimum in frequency and duration.
- Establish work control procedures including preventive, predictive and corrective maintenance so that the entire proposed water supply system /water supply systems shall work in automatic mode and/or semi- automatic at all times.
- Maintenance of the lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures within 24 hours.
- Maintaining;
- Repair history of all mechanical, electrical and instrumentation control equipment in the proposed water supply system and communication instruments;
- Every day power availability / power failures, hourly readings of input voltage and current, frequency, power factor, kWh, kW in HT Switchgear cubicles at each pump houses.
- Log books through PLC system; Daily log of operations of all the important equipment such as VT pumps (Raw water), clarifier, RGF, Clear water pumps, blower, compressor, Firefighting system, Ventilation Fans, filter, dosing, electrically actuated valves, etc., with time tag;
- Hourly readings of temperature and pressure at Inlet & Outlet of all equipment; o water quality test results as specified.
  - ✓ chemical test results as specified.
  - ✓ Daily list of alarms with time tag;
- Log book format and the data to be included in the log book shall be decided during commissioning in consultation with the Authority;
- Last periodic maintenance done for all equipment/buildings of the system;

- In addition to maintenance of above logbooks, the Agency is required to maintain one inspection book at each process water supply system and machinery area. The complaints entered in the complaint register must be investigated and remedial measures must immediately be taken.
- Providing required spares, special tools and test equipment and maintaining adequate inventory of required accessories or equipment itself for repair of system so that the electrical, mechanical, instrumentation and control system, pipe and the communication system can work efficiently as per the guarantees given or minimum required efficiencies asked for in the Contract, without any additional costs to Authority. The Agency may use spares and tools and tackles supplied with the Contract as required by him. However, at the end of the Contract, the Agency shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.
- Providing manpower for the required repairs of all facilities along with the manpower and materials for repair of the roads, buildings and campus area utilities.
- Proper maintenance of Water Supply, Sewerage, Roads, Paths, lawns including trimming and upkeep of gardens etc.
- Proper maintenance and housekeeping along with provision of all tools & equipment.
- Maintaining stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals and laboratory consumables. The maintenance of stores will include but shall not be limited to:
  i. Loading / unloading of materials received and issued for works;
  ii. Proper arrangement of material in stores to ensure its safety and easy availability;
  iii. Maintaining store areas in a neat and tidy condition;
  iv. Keeping records and accounting for the incoming materials,
  v. Keeping records and accounting for the consumed materials.
- The Agency shall be solely responsible for the safety and security of the goods in the store and will be responsible for any loss or damages in stores for any reason.
- Periodic routine maintenance of structures/buildings. Such maintenance must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition

to this, the general hygienic standards must be maintained and adequate water supply system, horticultural activities must be taken up to maintain the total environment of the campus / building pleasant.

- Updating and periodic submissions of the operation and maintenance manual as defined in specifications for O&M works. The Agency shall take up all periodic maintenance works provided in the approved O&M manual.
- Submission of monthly report.
- Co-ordination with other Agencies and/ or agencies responsible for the execution, operation and maintenance.
- The Engineer-in-Charge shall be entitled to audit any aspect of the system and the Agency shall ensure remedial action as directed.
- Safety reporting: Brief reports of all accidents and hazardous incidents including descriptions of causes, extent of injuries, action taken, and precautions instituted to prevent repetition of such events.
- Insurance: The Agency shall, without limiting his or the Authority's obligations and responsibilities, undertake the following;
- The insurance shall be at the Agency cost and shall cover the Authority and the Agency against all losses or damages from whatsoever cause arising from the start of the O&M until the date of completion of O&M in respect of the facility or any section or part thereof as the case may be.
- Insurance shall cover for all the civil, mechanical, electrical and instrumentation works together with material and water supply system to the full replacement cost.
- Any amount not insured or not recovered from the insurer shall be borne by the Agency.
- The agency shall maintain all civil structures, pipeline, boundary wall, approach bridge & roads, storm water drainage network, sewerage network, electrical installations, instrumentation & SCADA etc. properly and keep in good working condition.

Maintenance of Civil structures

The agency shall maintain all civil structures including pipeline, boundary wall, approach bridge & roads, storm water drainage network, sewerage network, electrical installations, instrumentation & SCADA etc. in good condition throughout the maintenance period. There shall not be any sign of leakage in any water retaining structure, any splashing of concrete, worn out plaster, moss blisters etc. over the surface of the building. The agency shall maintain all sanitary plumbing installation properly. The agency shall provide painting to all MS structures as per the provision of CPHEEO manual. The agency shall provide painting to al civil structures at least twice during the maintenance period.

3.2 General Obligation

The Agency shall operate and maintain the entire water supply system under this contract for the period specified in this contract. The Agency will submit a detailed operation and maintenance plan for approval of the Engineer-in-Charge. All operation and maintenance activities shall be carried out strictly in accordance with the approved plan. The services shall include but not be limited to the following items.

- Operation and maintenance of the complete water supply system.
- Training for the O & M staffs designated by Authority's requirement.
- Generation and maintenance of periodic reports.

3.3 Operational Services

- The Agency shall operate the complete water supply system, and other associated services on a continuous 24- hour basis.
- The Agency shall operate and utilize the control and monitoring systems provided. If found necessary, he shall make adjustments (within the operation range) of the control

  system and equipment, so that the Water supply system operation matches the treatment process requirements.
- The Agency will be required to furnish the details of format for all water supply system operation and monitoring including electricity consumption in the format prescribed by the Engineer-in-Charge.

- Agency will be responsible for any penalty due to power factor, hence Agency has to maintain power factor in the limit.
- The Agency shall provide all consumables and spare required operating and maintaining the Water supply system in good condition. Any garbage generated in the water supply system shall be removed from the site on daily basis. No accumulation of such residues shall be permitted within the Water supply system campus without express application by the Agency giving adequate reasons as well as permission of Engineer-in-Charge. The Engineer-in-Charge may, if required, decide the mode and timing of disposal of such residues in consultation with concerned Environmental and Civic Authorities. Such directions shall be followed by the Agency promptly, both in letter and spirit, without any reservations and without any increase in O&M /other costs. The loading, unloading and transportation cost of these shall be borne by the Department.
- The Agency shall provide all tools & special tools, equipment, testing and checking instruments, monitors, safety items etc required for operation & maintenance of complete electrical system, Lighting system & earthing system.
- The Agency at his own expense shall provide all tools, cleaning, and housekeeping equipment, security and safety equipment.

3.4 Agency Care of Pumping Plant

The Agency shall take full responsibility for the care of the pumping plants and all other systems like control rooms, pipelines, valves and other allied systems during the contract period till it is handed over to the Authority at the end of 8 years of O&M.

If any loss or damage occurs to the treatment works or to any other system, during the period for the Agency is responsible, the Agency shall rectify such loss or damage, at his cost, so that all Pumping stations conforms to its condition when the Agency took possession of the treatment works at the commencement of the contract.

4. Instrumentation, Control & Automation (ICA)

4.1 General Maintenance

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA Systems / ICA systems. Periodic device calibration, preventive maintenance, and testing allow potential problems to be identified before they can

cause mission failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components.

4.2 Preventive Maintenance

The PLC/SCADA system shall be part of the overall preventive maintenance (PM) program for the facility.

Table below provides a list of recommended maintenance activities and frequencies for SCADA systems and their components.

Preventive maintenance schedules for SCADA components and subsystems shall be coordinated with those for the mechanical/electrical systems they serve to minimize overall scheduled down time.

Many components of SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason, the system shall be tested periodically under actual or simulated contingency conditions. These tests shall approach as closely as possible the actual off- normal conditions in which the system must operate. For example, SCADA for Dual Redundant system shall be tested by interrupting the utility source as far upstream of the normal service as possible.

Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.

The SCADA software maintenance shall include timely updates of any new versions from the supplier and testing to verify proper installation on the SCADA computer. In addition, software antivirus updates shall be maintained. This shall be performed any time after the computer is connected to the Internet or the antivirus patch shall be downloaded as and when the updates are available. Normal operation requires that the PLC/SCADA computer not be connected to the Internet. Faulty Instruments, sensors, transmitters, communication modules, computer hardware shall be replaced with new components. Repair of the failure items would not be accepted. Instruments, modules would have to replace with a new instruments and components.

5.0 APPLICABLE STANDARDS

Operation & Maintenance Procedures of proposed Water supply system under this contract shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

- Manual on EHV Substation Equipment maintenance - CBIP Publication No. 294
- Indian Electricity Rules - 1956 updated
- ASHRAE 2007 Systems and Application Handbook (with latest amendments) For building & control room air conditioning.

Other sources of information must be consulted (e.g., manufacturer's recommendations, unusual operating conditions, personal experience with the equipment, etc.) in conjunction with the maintenance recommendations.

6.0 EXPERIENCE & QUALIFICATION OF STAFF

6.1 Requirements

Operation and maintenance staff shall have sufficient experience, good health condition and adequate educational/technical qualification in addition to possessing best knowledge, abilities and skills.

6.2 Knowledge and Abilities

- Knowledge of total Water supply system & Distribution Network of similar capacity, unit operation;
- Knowledge of the method, materials, and equipment of Water supply system & Distribution Network operation;
- Knowledge of unit operation, maintenance, and servicing of pumps and other water supply system equipment and machinery;
- Abilities to make repairs and/or adjustments to water treatment plant & Distribution Network equipment and to keep records and prepare reports;
- Abilities to read and interpret gauges and recording devices used in the Water Supply System & Distribution Network;
- Abilities to lift sacks of chemicals and to read and follow written and oral instructions;
- Abilities to work efficiently with others.

For all operation and maintenance works, the Agency shall provide skilled staff, which has adequate qualifications and sufficient experience of similar works. CV of plant in charge, Plant Supervisors, Shift-in-charge, Electrical Engineer-in-Charge and ICA/ SCADA Engineer-in-Charges etc. will have to be got approved from the Authority.

Operating Personnel

MINIMUM MANPOWER DURING OPERATION AND MAINTENANCE FOR Intake well, WTP & WDC IN THE CONTRACT

Sl. No.	Position	Minimum Qualification	Experience in Years	Proposed Minimum No. of Posts
1	Station In-charge	B.E. Environmental /Civil/Mechanical	10-15	1
2	Process In-charge	B.E environmental/Civil	5-10	5
3	Electro- Mechanical Shifts in Charge	BE/Diploma Mechanical/Civil	5-10	8
4	Operator	ITI Fitter/Elec	5-10	24
5	Electrician	ITI (Elec.)	3	8
6	Fitter	ITI (Fitter)	3	8
7	Chemist	BSC (Chem.)	3	1
8	Security Staff	10+2	--	16
9	Operators cum Incharge at Cushion tanks	ITI	3-5	200
10	Fitter/Electrician at SUGRs	ITI	3-5	32
11	Operators cum Incharge at SUGRs	ITI	3-5	32
12	Special Maintenance, technical audit team	--	--	As and when required

6.3 Minimum levels of Staffing

The following paras describes the minimum levels of staffing, and their minimum qualifications and experience in similar works. The Agency shall be required to deploy these staffs for carrying out the O&M functions.

The Agency shall deploy the following persons as detailed in the General conditions of contract.

Plant in Charge:

An Engineer-in-Charge with Degree in Mechanical Engineer-in-Charge having knowledge of related electrical equipment and system with at least 10 years of experience in operation and maintenance of similar kind of water treatment Water supply system and Distribution Network. He shall be overall in charge for Pumps and Distribution Network. He shall be posted in General/Day shift (9AM - 5:30PM) and responsible for functioning of Water Treatment Plant and Distribution Network. Arranging shut downs, programming for maintenance, co-ordination between Owner and other agencies involved etc. Working knowledge in Telugu, English language is essential. Computer literate with knowledge of MS Word, Excel & MS Project.

Process in Charge:

Engineer-in-Charge Degree/Diploma of environmental/Civil Engineer-in-Charge having knowledge of Water treatment process with at least 3 years of experience of shift duties of similar kind of Water supply system and Distribution Network. He shall be posted in shift of 8 hours. There will be three Engineer-in-Charges per day and one as a Reliever. He shall be responsible for process monitoring of Water Treatment Plant and Distribution Network. He shall be shift in charge. Responsible for reporting to the Station in charge. Working knowledge in Telugu, English language is essential. Computer literate with knowledge of MS Word, Excel & MS Project.

Electrical Mechanical Shifts in Charge:

Engineer-in-Charge Degree/Diploma of Mechanical/Electrical Engineer-in-Charge and at least 5 years of experience of shift duties of similar kind of Water Treatment Plant. He shall be posted in shift of 8 hours. There will be Six Engineer-in-Charge-ins (1 Engineer-in-Charge per shift for intake well and WTP) per day and Two as a Reliever. He shall be responsible for operation of Water Treatment Plant. He shall be shift in charge. Responsible for reporting to the Station in charge. Working knowledge in Telugu, English language is essential. Computer literate with knowledge of MS Word, Excel & MS Project.

Operators:

The Operator is having Diploma of Mechanical Engineer or ITI having knowledge of related electrical equipment and system and adequate experience of shift duties of similar kind of Water Treatment Water supply system and Distribution Network. two operator intake well and four operators shall be posted in each shift of 8 hours. There will be 18 operators per day and six relievers. He shall be responsible for maintaining log books, operations during his shift. Working knowledge in Telugu, English language is essential. Computer literate with knowledge of MS Word, Excel & MS Project.

Maintenance Crew

The maintenance crew would consist of

- ✓ **Maintenance Engineer-in-Charge**

Engineer-in-Charge having Degree or Diploma of Mechanical Engineer having knowledge of related equipment and system and having adequate experience of Maintenance of similar kind of WATER TREATMENT Water supply system and Distribution Network. He shall be posted as and when required and responsible for routine and breakdown maintenance of WATER TREATMENT Water supply system and Distribution Network.

- ✓ **Electrical Maintenance Engineer-in-Charge:**

Engineer-in-Charge having Degree or Diploma of Electrical Engineer-in-Charge and having adequate experience of Maintenance of similar kind of WATER TREATMENT Water supply system. He shall be posted as and when required and responsible for routine and breakdown maintenance of WATER TREATMENT Water supply system.

- ✓ **Additional Staff**

The additional staff comprising of skilled, unskilled workers headed by Engineer-in-Charge shall be posted for routine, yearly, half yearly maintenance during break downs and shut downs as per requirement and quantum of work. Apart from above, the Testing Engineer-in-Charges along with skilled staff shall visit WATER TREATMENT Plant and Distribution Network for annual relay testing and in event of emergency whenever their services are required for smooth functioning of WATER TREATMENT Plant and Distribution Network.

Operation staff shall be exclusive and not utilized for regular, periodic and breakdown maintenance works. All the persons of the Agency shall have working interaction with the Engineer-in-Charge to enable the Agency.

Operators cum In-charge at Cushion tanks & SUGRs:

The Operator shall have ITI having knowledge of system and adequate experience of shift duties of similar kind of Water supply system and Distribution Network. Three operators shall be posted in each shift of 8 hours and additional one operator shall be posted as a standby at all WDC premises (including all cushion tanks & SUGRs compounds). He shall be responsible for maintaining log books, operations during his shift, landscaping activity, security for the entire compound area. Working knowledge in Telugu, English language is essential. Computer literate with knowledge of MS Word, Excel & MS Project.

Fitter/Electrician at SUGRs

Engineer-in-Charge having Degree or Diploma of Electrical Engineer and having adequate experience of Maintenance of similar kind of water supply system. He shall be posted as and when required and responsible for routine and breakdown maintenance of Water supply system at all SUGR premises.

Note:

1. The above requirement is minimum only. The Agency will arrange extra work force, as and when required, so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.

2. The above staff strength is exclusive of leave reserve required for different category of staff. The Agency shall ensure availability of the personnel given in the above table for all seven days in a week.

3. The Agency shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfill its obligations under O&M Contract.

4. In the event of absent of staff during the O&M, the deduction of payment shall be done on per day basis for the number of days absent, as per relevant Sub-clause.

5. The Agency shall provide manpower detail as per Annexure 3

7.0 DEFECT LIABILITY

A defect liability period of two years shall commence upon issue of the Construction Completion Certificate by the Engineer-in-Charge/Authority. During defect liability period, the Agency shall be responsible for the followings:

- Provide to Authority the advisory services and follow-up training required.
- Complete any outstanding work notified to Agency in Contract Completion Certificate or Taking Back Certificate (as applicable as per contract), issued by the Engineer-in-Charge under this clause.
- If during Defect Liability period, any defect shall be found in the system, the Agency shall promptly, in consultation and agreement with the Authority/Authority regarding appropriate remedying of the defects, and at its cost, repair, replace or otherwise make good as the Agency shall determine at its discretion, such defect as well as any damage to the facilities caused by such defect.

7.1 Extension of Defect Liability Period

The defect liability period shall be extended by the period during which any part of the works could not be used by reasons of a defect or damage, for which Agency was liable.

7.2 Failure to Remedy Defects

- If the Agency fails to remedy any defect or damage within a reasonable time, a date may be fixed by the Engineer-in-Charge, on or by which the defect or damage is to be remedied.
- If the Agency fails to remedy the defect or damage by such date, the Authority may carry out such works himself at the Agency risk and cost. Such cost, determined by the Engineer-in-Charge, shall be final and binding.

7.3 Defect Liability Certificate

Within 28 days of the expiry of the defect liability period, Engineer-in-Charge shall issue a Defect Liability Certificate stating the date by which the Agency completed all his obligations under O & M, including remedying all the defects, to his satisfaction.

The decision of the Authority on all the sub clauses of this clause shall be final and binding on the Agency.

8.0 OPERATION & MAINTENANCE EQUIPMENT

All tools and tackles required for the safe and satisfactory operation and maintenance including preventive and break down maintenance of the Water supply system and Distribution Network and related equipment covered under this tender shall be provided by the Agency.

8.1 Tools and Tackles:

1. Sling psychrometer
2. Set of pocket hand thermometers
3. Refrigerant leak detector kit
4. Combustion testing kit
5. Voltage and community tester
6. Volt-ohm-milli-ammeter with temperature adapters
7. Stroboscope tachometer
8. Vibration meter
9. Temperature recorders
10. Air velocity meter
11. Sound level meter
12. CO2 monitor meter
13. CO monitor meter
14. Combustible gas detector set
15. Clamp-on volt-ohm meter
16. Inclined manometer
17. Automatic temperature control instrument testing: air regulators, air filters and control manufacturers test tools and instruments
18. Air balancing hoods
19. Ductwork leakage testers
20. Smoke gun/candles
21. Digital pressure gauges
22. Pressure and vacuum gauges
23. OSHA- approved oxygen/acetylene welder and arc welder
24. Grinder
25. Drills

26. Grease pump
27. Vacuum pump
28. Ultrasonic flow meters
29. Refrigerant charging and testing unit
30. OSHA-approved ladders
31. Digital thermometers
32. Infrared thermometers
33. Humidity meter
34. Voltage recorder
35. Soldering gun kit
36. Combination wet/dry vacuum cleaner
37. Barrel with hand pump set
38. Electric short circuit locator
39. Megohmeter
40. Electrical cable testers
41. Hand oil pump
42. Punch and chisel set
43. Pipe wrenches
44. Flaring and swaging tool set
45. Tube bender
46. Inner-outer tube reamer
47. Tube cutter
48. Screwdrivers, Phillips head and Allen wrenches
49. Steel work benches
50. Inside and outside calipers
51. Bench vise
52. Claw hammer
53. Rubber mallet
54. Machinist’s square
55. Dividers
56. Level
57. Tap and die sets

58. Files, cabinets and tool kits
59. Snips- straight, left and right
60. Wrecking bar
61. Ratchet wrench and socket set, multiple drives and depths
62. Set of open and box-ended wrenches
63. Pie and fitting chain wrenches
64. Strap wrenches
65. Heavy-duty pipe cutter
66. Locking pliers
67. Set of pipe taps
68. Pipe threader set
69. Pipe reamer
70. Pipe cutter and tri-stand
71. Gasket-cutting tool
72. High-pressure air hose and compressor set
73. High pressure portable fan for winterizing coils
74. Set of Discharge rods (Minimum six nos.)
75. Complete set of all sizes of Double ended, Ring, Tubular & box spanners - 2 sets.
76. Complete set of all sizes of screw drivers - 2 sets
77. Complete Tool Box -2 nos.
78. 1 No. Blower & Vacuum Cleaner.
79. One derrick capable of handling highest equipment of the Water supply system Guy ropes suitable for hoisting above derrick.
80. Minimum two sets of heavy duty hand gloves of highest voltage rating available in the market, 6 No Helmets, 6 No safety belts & Safety shoes.
81. 2 No of heavy duty dry cell or rechargeable (without acid) torches. Rain coats and gum boots as required.
82. First aid box
83. 1 No. Insulation tester 5 kV capacity 1 No. Insulation tester 1 kV capacity 2 nos. Multi meter Analog & Digital Tong tester
84. Temperature Gun

85. Cable crimping tools of adequate capacity etc. Extension Power supply boards (single phase) Phase Sequence meters
86. PC with printer

The above-mentioned tools & tackles shall be provided separately for Intake well and WTP.

8.2 Consumables

1. Minimum 20 kg of Petroleum jelly.
2. Minimum 5 bottles of Carbon tetra chloride(CTC) Minimum 5 bottles of contact cleaner spray
3. M seal, epoxy compound, sealing compound, paint, red oxide etc. Fuse wire, Insulation tape, emery paper, HT tape etc.
4. 20 kg of Silica gel, Gaskets sheet, cotton tape, Teflon tape etc.
5. Cotton waste, muslin cloth, waste cloth, cleaning agents etc. Transformer oil for topping up of Transformer, SF6 Gas Cylinder
6. All major consumable like Transformer oil, SF6 gas and its filling kit, indicating lamps, Luminaries, control and power wires/ cables, Battery solution, etc.

9.0 MANDATORY SPARES

Proper preservation norms are to be adopted to perform periodic Condition Monitoring tests on spares to keep them healthy and usable.

The practice of removing sub-assemblies from main spares during emergencies needs to be regulated properly. Any component removed needs to be replenished as early as possible so that the main spares are always kept complete. Proper transportation cases also need to be kept at central stores to avoid transportation delays when transported to the required destination.

All spares recommended by manufacturers of equipment as given in **Appendix – E** shall be installed in the Plant.

Nuts, bolts, washers of sizes used in Water supply system and other systems.

Fuse holders and HRC fuses, terminal links, control wires and lugs of rating used in the Water supply system and other systems.

The Agency shall keep ready stock of all items/ consumables for day to day maintenance/ repairing works.

10. MAINTENANCE SCHEDULES

Maintenance scope include both preventive and breakdown maintenance. Preventive maintenance shall be routinely carried as per details provided herein below.

Breakdown maintenance shall be provided as and when situation warrants with a failure or fault in the system. The breakdown maintenance shall be attended at the highest priority so to make good the faulted system and putting into operation. For breakdown maintenance, the Agency shall coordinate/liaison with Engineer-in-Charge and the original equipment manufacturer for replacement parts and services as necessary. Infrastructure, tools and tackles and site support shall be provided by the Agency for such jobs with priority and without unnecessary delays. OEM parts and services, if any, required for the completion of breakdown services shall be approved and cleared for execution by appropriate authorities.

During the preventive (routine) maintenance, the Agency shall carry out the following as listed for various system components given in Appendix D.

Though the list in Appendix D contains several individual jobs they could be executed in a combined scope as in servicing or overhauling of the component.

The maintenance jobs which are specifically underlined in the following list shall be carried out by OEM supplier or their authorized service provider only. The Agency shall be required to provide proof for the same before executing the job.

In addition to the Equipment given in Appendix D, visual Inspections and Required Periodic Maintenance shall also be carried out on the following:

- Control circuits
- Cranes and Hoists Motors and their wiring
- Electrical Drawings
- Emergency Lighting
- Fuses
- Motors
- Personnel Protective Equipment
- SCADA System

Apart from the above Maintenance Schedules, Preventive Maintenance Procedures, Condition Based maintenance, Residual life Assessment of all the Water supply system & Distribution Network Equipment shall be carried out.

10.1 Operations

Hourly:

- Taking readings of all meters installed at control panel. ACDB, DCDB, Battery Charger etc. Air and Gas pressures of Gas circuit breakers.
- Oil & Winding temperatures of Transformers.
- Taking the reading of surge arrestor counters of Lightning Arrestors, Checking any sparking or flash over / hot spots in the Water supply system.

Daily:

- Checking the operation of Circuit breaker.
- Visual Checking contacts of Isolators are in proper position or not.
- Checking oil levels of all bushings, Main & OLTC Conservator, CTs and PTs, etc.
- Checking oil leakages if any for Transformers, CTs & PTs & taking appropriate action for its timely repair
- Checking air / gas/ oil leakages if any for Circuit Breakers.
- Checking condition of Silica gel.
- Checking DC voltage & periodic maintenance of battery banks.
- Cleaning of premises, Control relay panels etc.
- Maintaining log books and daily check list.
- Checking Deposition of dust and dirt on Insulators.
- Checking Locks and doors of Water supply system are in good condition.
- Checking no leaks have developed in the roof, Ventilating systems.
- Checking the heating systems are working normally.
- Checking the prescribed safety aids are in place and in good order.
- Checking the earthing connections is unbroken.
- Checking the packing of cables entering and leaving the trenches or tunnels within the premises are intact.

- Checking the ventilating louvers are not damaged.
- Checking the access roads to the oil filled devices is not obstructed.
- Draining the air / moisture from air conservators of circuit breakers.
- Trouble shooting and repair of Electrical circuits components in case of any abnormal conditions.

Monthly:

- Checking Auto/ Manual operations of OLTC.
- Checking earthing points and their contact, tighten wherever required.
- Preparation of monthly checklist and events log for the month.

Events:

- Logging auto / manual operations of OLTC.
- Logging the breakdown events with relay indications etc.
- Logging shut down events, log of operations during shut down period.
- Logging of on / off of feeders in the 33kV, 6.6kV and 415V distribution system. Maintaining visitors registers along with their comments and details of their visits.

11.0 DOWN TIME

The Water supply system shall never be operated at less than its design capacity due to maintenance and repair reasons.

The maximum downtime for any electro-mechanical equipment shall not exceed 8 hours, the periods for repairs and maintenance have to be communicated to the Engineer-in-Charge at least one month in advance. For machinery and equipment which requires maintenance to be carried out by manufacturer/ manufacturer's authorized representative. Authority reserves the right to impose Liquidated damages, shall there be any default by Agency on this account. The Liquidated damages amount will be deducted in the next O & M bill if adequate reasons are not furnished by the Agency for delay.

Applicable rate for Liquidated damages have been given elsewhere in the document

12.0 PAYMENTS

The Agency, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, shall include all costs for carrying out all O&M responsibilities. O&M payment shall be released according to the KPI mentioned elsewhere in the bid document. The cost of electric power consumed, which will be paid directly by the Authority.

13.0 MAINTENANCE FORMATS

The Agency shall follow the Maintenance Formats of various system components as listed out in **Appendix – F**

14.0 OPERATION & MAINTENANCE LABOUR REGULATIONS

The Agency shall follow the Operation & Maintenance Labour Regulations as stated in **Appendix – G**

15.0 Key Performance Indicator (KPI)

The contractor/EPC Agency shall be subject to the following penalties for failure to carry out its operations as indicated below during "Performance Based O&M period" (10 years including DLP of 2 years) under Normal Operating Conditions. The Key Performance Indicators (KPIs) are as follows. The KPIs will be monitored through the sensors, PLC controlled SCADA system, Citizen Charter of Amaravati Capital or those observed and recorded by the officers' concerned in-charge of the project and accordingly the EPC Agency will be penalized for not complying with the following KPIs.

15.1 Water Quality:

Failure to achieve the specified treated water quality parameter at the common delivery manifold of the Clear Water Pump during the O&M period shall entail the following penalties as % of the O&M Monthly payment for failure to pass the Tests during O&M period for each additional "quantum" (as defined below) of the water quality parameter or part thereof beyond the specified maximum concentration present in the actual water produced during the Tests on Completion.

Parameter (Monthly Avg.)	Specified maximum concentration	Measured Parameter in excess of Specified	Penalty/day as % of O&M Monthly Payment
Turbidity (N.T.U.)	1 NTU	1.01to 1.2 NTU	**1.0%**
		1.21 to1.5 NTU	**2 %**
		1.51 to 1.8 NTU	**5 %**
Colour (Units on Platinum Cobalt Scale) TCU	5	6	**1.0%**
		7	**1.5%**
		8	**2.5%**
pH	6.5 to 8.5	6.8 or 8.7	**0.5%**
		6.7 or 8.8	**1.0%**
		6.6 or 8.9	**2.0%**
Residual Aluminum mg/l, Al	Less than 0.03	0.04 mg/lit,	**0.5%**
		0.045 mg/lit,	**1.0%**
		0.05 mg/lit,	**2.0%**
Residual Chlorine	0.8 to 1 ppm	0.7 or 1.5 ppm	**2%**
		0.6 or 2 ppm	**4%**

For the water quality and for a given water treatment plant, Performance Damages shall not exceed 25% of the O&M Contract Price. However, for non-compliance of the quality for more than one parameter, 25% Performance Damages limit shall apply separately with an overall cap of 50% of monthly O&M payment.

Further, all remedies other than performance damages, including but not limited to construction of additional facilities, additional equipment and repair and/or replacement of the installed equipment shall continue to be fully available to the Employer, and the Employer may choose to invoke any or all of them at any time in accordance with the terms of the Contract.

Loss of Water

Entire water distribution system designed for Zero Discharge basis. Water losses beyond the contractual condition leads to penalization. O&M period shall entail the following penalties as % of the O&M Monthly payment for failure to “Zero Discharge”

during O&M period for each additional "quantum" (as defined below) of the water quantity parameter

Parameter (Monthly Avg.)	Specified maximum concentration	Measured Parameter in excess of Specified	Penalty/day as % of O&M Monthly Payment
Loss of Water	1%	1.2 %	**1.0%**
		1.5 %	**2%**
		1.7 %	**3.5%**

15.2 Penalties against Excess Energy Consumption and low Power Factor:

15.2.1 Penalties for Excess Energy Consumption

The penalties for excess energy consumption for O&M of the constructed Works for various treatment components of entire WTP shall be as under:

The Bidder shall guarantee that the electrical energy usage of various treatment, pumping components of the Intake well, Raw water raising main, WTP, Clear water pumping station, Clear water pumping main and WDCs (including auxiliary) throughout the Operation and Maintenance Period. The bidder shall submit the energy consumption detail for treatment of water per Million Litre per month as per Table-1 for EIC approval.

Bidder shall conduct energy audit every year and take necessary remedy action to control within the approved guaranteed energy parameter. The energy audit report and action plan shall submit for EIC approval.

TABLE – 1

GUARANTEED POWER FOR OPERATION OF Intake well, Raw water raising main, WTP, Clear water pumping station, Clear water pumping main and WDCs (including auxiliary) UNDER DESIGN MONTHLY AVERAGE INFLUENT SEWAGE FLOW AND BOD CONDITIONS

Sl. No.	O&M YEAR	KWh/ YEAR	KWh/MONTH	KWH/ML/Month
1	FIRST	E_1	$E_1/12$	E_1/(12*(ML of water Produced in a month))
2	SECOND	E_2	$E_2/12$	E_2/(12*(ML of water Produced in a month))
3	THIRD	E_3	$E_3/12$	E_3/(12*(ML of water Produced in a month))
4	FOURTH	E_4	$E_4/12$	E_4/(12*(ML of water Produced in a month))
5	FIFTH	E_5	$E_5/12$	E_5/(12*(ML of water Produced in a month))
6	SIXTH	E_6	$E_6/12$	E_6/(12*(ML of water Produced in a month))
7	SEVENTH	E_7	$E_7/12$	E_7/(12*(ML of water Produced in a month))
8	EIGHTH	E_8	$E_8/12$	E_8/(12*(ML of water Produced in a month))
9	NINTH	E_9	$E_9/12$	E_9/(12*(ML of water Produced in a month))
10	TENTH	E_{10}	$E_{10}/12$	E_{10}/(12*(ML of water Produced in a month))

The penalties for excess energy consumption for O&M of the constructed Works for WTP and Pumping shall be as under:

Sl. No.	CONDITION	RATE OF PENALTY
a)	If the power consumption is lower than the guaranteed / assessed power consumption	Neither benefit nor deduction on account of power consumption shall be made.
b)	If the actual power consumption exceeds the guaranteed / assessed power consumption	Damages payable by the Contractor to the Employer on a monthly basis shall be ***equal to 2 times*** the cost of the excess energy used for O&M for WTP at the prevailing energy charges being paid by the Employer to APSPDCL.

The Bidder shall guarantee that the energy usage of various components of the Works will not exceed the values listed in the table above, as demonstrated by the Tests after Completion and throughout the Operation and Maintenance Period. The actual electrical energy usage shall be directly metered and compared to guaranteed numbers on a monthly average basis.

15.2.2 Penalty for low Power Factor:

Penalty for low power factor shall be imposed on the contractor in case the APSPDCL imposes the same on the Employer.

Sl. No.	Basis of Penalty	Benchmark	Penalty Value for each Parameter specified in the bid document
1	PF maintenance for H.T. Supply pertaining to the scope of work contemplated in this project	Above 0.99	No penalty
		0.95 & up to 0.9888	Additional Units (kWH) will be charged to the contractor with one-time penalty.
		Below 0.95 & up to 0.90	Additional Units (kWH) will be charged to the contractor with two-time penalty.
		Below 0.90	Additional Units (kWH) will be charged to the contractor with three times penalty or Termination of the contract.

15.3 Breakdown of Equipment:

In case of breakdown of equipment for more than the stipulated time period as below, on discretion of Engineer-in-Charge, the Contractor shall be penalized as mentioned below:

Equipment	Breakdown Time Period	Penalty Imposed
All Electro Mechanical Equipment and Instrumentation, online monitoring equipment, laboratory equipment	beyond 48 hours i.e. 48 hours	3% of Monthly O&M Cost per day of default beyond permitted breakdown time period
Semi-Critical Equipment		
Safety Equipment		
Filling of gas in safety equipment	Within 24 hrs	No penalty

Equipment	Breakdown Time Period	Penalty Imposed
	24 hrs to 48 hrs	0.5% of Monthly O&M cost
	48 hrs to 72 Hrs	1.5% of Monthly O&M cost
All safety Equipment	Within 24 hrs	No penalty
	24 hrs to 48 hrs	0.5% of Monthly O&M cost
	48 hrs to 72 Hrs	1.5% of Monthly O&M cost

15.3.1 Penalty of Non Compliance Safety Measure, Explosive Licence and Public Liability Insurance

Measure	Time Period	Penalty
Safety Measure Not using PPE (Personal Protective Equipment) devices, Noncompliance to Occupational Safety, Health & Environment guidelines, Non-Compliance to State & Central Statutes in O&M	Up to 2 occurrences/Month	No penalty
	>2 & up to 5 Occurrences/Month	Rs.1,0000/-per Occurrence
	>5 & up to 10 Occurrences/Month	Rs.5,0000/-per Occurrence
	Above 10 occurrences/Month	Rs.10,0000/- per complaint (or) Termination of the Contract
Explosive License	2 Days	No Penalty
	1 week	Double the penalty charged by Explossive Department or 100000 whichever is higher
Public Liability Insurance	2 Days	No Penalty
	1 week	Double the penalty charged by Insurance authority or 100000 whichever is higher

15.4 Additional Conditions:

i. The analysis for the Plant Performance Evaluation for Commissioning Certificate, Defects Liability Period and Operation & Maintenance, should be carried out at the Third Party Reputed Laboratory as approved by the Engineer-In- Charge.

Note:

a. The above stated analysis requirements are in addition to the routine analysis for commissioning or regular course of operation as per the tender document and can be done at plant scale.

b. The Charges for the Third-Party Laboratory Testing shall be borne by the Contractor.

c. The frequency of Sampling for

- Completion/ Commissioning – Three (03) Composite Samples per day, for Three (03) Consecutive Days (72 Hours)
- Operation & Maintenance - Four (04) Nos. of Composite Samples on any day (Weekly Once).

ii. The statutory Charges from APPCB / CPCB or any other Authority for any Compliance/Liasoning should be paid by the Contractor on behalf of the Client and would be reimbursed by the client at actual on production of proof of payment.

iii. Any Penalty imposed by APPCB / or any other Authority for Non-compliance of Effluent Discharge Standard/s shall be recovered from the Contractor at twice the Penalty imposed by the above authority/(ies) on the Employer.

15.5 The KPIs will be monitored through the Sensors, PLC controlled SCADA, complaints in the Citizen Charter of the concerned Corporation / Municipality / Department or those observed and recorded by the officers in-charge of the project during their inspections and accordingly the contractor will be penalized in case of its non-compliance with the above KPIs.

16.0 Biometric attendance

The agency has to show the record of 90% and above attendance of the approved organogram on monthly basis through biometric system. If the attendance record fall below 90% the monthly payment shall be on prorate basis as per the attendance percentage. Biometric system will be connected with SCADA for attendance report generation.

17.0 Maintenance of Civil structures

The agency shall maintain all civil structures in good condition throughout the maintenance period. There shall not be any sign of leakage in any water retaining structure, any splashing of concrete, worn out plaster, moss blisters etc. over the surface of the building. The agency shall maintain all sanitary plumbing installation properly. Any complaint from residents of quarters, officers/office staff, the agency shall take immediate action and complete the work within 2 days. If the agency fails to attend any complaint within 2 days, the agency shall be penalized. For noncompliance of the complaints, deduction @ twice the expenditure incurred for rectification or Rs. 25,000/- whichever is more shall be made from the agency bill for each incident.

18.0 Maintenance of pipelines & valves

The agency shall maintain entire pipe network and valves upto WDCs in Amaravati capital city in god condition throughout the maintenance period. The agency shall take immediate action on receipt of any leakages/damage in pipelines, valves and shall repair the leakages/damages within 48 hrs (2 days) failing which the agency shall be penalized. For noncompliance of the complaints, deduction @ twice the expenditure incurred for rectification or Rs. 50,000/- whichever is more shall be made from the agency bill for each incident.

Note: For all the complaints, rectifications etc., the online complaint redressal system will be the basis for levying the penalties and also those observed and recorded by the officers concerned.

ANNEXURE - 3

RESOURCES: PERSONNEL

a. Name of Staff Technical Administrative

b. Please list names and present position of Technical Staff:

S No	Name	Position

c. Details of qualification and experience etc. of Technical Staff:

Sr. No.	Name	Age	Qualification	Experience	Nature of works handled	Name of the projects handled and cost	Date from which in your organization	Any other remarks

Note: Indicate other points, If any, to show your technical and managerial competency

Under Agency scope:

- Office space (one-room) for Engineer-in-Charge & safe storage will be provided.
- Spares for replacement as and when required.
- Boarding & lodging to his personnel.
- Medical facility & Insurance coverage.
- All tests, measuring instruments & tools with valid calibration certificate as mentioned above. Any facility not mentioned in 'A'
- Uniform to staff.
- PC for data entry and printer for printout of technical reports.
- Safety gears like helmets, shoes and safety belts, aprons and gloves (general and insulated type).
- Transport facility for Agency staff.
- Stationery as per work requirement.
- Equipment like Filter Machine.

APPENDIX - D
MAINTENANCE SCHEDULES

D-Daily, W-Weekly, M-Monthly, QY-Quarterly, HY- Half Yearly, Y-Yearly, 2 Y- Once in 2 years, 3 Y- Once in 3 years, 4 Y- Once in 4 years, SOS - as and when required.

Always use a periodic maintenance program to ensure the best possible unit performance and efficiency.

The maintenance schedules to be adopted by O & M Personnel are:

Sr. No	Maintenance or test	Recommended Interval
1	Check pump's rpm.	D
2	Check for vibration or unusual sounds/ noise	D
3	Check bearing temperature	D
4	Check lubricating oil pressure/level	D
5	Check for excessive generation of heat in gland	D
6	Check for water leakage from gland packing	D
7	Check pressure gauge readings	D
8	Check position of valves	D
9	Checkup no loose bolts/nuts/tighten	D
10	Check bearing grease and lubricating oil level/deterioration. Fill or change if necessary.	M
11	Check gland packing wear.	M
12	Check pressure gauge readings.	M
13	Adjustment/Checkup sensors, safety devices and its performance	M
14	Re-tighten fastening bolts for stationary parts	HY
15	Check flow relay, pressure switch, temperature switch (etc.) and other protective devices	HY
16	Performance test.	Y
17	Replace bearing grease and lubricating oil.	Y
18	Replace gland packing.	Y
19	Disassembly inspection	Y
20	Overhaul and service unit	Y

Electrical motors

Sr. No.	Maintenance or test	Recommended Interval
1	Check for vibration or unusual sounds	D
2	Check bearing temperature	D
3	Check frame temperature	D
4	Remove any dirt or debris from slip rings and brush holder area	D
5	Check brush up/down movement, length and downward pressure	M
6	Check bearing grease and lubricating oil levels and fill if necessary	HY
7	Measure coil insulation resistance (MΩ).	HY
8	Check working order of flow relays, pressure switches, and temperature switch, protective devices, etc.	HY
9	Performance test	Y
10	Replace bearing grease and lubricating oil.	Y
11	Terminal connection checking	HY
12	Overhauling	SOS

LT panels

Maintenance or test	Recommended Interval
Cleaning of bus bars, insulators, etc.	Y
Tightness of the connections	Y

Sr. No	Maintenance or test	Recommended Interval
1	Fan guard attached	D
2	Fan fastened tightly to post	M
3	Check fan orientation	M
4	Clean fan guards	HY
5	Clean motor and controls	HY
6	Lubricate fans	Y
7	Repaint corroded metal	Y
8	Check total electrical circuit	Y

9	Cleaning of suction air filters	QY
10	Check for unusual noise & vibration	QY
11	Checking of all interlocks	Y

TRANSFORMERS

Without shut down activities

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of bushing oil level	M
2	Checking of oil level in conservator	M
3	Checking of oil level in OLTC conservator	M
4	Manual actuation of cooler oil pumps and fans	M
5	Checking of oil leaks	M
6	Checking condition of silica gel in breather	M
7	Checking of oil level in oil seal of breather	M
8	Testing of oil for DGA and other oil parameters	M

Shut down activities

Sr. No.	Maintenance or test	Recommended Interval
1	BDV, ppm of OLTC Diverter Switch compartment oil (Less frequently if operations are not more)	Y
2	External cleaning of radiators	Y
3	Cleaning of all bushings	Y
4	Checking of auto starting of cooler pumps and fans	Y
5	Marshalling boxes of transformer (i) Cleaning of marshaling boxes of transformer (ii) Tightening of terminators (iii) Checking of Agency, space heaters, illumination, etc.	 Y Y Y
6	Maintenance of OLTC driving mechanisms	Y
7	Checking of all remote indicators (WTI and Tap position indicator) and top up oil in pockets, if required	Y
8	Electrical checking/testing of pressure relief device, Buchholz relay, OLTC surge relay/checking of alarm/trip and checking/replacement of the gaskets of the terminal box	Y
9	Checking/testing of Buchholz relay by oil draining	Y
10	Frequency response analysis	SOS
11	Tan measurement of bushings	Y

12	Recovery voltage measurement	SOS
13	IR measurement of Windings (Polarization Index and D.A. Ratio)	2Y
14	Tan measurement of Windings	2Y
15	Checking and cleaning of diverter contacts	2Y
16	Checking and calibration of OTI, WTI	2Y
17	Measurement of Windings resistance at all tap positions	4Y
18	Filtration/degassing of main tank oil	SOS
19	Testing of bushing CT's	SOS
20	Filtration/replacement of oil of OLTC	SOS
21	Measurement of Windings Ratio	SOS
22	Checking of earthing connections	Y

Note:

(i) Insulation resistance measurement, tan delta of winding resistance at all taps to be carried out once before expiry of warranty and then to be continued as per schedule.

(ii) FRA at factory and during pre-commissioning is preferable to serve as base signature.

CIRCUIT BREAKERS

Most breaker maintenance (except thermovision scanning) must be performed with equipment de-energized.

Maintenance Schedule for Circuit Breakers:

(i) Breaker operations checks

Sr. No.	Maintenance or test	Recommended Interval
1	CB operating timings (Main, PIR, Aux.)	Y
2	Static contact resistance measurement	2Y
3	Dynamic contact resistance (DCRM), contact travel, contact speed, contact wipe, arcing contact length	2Y
4	Checking of pole discrepancy relay	Y
5	Functional checks, duty cycle operations including rapid re-closing (O-0.3s-CO)	Y
6	Checking of all operation lock-outs including SF6 density monitor	Y
7	Checking of all interlocks	Y

8	Checking of pressure settings	Y
9	Cleaning of breaker interrupter, support insulators, PIRs and grading capacitors	Y

(ii) Measurement/testing

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of close/trip coil currents	Y
2	Checking of healthiness of operation counter	Y
3	Capacities and tan measurement of grading capacitors	4Y

(iii) Control cabinet

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of tightness of all cable terminations in MB	Y
2	Checking of door sealing gaskets and replacement, if necessary	Y
3	Repainting of metallic surfaces	SOS
4	Checking of space heater (before monsoon)	Y

(iv) SF6 circuit breakers

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of oil leaks from grading capacitors	M
2	SF6 gas leakage test	SOS
3	Dew point measurement of SF6 gas	3Y
4	Checking tightness of foundation bolts	Y

(v) Vacuum circuit breakers

Sr. No.	Maintenance or test	Recommended Interval
1	Cleaning of control cubicle and checking for loose connections	QY
2	Checking of ON/OFF indicator, spring charge indicator and Checking manual and electrical operation	HY
3	Checking vacuum of interrupter by application of high voltage by disengaging with operation mechanism	Y
4	Checking erosion of contacts by erosion mark on operation rod or measurement of gap specified in closed position of contacts (wherever provided)	Y

5	Checking tightness of foundation bolts	Y
6	Replacement of vacuum interrupter	SOS

(vi) Spring operated mechanism

Sr. No.	Maintenance or test	Recommended Interval
1	Oil leakages from close and open dashpots, replace the same if leakages observed	Y
2	Greasing/lubrication of gears and various latches in the operating mechanism	Y
3	Checking of play of gaps in catch gears	Y
4	Maintenance of spring charging motors, cleaning of carbon brushes and Agency	Y
5	Replacement of oil in dashpot	SOS

D) CURRENT TRANSFORMERS

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of bellow expansion	M
2	Visual inspection of CT for oil leakages and crack in insulator etc.	M
3	Thermo vision scanning of CT	Y
4	Checking of oil leakages in terminal box	Y
5	Checking of primary connection strips, if provided externally	Y
6	N2 pressure checking	2Y
7	Measurement of tan delta and capacitance	2Y*
8	I R measurement (DAR)	2Y
9	Checking of primary connection strips, if provided externally	SOS
10	Measurement of CT secondary resistance	SOS
11	Magnetization characteristics	SOS
12	CT ratio test	SOS
13	DGA and testing of other parameters of oil	SOS
14	Checking of burden on the second winding	SOS

**To be repeated before one year from commissioning and then as per schedule*

E) POTENTIAL TRANSFORMERS

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of oil leaks	M
2	Measurement of voltage at control room panel	HY
3	Visual checking of earthing HF point	Y
4	Checking for any breakage or cracks in cementing joint	Y
5	Capacitance and Tan delta measurement	3Y*
6	Testing for EMU tank oil for BDV (if oil found discoloured)	SOS
7	Checking for rust and painting	SOS

**To be repeated before one year from commissioning and then as per schedule. This test is not possible to be conducted at site if isolation of neutral or immediate PT is not possible at site.*

F) LIGHTNING ARRESTORS

Lightning arresters are static devices which require fairly infrequent maintenance. Most maintenance must take place while the associated circuit is de-energized. However, crucial visual inspections and thermovision scans can take place while energized.

Maintenance Schedule for Lightning Arrestors:

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of leakage current (Third harmonic resistive current)	Y
2	Testing of counters and leakage current meters	Y
3	Cleaning of insulator	Y
4	Checking of earth connection between surge arrester, surge monitor and earth	Y
5	Measurement of capacitance and tan delta and IR of each stack	SOS

G) BUS-BAR, WATER SUPPLY SYSTEM ILLUMINATION, ETC.

Except for thermovision scanning, bus maintenance must be conducted de-energized.

Sr. No.	Maintenance or test	Recommended Interval
1	Measurement of station earth resistance	Y

2	Cleaning of insulator	Y
3	Cleaning of insulator for cracks	Y
4	Thermovision scanning of all conductor joints, connect-ors/clamps, terminator	Y
5	Removal of hot spots	Y
6	De-weeding of substation	SOS
7	Checking of earth connection of MOM box	SOS
8	Repainting, rust removal of all structures, equipment, etc.	SOS
9	Checking of Water supply system lighting	SOS

H) PROTECTION SYSTEMS

Calibration and Periodic functional testing is recommended to ensure the integrity of protec-tion circuits.

Sr. No.	Maintenance or test	Recommended Interval
1	Testing of DR/EL with time synchronization unit	M
2	Calibration of tariff energy meters	-
3	Checking of voltage (in service) for relays	Y
4	Checking of DC logic circuits for trip and annunciations in-cluding timers by simulation	Y
5	Calibration of panel meters (Indicating/recording instru-ments along with the transducers)	4Y

(i) Bus bar protection

Sr. No.	Maintenance or test	Recommended Interval
1	Primary injection test	SOS
2	Protection stability and sensitivity checks	SOS
3	Relay and DC logic check	1Y

(To be done whenever the protection AC circuits are disturbed like addition of new feeder)

(ii) Differential relays

Sr. No.	Maintenance or test	Recommended Interval
1	Pick up current at the fixed/selected setting	Y
2	Operation of high set element/instantaneous unit at the fixed/selected setting	Y

3	Operation of the relay at the selected restraint bias setting	Y
4	Checking of 2nd harmonic current restraint feature	Y
5	Operation of alarm and trip contacts	Y
6	Through current stability checks on the existing load	Y

(iii) Under voltage relay

Sr. No.	Maintenance or test	Recommended Interval
1	Starting and pick up of the relay as per plug setting	Y
2	Relay Operating time as per relay characteristics	Y
3	Operation of alarm and trip contacts	Y
4	Verification of input voltage on relay terminals	Y

(iv) Over voltage relay

Sr. No.	Maintenance or test	Recommended Interval
1	Starting and pick up of the relay as per plug setting	Y
2	Relay Operating time as per relay characteristics	Y
3	Operation of high set element/instantaneous unit at voltage setting, if applicable	Y
4	Operation of alarm and trip contacts	Y
5	Verification of input voltage on relay terminals	Y

(v) Over current and earth fault relay

Sr. No.	Maintenance or test	Recommended Interval
1	Starting and pick up of the relay as per plug setting	Y
2	Time of Operation as per relay characteristics	Y
3	Operation of high set element/instantaneous unit at current setting, if applicable	Y
4	Operation of alarm and trip contacts	Y
5	Verification of input currents	Y
6	Verification of directional feature, if applicable	Y

(vi) Under frequency relay

Sr. No.	Maintenance or test	Recommended Interval
1	Pick up value of the relay as its settings by slowly decreasing the frequency from 50 HZ	Y
2	Drop off value of the relay as its settings by slowly increasing the frequency from pick up value	Y
3	Verification of df/dt feature of the relay, if applicable	Y
4	Operation of alarm and trip contacts	Y
5	Verification of input voltage on relay terminals	Y

- **Local breaker back up protection, restricted earth fault (REF) and other instantaneous current operated relays**

Sr. No.	Maintenance or test	Recommended Interval
1	Pick up value of the relay at the selected setting	Y
2	Operating time of the relay	Y
3	Operation of alarm and trip contacts	Y
4	Verification of input voltage on relay terminals	Y
5	Through current stability checks on the existing load in case of REF/circulating current differential protection	Y

- **Fuse failure relays**

Sr. No.	Maintenance or test	Recommended Interval
1	Remove main fuse of each phase voltage input to the distance protection scheme one by one in the relay panel	Y
2	Checking that the "VT Fuse Fail Alarm" is received	Y
3	Checking that the distance protection does not operate	Y

- **HT SWITCHGEAR, HT PANEL, ETC.**

  - **<u>HT panels</u>**

Sr. No.	Maintenance or test	Recommended Interval
1	Cleaning of bus bars, insulators, etc.	Y

2	Relays testing	Y
3	Tightness of all electrical connections	Y
4	Checking of indicating meters	Y
5	Check for change-over facility, if provided	Y
6	Check operation/Indications in Off-load conditions of VCB	Y
7	Check spring charging of VCB	Y

- **HT switchgears**

Sr. No.	Maintenance or test	Recommended Interval
1	Functional Checking (Trip, close, etc.) of 33/11kV CB's	Y
2	Measurement of operating timings	Y
3	Cleaning of insulators and tightness of terminal connections of CB's, CT's, PT's, Isolators, etc.	Y
4	Alignment Checking of isolators	Y

I) TELEPHONE EXCHANGE

Sr. No.	Maintenance or test	Recommended Interval
1	Maintenance of EPAX as per recommendations of the manufacturers	SOS

J) BATTERIES AND DC DISTRIBUTION SYSTEM

Battery system maintenance shall have highest priority. Computerized, online battery monitoring systems can greatly reduce maintenance required on battery systems and actually improve battery reliability and increase battery life. Battery chargers, important to the health and readiness of battery systems, require regular maintenance as well.

Maintenance Schedule for Batteries and DC Distribution system:

Sr. No.	Maintenance or test	Recommended Interval
1	Measurement of specific gravity and voltage of cell	M
2	Checking electrolyte level and topping up with DM water, if required	M
3	Checking of Emergency DC lightening to control Room	M
4	Checking of any earth fault (If E/F relay not provided)	M

5	Checking of electrical connections of charger panel and DCDB panels for tightness and cleanliness	Y
6	Checking of electrical connections for batteries and application of petroleum jelly on cell terminal, if required	Y
7	Checking control cards of charger and measurement of test point voltage values	Y
8	Battery impedance testing (Optional)	Y
9	Testing of DC E/F and under voltage relays	Y
10	IR measurement of charger transformer	Y
11	Discharge test of battery set	3Y

K) FIRE PROTECTION SYSTEM

Compressor

Sr. No.	Maintenance or test	Recommended Interval
1	Cleaning/replacement of air filter	M
2	Checking of compressor oil and replace, if necessary	QY
3	Maintenance and cleaning of compressor valves, gaskets, valve plates and replace, if necessary	QY
4	Operation check of low oil level switch	QY
5	Cleaning and Checking for seating of the breather valve	QY
6	Cleaning of NRV/HP tank	Y
7	General overhaul	SOS

Fire alarm system

Sr. No	Maintenance or test	Recommended Interval
1	Sequence test for annunciation in control room panel	M
2	Smoke test	M
3	Cleaning	M
4	Battery electrolyte level checking	M

Diesel engine

Sr. No	Maintenance or test	Recommended Interval
1	Checking of auto starting of diesel engine	M
2	Check oil level, top up if required	M

3	Checking/replacement of fuel oil/lube oil/air filter	Y

Jockey pump

Sr. No	Maintenance or test	Recommended Interval
1	Checking leakage and oil lubrication	M
2	Pump overhauling	SOS

V-belt drive

Sr. No	Maintenance or test	Recommended Interval
1	Checking of belt tightness	QY

Strainers

Sr. No	Maintenance or test	Recommended Interval
1	Checking of oil strainer	QY

Motors

Sr. No	Maintenance or test	Recommended Interval
1	Checking of terminal connection	HY

Pumps

Sr. No	Maintenance or test	Recommended Interval
1	Checking of operation of hydrant pumps sump pumps, jockey pumps	M
2	Adjustments of glands for leakages and tightening of nuts and bolts	HY
3	Checking of alignment of pump set	Y
4	Replenishment of grease	SOS
5	Overhauling	SOS

Hydrant system

Sr. No	Maintenance or test	Recommended Interval

1	Checking of pressure of the hydrant system, at the remotes end, auto starting of pumps, diesel engine, etc.	Y

Deluge system

Sr. No.	Maintenance or test	Recommended Interval
1	Operation of deluge system, check outlet pressure, check alarm, check starting of diesel/electrical pumps	Y

Electrical panels

Sr. No.	Maintenance or test	Recommended Interval
1	Cleaning and tightening of terminals	Y

General

Sr. No.	Maintenance or test	Recommended Interval
1	Greasing of all values	HY
2	Painting of pipes, air lines, marshaling box	SOS

Fire extinguishers

Sr. No.	Maintenance or test	Recommended Interval
1	Re-filling of fire extinguishers	SOS

LT SWITCHGEAR, LT TRANSFORMER, LT PANEL, ETC.

LT panels

Sr. No.	Maintenance or test	Recommended Interval
1	Cleaning of bus bars, insulators, etc.	Y
2	Relays testing	Y
3	Tightness of all electrical connections	Y
4	Checking of indicating meters	Y
5	Check for change-over facility, if provided	Y

6	Check operation/Indications in Off-load conditions of air CB	Y
7	Check spring charging of air CB	Y

LT switchgears

Sr. No.	Maintenance or test	Recommended Interval
1	Functional Checking (Trip, close, etc.) of ACB's, MCCB's & MCB's	Y
2	Measurement of operating timings	Y
3	Cleaning of insulators and tightness of terminal connections of CB's, CT's, PT's, Isolators, etc.	Y
4	Alignment Checking of isolators	Y

LT transformers

Sr. No.	Maintenance or test	Recommended Interval
1	Testing of oil BDV	Y
2	IR measurement	Y
3	Testing/Checking of OTI, WTI and Buchholz (if provided)	Y
4	Checking healthiness of pressure relief diaphragm	Y
5	Checking healthiness of Buchholz relay	Y
6	Checking tightness of earthing connections	Y

L) ANNUNCIATORS

Annunciators provide essential Switchyard condition status information to O&M personnel. Two aspects must be considered:

- correct operation of the annunciator itself and
- integrity of the alarm devices and interconnected wiring.

Annunciator operation is easily tested using the "Test" button provided on most annunciators and is considered an "operations" activity. Verifying integrity of the alarm devices and interconnecting wiring requires a "functional test" of these circuits. Functional testing is accomplished by

- resetting the annunciator,

- closing (or opening) contacts at the alarm device, and
- verifying that the correct annunciator window is activated.

Maintenance Schedule for Annunciators:

Sr. No.	Maintenance or test	Recommended Interval
1	Operational test	Each shift - staffed
		Each visit - unstaffed
2	Functional test	Y

M) CABLES

Maintenance tests can detect problems in cables that are approaching failure without accelerating the insulation deterioration process due to operational or environmental conditions. Except for infrared scanning, de-energize the cable circuit before maintenance.

Maintenance Schedule for Cables:

Sr. No.	Maintenance or test	Recommended Interval
1	Equipment Ratings	5Y
2	Visual inspection of cables	M
3	Checking and recording or IR values of all cables with megger of suitable range.	M
4	Checking all cable terminals & joins for overhauling / loose connections and tightening, terminating, rejoining, if required	M

N) EARTHING SYSTEM

Sr. No.	Maintenance or test	Recommended Interval
1	Checking of all earthing connections, joints and cleaning and tightening thereof	QY
2	Putting adequate quality of water in earth pits.	QY
3	Checking and recording of earth resistance of all points, pits and taking corrective action to improve it, if required.	QY
Sr. No.	**Maintenance or test**	**Recommended Interval**

1	Checking of each meter (analog/digital) for its correct operation	Y
2	Calibration of indicating meter.	M

O) SCADA SYSTEM

Sr. No.	Maintenance or test	Recommended Interval
Pneumatic Systems/Components/Instruments		
1	Check Regulators and Filters	M
2	Inspect Tubing and Piping	M
3	Valve Actuators servicing	M
4	Actuate Pressure Switches	QY
5	Calibrate Switches and Sensors	HY
6	Calibrate Pressure Gauges	HY
7	Calibrate Level Transmitters	HY
8	Calibrate Flow transmitters	HY
9	Calibrate Pressure Transmitters	HY
10	Calibrate Temperature transmitters, Vibration & bearing monitoring sensors	HY
Electronic Systems		
11	Verify Alarms	W
12	Inter site Communication Network	W
13	UPS setting with SCADA	W
14	Network Redundancy	W
15	Lamp Test/Verify Indicators	M
16	Inspect Enclosures for Dirt, Water, Heat	M
17	PLC Communication Modules	M
18	Test Automatic Control Sequences	M
19	Anti-virus Definition Updates	M
20	Inspect Wire, Cable and Connections	M
21	Communication Interface, Interface Panel	M
22	PLC Redundant Power back up	M
23	SCADA Redundancy	M

24	PLC Hot-Standby	M
25	Historian Package & ODMS package (Storage & archiving Capacity)	M
26	General Data Archiving	M
27	Run PLC Diagnostics	QY
28	Software Maintenance and Patching	QY
29	Dead Bus Relays	QY
30	Calibrate Sensors and Transmitters	HY
31	RTU Batteries	HY
32	Calibrate Meters	Y
33	PLC Batteries	Y

TYPICAL TROUBLE-SHOOTING

Parameters	**Description**
System/operation	Higher /lower discharge rates, extra pump operation to make up the flow, Overflows, Pump cavitations, excess power consumption, water hammer, etc.
Unit process (Mechanical)	Power switch, Mechanical performance, Over load, Noise, Vibration, etc
Unit process (Electrical)	Transformers, Meters, Over load-Motors, Moisture cut heaters, Overload protection, Wiring and connection, Lamp test etc
Precaution, Safety & Health	Handling any accidents, its emergency measure/first-aid treatment, Handling heavy load, Physical damage, Shock hazard, etc

Appendix E – Mandatory spares

A) PUMPS

Sl. No	Description of Equipment	Quantity
(For each model/ capacity)		
1	Pump Impeller	1
2	Pump bearings	1 set
3	Shaft sleeve	1 set
4	Shaft	1 set
5	Gaskets, dust seals and 'O' rings	2 sets
6	Motor	1 No.
7	VFD Drive	1 No.
8	Wearing rings	1 set
9	Nut and bolts etc.	2 sets
10	Mechanical Seals	2 sets
11	Couplings	1 set

B) DOSING PUMPS & ALUM AGITATOR

Sl. No	Description of Equipment	Quantity
1	Dosing pumps and drives	1 No. of each type and size
2	Agitator motor	1 No. of each type and size
3	Reduction gear assembly	1 No. of each type and size
4	Strainers	1 No. of each type and size
5	Valves	1 No. of each type and size

C) FLOCCULATOR

Sl. No	Description of Equipment	Quantity
1	Dosing pumps and drives	1 No. of each type and size
2	Agitator motor	1 No. of each type and size
3	Reduction gear assembly	1 No. of each type and size
4	Strainers	1 No. of each type and size
5	Alum strainer	1 No. of each type and size
6	Valves	1 No. of each type and size

D) BLOWER

Sl. No	Description of Equipment	Quantity
1	Motor	1 No. of each type and size
2	Blower assembly	1 No. of each type and size
3	V belt/coupler	1 No. of each type and size
4	Air strainer	1 No. of each type and size
5	Valves	1 No. of each type and size

D) AIR CONDITIONING UNITS & VENTILATION FANS

Sl. No	Description of Equipment	Quantity
1	(For each model/ capacity)	For each type & capacity
2	Indoor & outdoor unit	1 set
3	Copper tube	15 Rmt
4	Ventilation fan	1 set
5	Filters	4 sets

E. Electricals		
Sl. No	**Description of Equipment**	**Quantity**
1	Modulating motor for face & by-pass damper - for this package.	1 no for each type
2	Modulating motor for each type of valve	1 No

F) VALVES

SI. No.	Description	Quantity
(for each type and size)		
1	One (1) no. where total quantity of a particular type and size of valve is less than or equal to ten (10).	
2	Two (2) nos. where total quantity of a particular type and size of valve is less than 40 but more than 10.	
3	10% of the total quantity (to nearest whole no. of a particular type and size where the total quantity of a particular type and size of valve is more than 40.	

G) VARIABLE FREQUENCY DRIVE (VFD) SYSTEM (IF APPLICABLE)

Sl. No.	Description	Quantity
1	Electrical cards	
a	Control modules	2 Nos. of each type and rating
b	I/O module	2 Nos. of each type and rating
c	Power supply modules Thyristor gate module including gate	2 Nos. of each type and rating
d	transformer	100% of installed quantity
e	Exciter module	1 No.
2	Thyristor bridge leg	10%
3	Over voltage limiter and surge suppressor network	2 sets
4	Semiconductor fuses for thyristor	1 set
5	Power and control fuse	100% of installed quantity
6	Control transformer	1 No. of each type and rating
7	Contactor/ breaker	2 nos.
8	CT/VT	1 No. of each type and rating
9	Indicating lamps	100% of each type and rating
10	Auxiliary contactors and relays	15% of installed quantity
11	Panel mounted meters	1 no. of each type and rating
12	Panel mounted printer	1 no.
13	Indicating lamp holder full set	15% of each type/colour
14	Parameter tuning device	1 no.
15	LT transformer (VFD)	
a	Bushings with metal parts and gaskets	Primary 3 nos. each rating Secondary 3 nos. each rating
b	Winding temperature indicator with alarm and trip contacts	1 no.
c	Oil temperature indicator with alarm and trip contacts	1 no.
d	Magnetic oil level gauge	1 no.
e	Pressure relief device	1 no.
f	Diaphragm for explosion vent	1 no.

g	Buchholz relay/ sudden pressure relay (as applicable)	1 no.
h	Silica gel charge	3 charge
i	Floats with contacts for buchholz relay	1 set
j	Set of gaskets	2 sets
k	Contacts tap changer	1 set
l	Set of valves	1 set
m	Pressure gauge (applicable for sealed tank)	1 no. each type
n	Set windings for one limb in a suitable oil container	1 for each rating

H) MEASURING INSTRUMENTS

SI. No.	Description	Quantity
1	Electronic transmitters	
a	Transmitters of all types, ranges and model no. (for the measurement of Pressure, differential pressure flow, level, etc.)	10% or 2 no. of each type and model, whichever is more
b	Electronic cards / PCB's for each type and model and model of transmitters	10% or 5 nos. of each type, whichever is more
2	Temperature Elements	
a	RTDs* of each type & length	10% or 2 nos. whichever is more
b	Thermocouples of each type like K-type, R-type, metal etc. and length *	10% or 2 nos. whichever is more
c	Cold junction compensation boxes of each model	10% or 2 nos. whichever is more
d	Thermostatic units for each model	10% or 2 nos. whichever is more
e	Thermo wells	10% or 2 nos. whichever is more
3	Local Indicators like temperature, pressure, differential pressure, flow gauges and flow meters etc.,	5% or 1 no. of each make, model and type whichever is more (to be divided to various ranges in proportion to main of all make, model, type population)
4	Process actuated switch devices including all types of pressure, differential pressure, flow, temperature, differential temperature, level switch devices.	5% or 1 no. of each type and model whichever is more
5	Indicators/Recorders	

a	Digital Indicators of each model, type & range (including relevant is digital indicators of electrical system)	10% or 2 nos. min. whichever more
b	Vertical Indicators of each type & model	5% or 1 no. of each model whichever is more.
c	Recorders for each type and model	5% or 1 no. whichever is more
d	Consumables for continuous recorders Charts Ink capsules	25 rolls per recorder/ 25 nos. per recorder/ 20 nos. per recorder / Ink Pads/Pens
e	Consumables for multi-point recorders	
	• Charts • Ink pads • Print mechanism/ print head assembly	5 nos. per recorder 5 nos. per recorder 10% or 5 nos. of each type whichever is more.
f	Level transmitters (displacer type)	
	• Electronic cards / PCB's of level transmitters • Level transmitters	5% or 1 no. whichever is more for each type and model 5% or 1 no. of each type, displacer, length and model whichever is more
g	PD type flow transmitters	5% or 1 set of each type and model whichever is more

I) TRANSFORMERS

SI. No.	Description	Quantity
1	Bushings	1 No. of each type
2	Oil cooler pumps with motor	1 set
3	Gaskets and 'O' rings	1 set
4	Expansion joint	1 set
5	Buchholz relay	1 No
6	Local winding temp. indicator	1 No
7	Remote winding temp. indicator with sensing device and matching unit	1 No
8	Oil temp. indicator with contacts	1 set
9	Pressure relief device	1 No
10	Magnetic oil level gauge	1 No
11	Cooler fan with motor	1 No
12	Set of valves	1 set

13	Set of starters, contactors, relays and switch for electrical control panel	1 set
14	Remote tap position indicator	1 No
15	Oil flow indicator with flow switch	1 No
16	Diaphragm/air cell for conservator	1 No
17	Breather assembly for conservator and OLTC	1 set
18	Terminal connector	1 set
19	Motor operating mechanism assembly for OLTC	1 set
20	Oil surge relay for OLTC	1 No
21	Auxiliary transformer for control power for cooler control cabinet	1 No
22	Transformer Oil	2 KI

J) SF6 CIRCUIT BREAKERS

SI. No.	Description	Quantity
1	One pole of circuit breaker with closet resistor and grading capacitor complete with pole column and in-terrupter with M.B. but without support structure and operating mechanism	
2	Rubber gaskets, 'O' rings and seals	1 set
3	Trip coils with resistor	6 Nos
4	Closing coils with resistor	6 Nos
5	Terminal pads and connectors	3 Nos
6	Molecular filter	3 Nos
7	Density/pressure monitoring systems (if applicable)	1 No.
8	Corona rings	1 No.
9	Relays, power contactors, switch fuse units, limit switches, push buttons, timers and MCB, etc.	1 Set
10	Closing assembly/valve	1 Set
11	Trip assembly/valve	1 Set
12	Pressure switches	1 set
13	Pressure gauge and coupling	1 set
14	SF6 gas	20 % of the total qty.
15	Auxiliary switch assembly	1 set
16	Operation counter	1 No.

K) Spring Operated Closing Mechanism

SI. No.	Description	Quantity
1	Closing dashpot	1 Set
2	Tripping dashpot	1 Set
3	Opening catchgear	1 Set
4	Closing catchgear	1 Set

L) CURRENT TRANSFORMER

SI. No.	Description	Quantity
1	Complete CT	1 No of each type
2	Terminal connectors	1 No
3	Primary Terminal bushings	1 Set

M) VOLTAGE TRANSFORMER

SI. No.	Description	Quantity
1	Complete PT	1 No
2	Terminal connectors	1 No

N) SURGE ARRESTOR

SI. No.	Description	Quantity
1	Complete LA with insulating base	1 set
2	Surge counter and accessories	1 set

O) FIRE PROTECTION SYSTEM

SI. No.	Description	Quantity
1	HVW spray pumps shaft sleeves	3 Sets
2	Diesel engine drive self-starter	1 Set
3	Shaft sleeves for hydrant pumps and jockey pumps	1 No
4	Grand packing for hydrant pumps and jockey pumps	1 Set
5	Quartzoid bulb detectors	10 % of population
6	Projectors (Merxles)	10 %
7	Smoke detectors	10 %
8	Heat detectors	10 %

9	Deluge valve	1 set
10	Isolation valve	1 set
11	Annunciation printed circuit boards	1 No
12	Strainer	1 Set
13	Level switch	1 No
14	Safety Valve for hydro pneumatic system	1 No
12	Pressure switch	1 No
13	Bronze pipe fitted with nozzle and guide coupling	1 No
14	Hydrant Valve	1 No

P) BATTERIES AND BATTERY CHARGER

SI. No.	Description	Quantity
1	Spare battery cell without electrolyte	5 Nos
2	Terminator connectors with bolts and nuts	5 Nos
3	Float level indicators	10 Nos
4	Vent plugs	10 Nos
5	Set of control cards for charger	1 set
6	Set of relays	10% of total number of relays
7	Smoke detectors	1 No
8	Rectifier transformer	1 set
9	Control transformer	1 Set
10	Series inductor	1 Set
11	Micro-switches	1 Set
12	Filter capacitors	1 Set
13	Thristor/diode	1 Set
14	Set of switches	1 Set
15	Set of wound resistors	1 Set
16	Potentiometers	1 Set
17	Fuses of thyristor with indicators	2 Sets

Q) C&R PANELS

SI. No.	Description	Quantity
1	Main relay, Aux. relay	1 No. of each type
2	Timers and relays	10% of the total used

3	PLC's	1 No of each type PLC
4	I/O Cards	20% of total I/O Cards used
5	Any Converters (Media, Power supply, etc)	2 No of each type
6	HMI	2 No of HMI loaded with all necessary software's
7	Over-voltage relay	1 No
8	Reactor REF (restricted earth fault) relay	1 No
9	Transformer differential relay	1 No
10	Transformer REF relay	1 No
11	Master trip relay and flag relay	1 Set
12	Switches, push-buttons and sockets (male and female)	1 Set
13	Meters with transcuders	5 No
14	Power supply module for all protective relay	1 Set
15	Metrocil (Nonlinear resistor)	1 Set
16	Interposing CT's, PT's etc	1 No
17	Panel indication lamp along with complete accessories	5 Nos
18	PT voltage changeover relay	1 No
19	Panel lamp and annunciation facia window lamps	50 Nos

R) L.T. SWITCHGEAR

SI. No.	Description	Quantity
1	Relays	1 set
2	CT's and PT's	2 sets
3	Switches, push-buttons and meters	1 set
4	TPN Switches/MCB	1 set
5	Spring charging motor for L.T. breaker	2 Nos
6	Aux. contact sets	1 set
7	Busbar seal off insulators	2 sets
8	Arc-chutes	1 set
9	Moving contacts	1 set
10	Arching contacts (fixed/moving)	1 set
11	Springs (closing/opening)	1 No

12	Closing coil	2 Nos
13	Tripping oil	2 Nos
14	Aux. finger contact	1 No
15	Limit Switches	1 Set
16	Jaw contacts	1 Set
17	Busbar insulators	5 Nos
18	Interphase barrier	2 Nos
19	Bus bar strip (aluminum)	5 Mts

S) LIGHTING

SI. No.	Description	Quantity
1	Fluorescent tube set complete unit	10%
2	Sodium vapour/mercury vapour lamps unit	10%
3	Incandescent lamp complete fittings of all types	10%
4	Single pole MCB	2% of each rating
5	Triple pole MCB	2% of each rating
6	Switches and sockets	5%
7	Junction box	2%

T) CONTROL AND POWER CABLES

SI. No.	Description	Quantity
1	Power cables upto 185 mm square	500 mts
2	Power cables more than 185 mm square	250 mts
3	Control cables 5/10/19 crore 2.5 sq.mm	1000 mts each
4	Control Cables single core 1.5 sqmm	1000 mts each

U) STATION AUXILIARY SUPPLY

SI. No.	Description	Quantity
1	Transformer bushings	1 Set
2	Lightning arrestor	1 No
3	Clamps and connectors	1 Set
4	Complete isolator assembly for one phase	1 No
5	OTI and WTI with sensing device	1 Set
6	Tap changer contacts	

7	Buchholz relays	1 No
8	Explosion vent diaghram	1 No
9	Silicagel container	1 No

V) 6.6kV BREAKERS

SI. No.	Description	Quantity
1	Closing coil	1 No
2	Tripping oil	1 No
3	Aux. contact sets	1 No

W) BUS BAR ASSEMBLY

SI. No.	Description	Quantity
1	Al.Pipe bus 4" Dia	10 mts
2	Rigid connectors	10 Nos
3	Sliding connectors	5 Nos
4	Pipe to twin moose T-connectors	5 Nos
5	Double tension hardware with insulators	1 No
6	Suspension hardware with insulators	1 Set
7	T-connectors for conductor	10 Nos
8	Yard marshaling box	1 No
9	Spacers	10 Nos
10	PG clamps, other clamp and connectors	10 Nos
11	Corona bell	3 Nos

W) Tools & Testing Kits

S.No	Description	Quantity
1	Megger5 kv , Make-Fluke	2 No
2	Megger 1kv, Make-Fluke	2 No
3	Multi Meters with facility to measure DC mA, Make-Fluke	5 No
4	Tong Testers	5 No
5	Fluke 725 Multi-Function Calibrator	2 No
6	Testing kits, Make-Omicron or equivalent	1 Kit for each
7	Zero voltage detector	1 Kit
8	Tool Kits for each Division (Electrical, Mechanical, SCADA), Make - Gedore	2 Kits For each
9	Earth Resistance measurement Kit	1 kit

Note: The mandatory spares listed above are the minimum required, Agency shall update the same for the satisfactory functioning of the system as per the instructions from EIC and final Spare list shall be prepared by the Agency with prior approval from EIC and submitted.

APPENDIX G

LABOUR REGULATIONS FOR OPERATION & MAINTENANCE

1. Working Hours

- Number of hours of work which shall constitute a normal working day:

  The number of hours which shall constitute a normal working day for an adult shall be EIGHT hours. The working day of an adult worker shall be so arranged that inclusive of intervals, if any, for rest, it shall not spread over more than twelve hours on any day; when an adult worker is made to work for more than EIGHT hours on any day or for more than FORTY-EIGHT hours in any week, he shall, in respect of overtime work, be paid wages at double at ordinary rate of wages.

- Weekly day or rest:

  Every worker shall be given a weekly day of rest which shall be fixed and notified at least TEN days in advance. A worker shall not be required or allowed to work on the weekly rest day unless he has or will have a substituted rest day, on one of the five days immediately before or after the rest day. Provided that no substitution shall be made which will result in the worker working for more than ten days consecutively without a rest day for a whole day.

  Where in accordance with the foregoing provisions a worker works on the rest day and has been given a substituted rest day he shall be paid wages for the work done on the weekly rest day at the overtime rate of wages.

NOTE: The expression "ordinary rate of wages" means the fair wage the worker is entitled to.

2. Display of notice regarding Wages, Weekly Day of Rest etc.

The Agency shall, before he commences his work on Contract, display and correctly maintain and continue to display and correctly maintain in a clean and legible condition in conspicuous places on the works, notice in English and in the local Indian Language spoken by majority of workers, giving the rate of fair wages, the hours of work for which such wages are payable, the weekly rest days workers are entitled to and name

and address of the Inspecting Officer. The Agency shall send a copy each of such notices to the Inspecting Officers.

3. Fixation of Wage Periods

The Agency shall fix wage periods in respect of which wages shall be payable. No wage period shall normally exceed one week.

4. Payment of Wages

a. Wages due to every worker shall be paid to him direct. All wages shall be paid in current coins or currency or in both.
b. Wages of every worker employed on the Contract shall be paid where the wage period is one week, within THREE days from the end of the Wage period; and in any other case before the expiry of the 7th day from the end of the wage period
c. When employment of any worker is terminated by or on behalf of the Agency, the wages earned by him shall be paid before expiry of the day succeeding the one on which his employment is terminated.

Payment of wages shall be made at the work site on a working day except when the work is completed before expiry of the wage period, in which case final payment shall be made at the work site within 48 hours of the last working day and during normal time.

NOTE: The term "working day" means a day on which the work on which labour is employed, is in progress.

5. Register of Workmen

A register of workmen shall be maintained in the Form appended to these regulations and kept at the work site or as near to it as possible, and relevant particulars of every workman shall be entered therein within THREE days of his employment. (Ref. Form 4)

6. Employment Card

The Agency shall issue an employment card in the Form appended to these regulations to each worker on the day of work or entry into his employment. If a worker already has any such card with him issued by the previous Authority, the Agency shall merely

endorse that Employment Card with relevant entries. On termination of employment the Employment Card shall again be endorsed by the Agency.

7. Register of Wages etc.

A Register of Wages-Cum-Muster Roll in the Form appended to these regulations shall be maintained and kept at the work site or as near to it as possible. (Form 6)

A wage slip in the Form appended to these regulations shall be issued to every worker employed by the Agency at least a day prior to disbursement of wages.

8. Fines and deductions which may be made from Wages

Wages of a worker shall be paid to him without any deduction of any kind except the following:

i. fines;

ii. deductions for absence from duty; i.e. from the place of his employment he is required to work. The amount of deduction shall be in proportion to the period for which he was absent;

iii. deduction for damage to or loss of goods expressly entrusted to the employed person for custody, or for loss of money which he is required to account for, where such damage or loss is directly attributable to his neglect or default;

iv. deductions for recovery of advances or for adjustment or overpayment of wages, Advance granted shall be entered in a register; and

v. any other deduction which the Institute may from time to time allows.

vi. No fines shall be imposed on any worker say in respect of such acts and omissions on his part as has been approved by the Chief Labour Commissioner.

vii. No fine shall be imposed on a worker and no deductions for damage or loss shall be made from his wages until the worker has been given an opportunity of showing causes against such fines or deductions.

viii. The total amount of fines which may be imposed in anyone wage period on a worker shall not exceed an amount equal to three paise in a rupee of the wages payable to him in respect of that wage period.

ix. No fine imposed on a worker shall be recovered from him in installments, or after expiry of sixty days from the date on which it was imposed. Every fine

shall be deemed to have been imposed on the day of the act or omission in respect of which it was imposed.

x. The Agency shall maintain both in English & the local Indian language a list, approved by the Chief Labour Commissioner, clearly stating the acts and omissions for which penalty or fine may be imposed on a workman and display it in a good condition in a conspicuous place on the work site.

xi. The Agency shall maintain a register of fines and the register of deductions for damage or loss in the Forms appended to these regulations which shall be kept at the place of work.

9. Register of Accidents:

The Agency shall maintain a register of accidents in such form as may be convenient at the work place.

i. Preservation of Registers

The Register of workmen and the Register of Wages – cum - Muster Roll required to be maintained under these Regulations shall be preserved for 3 years after the date on which the last entry is made therein.

ii. Enforcement

The Inspecting Officer small either on his own motion or on a complaint received by him carry out investigations, and send a report to the Engineer-in-Charge specifying the amounts representing Workers' dues and amount of penalty to be imposed on the Agency for breach of these Regulations, that have to be recovered from the Agency, indicating full details of the recoveries proposed and the reasons therefore. It shall be obligatory on the part of the Engineer-in-Charge on receipt of such a report to deduct such amounts from payment due to the Agency.

10. Disposal of amounts recovered from the Agency

The Engineer-in-Charge shall arrange payment to workers concerned within FORTY-FIVE days from receipt of a report from the Inspecting Officer except in cases where the Agency had made an appeal under Regulation 16 of these Regulations. In cases where there is an appeal, payment of workers dues would be arranged by the Engineer-

in-Charge, wherever such payments arise, within THIRTY days from the date of receipt of the decision of the Regional Labour Commissioner (RLC).

a. Welfare Fund

All moneys that are recovered by the Engineer-in-Charge by way of workers dues, which could not be disbursed to workers within the time limit prescribed above, due to reasons such as whereabouts of workers not being known, death of workers, etc. and also amounts recovered as penalty, shall be credited to a Fund to be kept under the custody of GIFT for such benefit and welfare of workmen employed by Agency.

b. Appeal against decision of Inspecting Officer

Any person aggrieved by a decision of the Inspecting Officer may appeal against such decision to the Regional Labour Commissioner concerned within THIRTY days from the date of the decision, forwarding simultaneously a copy of his appeal to the Engineer-in-Charge. The decision of the Regional Labour Commissioner shall be final and binding upon the Agency and the workmen.

c. Representation of parties

A workman shall be entitled to be represented in any investigation or enquiry under these Regulations by an officer of a registered trade union of which he is a member or by an officer of a Federation of Trade Unions to which the said trade union is affiliated or where the workman is not a member of any registered trade union, by an official of a registered trade union, connected with, or by any other workman employed in, the industry in which the worker is employed.

A Agency shall be entitled to be represented in any investigation enquiry under these Regulations by an officer of an association of Agency of which he is a member or by an officer of a Federation associations of Agency to which the said association is affiliated where the Agency is not a member of any association of Agency, by an officer of association of Authoritys, connected with, or by any other Authority engaged in, the industry in which the Agency is engaged.

No party shall be entitled to be represented by a legal practitioner in investigation or enquiry under these Regulations.

d. Inspection of Books and other Documents

The Agency shall allow inspection of the Registers and other documents prescribed under these Regulations by Inspecting Officers and the Engineer-in-Charge or his authorised representative at any time and by the worker or his agent on receipt of due notice at convenient time.

e. Interpretation etc.

On any question, as to the application interpretation or effect of these Regulations, the decision of the Chief Labour Commissioner or Deputy Chief Labour Commissioner (Central) shall be final and binding.

f. Amendments

Central Government may from time to time, add to or amend these Regulations and issue such directions as it may consider necessary for the proper implementation of these Regulations or for the purpose of removing any difficulty which may arise in the administration thereof.

LIST OF DOCUMENTS AND SUBMITTAL

S. No.	Items
1	4-Sets of Technical Literature
2	Performance Guarantee
3	All Permits/ Licenses
4	Technical Data
5	Manufacturer's Certificates, Drawings, Catalogues & Pamphlets & Other Documents
6	Material submittals
7	Material inspections/ installation inspections
8	Nonconformance reports
9	Factory tests/ calibration tests etc.
10	Material safety data sheets
11	Spare parts list
12	Shop Drawings
13	Electrical Installation Certificate
14	Results of Summer & Monsoon Tests.
15	Operating Instructions & Maintenance Manual
16	Balancing, Testing, and Commissioning Reports
17	Training Modules and certificate
18	Guarantee
19	Quality Assurance Plan
20	List of subAgency, supplier and superintendents
21	Project Schedule
22	Construction Methodology

23	Total Estimated Power & Water Requirement

Note:

(i) Soft copies of the above shall also be provided on CD or media as approved by Engineer-in-Charge. All drawings shall be in AutoCAD format.

(ii) The above list is only for guide line of the Agency. The Agency shall thoroughly check all the documents and submittals required as per the tender documents and submit them in time as per the requirement.

SECTION - IX

Special Conditions of Contract

1. GENERAL

1.1 Extended Scope of the Contract

The contract comprises the planning, designing, drawing, supplying materials and equipment, construction, testing of Intake, WTP, Clear Water Reservoir-cum-Pumping Station and GLSRs at WDCs, trial run for three months and maintenance for a period of ninety-six months upon completion of the works and commissioning and except in so for as the contract otherwise provides, the provision of all labour, materials, constructional plant, temporary works and everything (whether on a temporary or permanent nature) required in and for such planning, design, construction, completion and maintenance so far as the necessity for providing the same in specified in or reasonably to be inferred from the contract.

1.2 Store Shed

The Agency shall provide at his own cost a store shed of adequate capacity for storing materials. The shed shall be of such construction that it must protect the materials against deterioration. A raised platform well above the highest flood level (+21.5m) shall be made for stacking cement in such a way that the cement received earlier can be consumed first to avoid deterioration due to prolonged stacking. If any modifications to the store shed is suggested by the Engineer-in-Charge for better storing of materials that shall be carried out by the Agency at his own cost.

1.3 Land for Agency Establishment

For constructing Agency Store yard, godowns, site office and ancillaries, he may utilize portion of the land belonging to the Authority at such location as would not interfere to execute other co-works. For all these, the Agency shall have to obtain the requisite permission of the Engineer-in-Charge. The Agency shall for this purpose submit to the Engineer-in-Charge for his approval a plan of the proposed layouts for the site facilities. The Engineer-in-Charge reserves the right to alter and modify the Agency proposals as the Engineer-in-Charge may deem fit.

1.4 Water and Electricity for Construction

1.4.1 The Agency shall have to make his own arrangement for supply of water and for electrical power that may be required for or regarding the works. No payment on this account shall be entertained. However, Authority may assist in getting power.

1.4.2 Water may be available from the Authority from a designated point as directed by the Engineer-in-Charge. The Agency shall have to arrange for the necessary equipment and labour, such as, pumps, valves, pipeline, storage facility etc. and as well as the connection with the existing source at his own cost. The Agency shall have to provide a water meter of approved make at the delivery pipeline, which may be available from the Authority, if stock is available. The Agency shall pay for the water at a rate designated for industries. If arrangement for supply of piped water supply shall not be possible, the Agency shall have to make arrangement for supply of drinking water and water required for construction works by sinking tube wells or other suitable alternatives. The Tenderers shall investigate this matter during site inspection before submission of tenders. No payment shall be entertained on this account.

1.4.3 Nevertheless, electrical power from usual supply agencies may not be continuously available due to various reasons including load shedding. In case of non-availability of electrical power, the Agency shall have to make his own arrangements for electrical power through DG set. Agency shall include such aspects while quote his rate. No payment shall be entertained on this account. When drawing power from the AP-TRANSCO's electric power source, the Agency shall have to bear the cost of electrical charges at a rate fixed by this Authority. The route of conveyance shall be subject to approval by the Engineer-in-Charge and shall be in accordance with I.E. Rules.

1.5 First-Aid Facilities

The Agency shall arrange for medical attentions to be promptly available when necessary. He shall for this purpose provide a number of First-Aid stations at suitable locations within easy reach of the workmen and other staff engaged in the Works. Each First-Aid facility shall be properly equipped and shall remain in charge of a suitably qualified person. The Agency shall also provide for transport of serious cases to the nearest hospital. All these arrangements shall be to the approval of the Engineer-in-Charge.

1.6 Fire Fighting Arrangement

The Agency shall provide suitable arrangement for firefighting. For this purpose, he shall provide requisite number of Fire-Extinguishers and adequate number of buckets, some of which are to be always filled with sand and some with water. This equipment shall be provided at suitable prominent and easily accessible places and shall be properly maintained.

1.7 Safety Measures

The Agency shall be responsible for the safety of all workmen and other persons entering or in the works and shall at his own expense and to the approval of the Engineer-in-Charge, take all measures necessary to ensure their safety.

Such measures shall include the provisions of helmets (specially where work at a height is involved), provision of gum-boots to workers engaged in cement concrete or other works. Scaffolding or other measures required for working at a height, shall be strong and rigid and must be provided with suitable and convenient access. Shoring required for deep excavation must be adequate and rigidly braced and strutted. Other safety measure that the Engineer-in-Charge may direct, depending on the exigencies of the location and nature of work and other relevant factors, shall be provided by the Agency.

1.8 Supervisory Staff

The Agency shall engage an experienced and qualified Site Manager to be in day to day charge of the work and he shall be authorized to receive instructions from the Engineer-in-Charge. He shall receive orders given by the Engineer-in-Charge from time to time and shall act on them promptly. The Agency shall, during working hours, maintain Engineers and supervisors of sufficient training and experience to supervise the various items and operations of the work. Orders and directions given to such Engineer-in-Charges and supervisors or other staff of the Agency shall be deemed to have been given to the Agency. The Chief Engineer of the Agency responsible for this work, by whatever designation he may be known, but who shall be specified on award of the Contract shall at least once in a fortnight inspect the works and shall discuss with the Engineer-in-Charge the conduct and progress of the work.

1.9 Joint Survey

The Agency shall satisfy himself regarding the correctness of the layouts, levels etc. as are shown in the drawings or given in the specifications. Before starting the work, he shall also carry out at his own cost, survey of the whole work site jointly with the representative(s) of the Authority. Discrepancies noticed between drawings and the joint survey shall be informed in writing to the Engineer-in-Charge and got set right before execution of works. Such deviations as may arise out of the joint survey shall not vitiate the provisions of contract or entitle the Agency to any extra claim in any way.

1.10 Layout and Checking

The Agency shall provide all labour, skilled and unskilled and all materials needed for carrying out, as directed, survey, laying out, setting out, checking of works, taking measurements, testing hydraulic and other structures, without any extra payment.

The Agency shall also provide approach and access to all the works and stores without any extra cost.

1.11 Reference Points

After the joint survey has been plotted and approved by the Engineer-in-Charge, permanent base lines, cross line and bench marks shall be established by the Agency to serve as reference points and "Dimensional Control Basis" of works. He shall prepare and submit a plan showing such reference points with their full descriptions.

1.12 Cooperation with other Agencies

Some works in project site have been already done/are being done/shall be done through other Agencies. In the event of any such work, the Agency shall have to work in full co-operation and in close coordination with other Agency/Agencies. Any difficulty that may arise in this connection shall have to be amicably settled by the Agencies amongst themselves. If that is not possible, the matter shall be referred to the Engineer-in-Charge whose decision shall be final and binding on all the parties.

The site allocated to the Agency may be fenced at the Agency cost, provided any necessary access to others, as may be required, is given. The Agency shall be permitted to use only the access to the site as indicated on the site plan in Tender Drawing.

1.13 Approval of Materials and Equipment to be used

Samples in large enough quantity of materials and descriptive data requiring prior approval shall be furnished by the Agency to the Engineer-in-Charge in good time before the collection of such materials and equipment so as to permit inspection and testing. The samples shall be properly marked to show the name of the materials, name of the manufacturer, place of origin and item for which it is to be used. Only upon approval, the materials of approved quality shall be brought to site. Samples approved shall be on exhibition always, properly stores and prevented from deterioration for the purpose of comparison with the materials brought to site of work from time to time for use in work.

1.14 Testing & Testing Equipment

1.14.1 Testing of materials to be used in the permanent work, or of the quality of finished items, shall have to be done from approved laboratory at the expense of the Agency.

The Agency shall afford at his own cost necessary facilities in providing the requisite materials and other assistance that may be required by the Engineer-in-Charge including transport of the test specimens to the laboratory referred to above.

1.14.2 The Agency shall provide at his own cost necessary equipment for such testing which by the nature of work may have to be done at site or for taking samples for testing in laboratories. These include sufficient number of slump cones, standard 150 mm metal cube moulds, sets of I.S. sieves, weighing balances, graduated measuring cylinders, complete set of equipment for in-situ density test, thermometers and any other miscellaneous equipment that may be required by the Engineer-in-Charge or his representative(s). The Agency shall also provide necessary arrangement for curing of concrete cube specimens, as instructed by the Engineer-in-Charge.

1.15 Construction Records

The Agency shall keep and supply to the Engineer-in-Charge the up-to-date records of the dimensions and positions of all permanent works (showing therein any approved deviation between the drawing and the work as actually executed). The information available from the records must be adequate and complete to enable preparation of "as-made" drawing by the Agency from these records. A weekly report is mandatory for the Agency describing the detailed status of the progress of work in a format as prescribed by the Engineer-in-Charge.

1.16 Progress Photographs

The Agency shall, at his own cost and expense, arrange to take periodic photographs to show the progress of work or interesting features thereof. The time and the position where from a photograph is to be taken shall be as per direction of the Engineer-in-Charge or his Representative. Three copies of each of these photographs to an enlarged size of about 25 cm x 20 cm together with the CD/DVD, shall be supplied to the Engineer-in-Charge and these shall become the property of the Authority. Each photograph shall be suitably captioned with the date of the photograph, location and other relevant particulars. Further prints and CD of the photograph, location and other relevant particulars shall not be kept by the Agency or reproduced without written permission of the Authority. Digital Camera with 6.0 Mega pixel shall be used for taking photos.

Restrictions to photography or security restrictions that may be applicable to any particular area, must be carefully and rigidly observed.

The number of photographs (each consisting of three prints and the CD/DVD as aforesaid) for the complete works is not expected to exceed 100 (one hundred). No photograph of the plant and other installations shall be taken without prior approval of the concerned officers.

1.17 Satisfactory completion of various items

The various items of the sub-work are to fit in perfectly in the whole plant in every respect so as to form effective working parts of the whole plant as per satisfaction of the Engineer-in-Charge. Each sub-work shall be considered as complete when it is completed as per specifications and put into commission, as per standards, as a successful component part of the whole plant.

1.18 Checking Quality of Work

If the Engineer-in-Charge considers it necessary to satisfy himself as to the quality of the work, the Agency shall, at any time during continuance of the contract, offer sample of work done or if necessary pull down a reasonable part of the work enough for such inspection and testing as the Engineer-in-Charge may direct and the Agency shall make good the same at his cost and to the satisfaction of the Engineer-in-Charge without any extra cost.

1.19 Recording Measurements

Though the offer is on lump sum basis, the Agency shall give not less than five days' notice, in writing to the Engineer-in-Charge, about the work which is proposed to be covered or placed beyond the reach of measurements so that measurements may be taken before the work is covered, bar bending schedule is to be provided five days before the casting date. If any work is covered without such written notice, the same shall be uncovered at the cost of the Agency, and in default hereof, no payment or allowances shall be made for such work. These requirements apply for all the component items executed for the sub-work for which lump sum price is quoted.

1.20 Reports and Returns

The Agency shall maintain at site daily records of progress with regard to the works carried out, labour engaged and construction equipment deployed. These shall form the basis of preparing periodic reports and returns as may be required by the Engineer-in-Charge and in the manner as directed by him.

These daily records shall be made accessible to the Engineer-in-Charge or his Representative as and when desired by him.

1.21 Site Books

1.21.1 For the purpose of quick communication between the Engineer-in-Charge or his Representative and the Agency or his Agent or Representative, Site Books shall be maintained at site in the manner described below. Any communication relating to the works may be conveyed through records in the Site Books. Such a communication from one party to the other shall be deemed to have been adequately served in terms of relevant clause / sub-Clause of the General Conditions of Contract. Each Site Book shall have machine-numbered pages in triplicate and shall be carefully maintained and preserved.

1.21.2 The Agency shall keep Site Books at various places Site work is being carried out so as to be readily available to the Engineer-in-Charge or his Representative. Any instruction or order which the Engineer-in-Charge or his Representative may like to issue to the Agency may be recorded by him in the Site Book and two copies thereof taken by him for his record. The Agency or his Agent or Representative may similarly maintain separate Site Book for any communication he may like to send to the Engineer-in-Charge

or his Representative. Two copies thereof when sent to the Engineer-in-Charge's Representative and receipt obtained thereof, shall constitute adequate service of the communication to the Engineer-in-Charge.

1.21.3 It is mandatory to the Agency to submit a Weekly Report on every Monday morning describing the progress of work till the night of the day before. The Weekly Report shall include the volume of works done in all the categories like, earthwork, piling, concreting, reinforcement works and all other miscellaneous works. As this report shall be the basis of the Running Bills, the said bills may not be accepted by the Authority in absence of such regular report.

1.22 TECHNICAL ASSISTANCE

1.22.1 Training of Technical Personnel

The Agency shall undertake to train two Engineers selected and sent by the Authority to the works of the Agency. These Engineers shall be given special training in the shop and drawing office where the equipment shall be designed and manufactured, and where possible, in any other plant where Agency manufactured equipment of similar type is under installation, tests or maintenance, to enable them to become fully familiar with the equipment being supplied by the Agency. The period of training shall be as decided by the Authority but in any case, shall not exceed six months for any individual. During the period of training, the Agency shall arrange for reasonable accommodation of the Engineers and transport from the place of accommodation to the works or plant.

The Agency supervisory personnel at site shall continuously and intensively instruct and train an adequate number of the Authority's authorized operating and maintenance personnel at site during erection and commissioning of the plant to enable them to take over the operation and maintenance of the plant after the maintenance period.

No extra payment shall be made by the Authority for the training of personnel under this clause.

1.23 DISPOSAL OF THE EXCAVATED MATERIALS

All materials obtained from any excavation required to be carried out under this contract shall be the property of the Authority and the Agency shall not have any claim on it. It

shall not be used for any purpose other than refilling the excavations as needed or levelling the compound or in construction of any embankment or in any manner as directed by the Engineer-in-Charge. After completion of work or earlier, if so directed by the Authority, the surplus excavated materials shall be disposed of by the Agency to any distance without any extra cost, but only after being so directed by the Authority.

1.24 POSSESSION PRIOR TO COMPLETION

The Authority shall have the right to take possession for use of any completed or partly completed part of the work. Such possession or use shall not be deemed to be an acceptance of any work not completed in accordance with the agreement.

1.25 TENDER TO STRICTLY COMPLY WITH SPECIFIED CONDITIONS AND ALL OTHER SPECIFICATIONS

It shall be clearly noted that the tenderers shall strictly comply with the specifications and other terms and conditions laid down in this document and no variations are permissible. This is necessary for the purposes of comparison of tenders received.

The Agency shall stand guarantee for producing potable water as per the standards laid down in the Tender and for the works to be carried out under this contract.

Annexure – I (C) - ii
Potable Water Supply

1.0 Water Supply Network

Standards and Specifications for the Design and Construction of Water Supply Network are given in this section.

2.0 Applicable Codes & Standards

The manufacturing, testing, supplying, jointing and testing at work sites of pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern. However, other codes as approved by Employers Engineer but not specifically mentioned below pertaining to the use of MS, DI Pipes,Tytan gasket, welding , PLB HDPE Conduit shall form part of these specifications.

DI Pipes

Code	Description
IS: 8329	Specification for Centrifugally Cast (spun) Ductile Iron pressure pipes for water, gas and sewage specification.
IS: 5382	Specification for Rubber sealing ring for gas mains, water mains and sewers
IS: 638	Sheet rubber jointing and rubber insertion jointing.
IS: 1387	General requirements for supply of metallurgical materials.
IS: 1500	Methods for Brinell hardness test for metallic materials.
IS: 9524	Ductile Iron fittings for pressure pipes for water, gas and sewage.
IS: 12820	Dimensional requirement of rubber gaskets for mechanical Joints and push on joints for use with cast Iron pipes and fittings for carrying water, gas and sewage.
ISO:4179	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining - General requirements.
ISO:2531	Ductile iron pipes, fitting and accessories for pressure pipe lines. Code of Practice
IS: 12288	Code of practice for use & laying of Ductile iron pipes.
IS: 13382	Cast iron specials for mechanical and push-on-flexible joints for pressure pipe lines for water, gas and sewage.

MS Pipes

Code	Description
IS: 2062-2011	Hot Rolled Medium and High Tensile Structural Steel-Specification
IS: 814	Covered Electrodes for manual Metal Arc Welding of carbon and C-Mn steel.
ASME B31.3	Pressure Piping Code for Process Piping
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grain Steel. Classification
AWS: A-5.1	Specification for Mild Steel Covered Arc Welding Electrodes.
IS: 3613	Acceptance Tests for Wire Flux combinations for Submerged – arc Welding.
AWS: A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding. IS: 1377 - Technical Supply Conditions for Threaded Fasteners
IS: 1367	Technical Supply Conditions for Threaded Steel Fasteners (Parts 1 to 3).
IS: 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming- specification.
IS: 102	Ready Mixed Paint, Brushing, Red Lead, non-setting, Priming.
IS: 816	Code of practice for use of Metal Arc Welding for General Construction in mild steel.
IS: 4353	Submerged Arc Welding of Mild Steel & Low Alloy Steels – Recommendations.
IS: 817	Code of practice for Training and Testing of Metal Arc Welders
IS: 1182	Recommended practice for Radiographic examination of Fusion - Welded Butt Joints in steel plants
IS: 2595	Code of Practice for Radiographic Testing.
IS: 3658	Code of Practice for Liquid Penetrate Flaw Detection
IS: 5334	Code of practice for Magnetic Particle Flaw Detection of welds.
ASTM E 94	Guide for Radiographic Testing
IS: 3600	Methods of Testing Fusion Welded Joints and weld metal in steel (Parts 1 to 9)
IS: 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes
IS: 3589	Seamless or Electrically welded steel pipes for Water Gas and Sewage (168.3 to 2540 Outside Diameter)
IS: 6631	Specification for Steel pipes for Hydraulic Purposes
IS: 7343	Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products

IS: 2598	Safety Code for Industrial Radiographic Practice
IS: 5822	Code of Practice for Laying of Electrically Welded steel pipes for water supply
IS: 1608	Metallic material-tensile testing at ambient temperature
IS: 9595	Metal Arc welding of Carbon and Carbon-Manganese Steels – Recommendations
IS: 2825	Code of unfired Pressure Vessels
IS: 5504	Specification for Spiral Welded pipes
IS: 10748	Hot-rolled Steel Strip for Welded Tubes and Pipes - Specification
IS: 228	Method of chemical analysis of steel (Second revision)
IS: 1599:1985	Method for Bend test (Second revision)
IS: 1608:1995	Mechanical testing of metals- Tensile testing
IS: 3803:1984	Steel conversion of elongation value part-I Carbon and low alloy Steel (Second revision)
IS: 8910:1978	General Technical delivery requirements for steel and steel product.
IS: 9595:1996	Metal arc welding of carbon and carbon manganese steels (First revision) - Recommendation
IS: 1730:1989	Dimension for steel plates, sheets, strips & flats for general engineering purposes (second revision)
IS: 1852:1985	Rolling & cutting tolerances for Hot re-rolled steel products. (Forth revision)
BS 3900	Methods of Test of Paints
BS 7079	Preparation of Steel Substrates before Application
ANSI/AWWA C213	Standard for Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
AWWA C 200-97	Steel water pipe line
DIN 30670	Polyethylene Coatings of Steel pipes and Fittings – Requirements and Testing.
DIN EN ISO 9001 2000	Quality management systems – Requirements
ANSI/AWWA C214	Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines
ANSI/AWWA C604	Installation of Buried Steel Water Pipe
ANSI/AWWA C209	Standard for cold applied tape coatings for the exterior of special sections, connections and fittings for steel water pipelines.
ANSI /AWWA C210	Liquid Epoxy Coating systems for Exterior and Interior of Steel Water Pipelines
ANSI/AWWA C 216	Standard for Heat - Shrinkable Cross-linked Polyolefin coatings for exterior of special sections, connections and fittings of steel water pipelines.
AWWA Manual M11	Steel Pipe – A Guide for Design and Installation

PLB HDPE Ducts

TEC GR No. TEC/GR/TX/CDS-008/03/Mar-11: PLB HDPE Duct

Any other relevant codes required for the project will be applicable as per the directions of Engineer-in-Charge.

General

Prior to the procurement of Pipes, the Contractor shall obtain the Engineer-in-charge approval for the QAP & Data sheet. Shop inspection, Pressure testing of Pipes, Material testing at manufacturer's testing facility in presence of EIC/Representative of EIC followed by a certificate from the manufacturer's shop testing shall be provided for review by the Engineer-in-charge.

PIPE LINE SPECIFICATIONS

DUCTILE IRON PIPES

1.1 Scope

This specification covers the requirements for manufacturing, testing, supplying, jointing and testing at work site Ductile iron pipes (for potable - DI-K9 & DI-K7) and fittings used for water conveyance. Schedule -B covers the specific requirement for the project.

1.2 Applicable Codes

The manufacturing testing, supplying, jointing and testing at work sites of Ductile Iron pipes and fittings shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless specified herein shall be referred. In all cases, the latest revision of the codes shall be referred to. If requirements of specifications conflict with the requirements of the codes and standards, this specification shall govern.

1.3 References

Code	Description
IS: 8329	Specification for Centrifugally Cast (spun) Ductile Iron pressure pipes for water, gas and sewage specification.
IS: 5382	Specification for Rubber sealing ring for gas mains, water mains and sewers
IS: 638	Sheet rubber jointing and rubber insertion jointing.
IS: 1387	General requirements for supply of metallurgical materials.
IS: 1500	Methods for Brinell hardness test for metallic materials.

IS: 9524	Ductile Iron fittings for pressure pipes for water, gas and sewage.
IS: 12820	Dimensional requirement of rubber gaskets for mechanical Joints and push on joints for use with cast Iron pipes and fittings for carrying water, gas and sewage.
ISO:4179	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining - General requirements.
ISO:2531	Ductile iron pipes, fitting and accessories for pressure pipe lines. Code of Practice
IS: 12288	Code of practice for use & laying of Ductile iron pipes.
IS: 13382	Cast iron specials for mechanical and push-on-flexible joints for pressure pipe lines for water, gas and sewage.

Supply of Material

The General requirements relating to the supply of material shall be as laid down in IS:1387. The material for DI fittings shall conform to IS:9523.

1.4 Manufacturing

The metal used for the manufacture of pipes shall be of good quality, commensurate with the mechanical requirements laid down in 19. It shall be manufactured by any method at the discretion of the manufacturer provided that the requirements defined in this standard are complied with.

The pipes shall be stripped with all precautions to avoid warping or shrinkage defects, detrimental to their good quality. The pipes shall be sound and free from surface or other defects. Pipes showing small imperfections inherited with the method of manufacture, and which do not affect their serviceability, shall not be rejected on that account alone. Minor defects arising out of manufacturing process may be rectified, for example, by welding in order to remove surface imperfections and localized defects which do not affect the entire wall thickness provided that the repairs are carried out in accordance with a written assurance system and the repaired pipes comply with all the requirements of classes K9 and K7 with the approval of the purchaser.

Pipes centrifugally cast shall be heat-treated in order to achieve the necessary mechanical properties and to relieve casting stresses caused due to the method of manufacture and repair work.

If necessary, the pipes may be subjected to reheat treatment to ensure that Brinell hardness does not exceed the specified value and the other mechanical properties specified in the standard are achieved.

1.5 Rubber Gasket

Rubber gaskets used with push-on-joints or mechanical joints shall conform to IS 5382.

Material of rubber gaskets for push-on mechanical or flanged joints shall be compatible with the fluid to be conveyed at the working pressure and temperature.

Rubber gaskets for mechanical joint for conveyance of town gas may be suitably protected so that the elastomer does not come in direct contact with the gas.

Rubber gaskets for use with flanged joints shall conform to IS:638.

While conveying potable water the gaskets should not deteriorate the quality of water and should not impart any bad taste or foul odour.

1.6 Sampling

Sampling criteria for various tests, unless specified in this standard, shall be as laid down in IS 11606.

The mechanical acceptance tests shall be carried out on samples of ductile iron pipes which shall be grouped in following batch sizes.

DN (mm)	Maximum Batch Size
80-250	200 pipes
300-600	100 pipes
700-1000	60 pipes
1100-1400	40 pipes
1600-2000	30 pipes

In order to check compliance with the requirements specified, a sample ring or bar shall be taken from the spigot end of pipe.

1.7 Mechanical Tests

Mechanical tests shall be carried out during manufacture. One test shall be conducted for every batch of production. The results obtained shall be taken to represent all the pipes of that batch.

1.7.1 Tensile Test

The thickness of the sample and the diameter

Castings Thickness mm	Test Bar. Method A Nominal Diameter mm	Test bar Method B		
		Nominal Area S_o mm^2	Nominal Diameter mm	Tolerance on Diameter mm
Centrifugally Cast Pipes				
- less than 6	2.5	5.0	2.52	0.01
-6 up to but not including 8	3.5	10.0	3.57	0.02
- 8 up to but not including 12	5.0	20.0	5.05	0.02
- 12 and over	6.0	30.0	6.24	0.03

A Sample shall be cut from the spigot end of the pipe. This sample may be cut perpendicular to or parallel with the pipe axis, but in case of dispute the parallel to axis sample shall be used.

Test Specimen: A test bar shall be machined from each sample to be representative of the metal at the mid-thickness of the sample, with a cylindrical part having the diameters given in Data sheet.

The test bars shall have a guage length at least five times the nominal test bar diameter. The ends of the test bars shall be such that they will fit the testing machine.

Two methods of measuring the tensile strength may be used at the manufacture's option:

Method A - Machine the test bar to its nominal diameter + 10 percent, measure the actual diameter before the test with an accuracy of 0.01 mm and use this measured diameter to calculate the cross-sectional area and the tensile strength; or:

Method B - Machine the test bar to its nominal area So within a specified tolerance on diameter (see19.1.2) and use the nominal area to calculate the tensile strength.

Equipment and Test Method: The sample shall be tested as per procedures laid down in IS 1608. The tensile testing machine shall have suitable holders or grips to suit the test bar ends so as to positively apply the test load axially.

1.7.2 Brinell Hardness Test

When tested in accordance with IS 1500, the Brinell hardness shall not exceed 240 HP on the external un-machined surface.

1.7.3 Retest

If test piece representing a batch fails in the test in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same batch. If both the test results satisfy the specified requirements, the batch shall be accepted. Should either of these additional test pieces fail in the test, the batch shall be deemed as not complying with this standard.

1.7.4 Hydrostatic Test

All pipes shall be tested hydrostatically at a pressure specified in Table. To perform the test, pressure shall be applied internally and shall be steadily maintained for a period of 10s. The pipes shall withstand the pressure test and shall not show any sign of leakage, sweating or other defects of any kind.

It is recommended that the Hydrostatic test pressure at works 'p' be expressed in MPa as a function of the coefficient K be calculated using the following formulae:

For DN 80 to 300 $p = 0.05 (K+1)^2$

For DN 350 to 600 $p = 0.05 (K)^2$

For DN 700 to 1000 $p=0.05 (K-1)^2$

For DN 1100 to 2000 $p = 0.05 (K-2)^2$

When pipes are required to be tested for higher pressure, the test pressures are subject to agreement between the purchaser and the manufacturer at the time of enquiry and order.

Test shall be carried out before the application of surface coating and lining.

	Minimum Hydrostatic Test pressure at Works, MPa

Nominal Diameter (DN) Mm	Centrifugally cast pipes with flexible joints		Pipes with Screwed or welded on flanges		
	Class K7	**Class K9**	**PN10 Flange**	**PN16 Flange**	**PN25 Flange**
80 to 300	3.2	5.0	1.6	2.5	3.2
350 to 600	2.5	1.0	1.6	2.5	3.2
700 to 1000	1.8	3.2	1.6	2.5	3.2
1100 to 2000	1.2	2.5	1.6	2.5	2.5

1.8 Sizes

The standard nominal diameters DN, of pipes and flanges followed in this standard are as follows: 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 4000, 800, 900, 1000 mm.

1.9 Dimensions

Length: The standard working length of socket and spigot pipes shall be 4m, 5m, 5.5m and 6m and for flanged pipes shall be 4m, 5m and 5.5 m other lengths are available by agreement between the manufacturer and the purchaser.

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS.8329/IS:9523 for different class of pipes and fittings. The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes. The standard weight of uncoated pipes and fittings and the permissible tolerances shall be per relevant IS codes.

1.10 Materials in contact with Potable water

When used under the conditions for which they are designed, in permanent or in temporary contact with water intended for human consumption, ductile iron pipes and their joints shall not have detrimental effects on the properties of the water for its intended use.

1.11 Tolerances

1.11.1 Diameter

External Diameter: The values of the external diameter (DE) of the spigot end of socket and spigot pipes and when measured circumferentially using a diameter tape shall confirm to the requirements specified. The positive tolerance is +1 mm and applies to all thickness classes of pipes.

The negative tolerance of the external diameter depends on the design of each type of joint and maximum negative tolerance is specified in this standard.

EXTERNAL DIAMETER DE (mm)

DN	Nominal	Tolerance
100	118	+1, -2.8
125	144	+1, -2.8
150	170	-1, -2.9
200	222	+1, -3
250	274	+1, -3.1
300	326	+1, -3.3

1.11.2 Tolerance on Ovality

Pipes shall be as far as possible circular internally and externally. In case of oval spigot ends for push on joints (DE), the minor axis is permitted to be less than the minimum allowable diameter by the value given below provided the mean diameter DE measured by circumferential tape, comes within the minimum allowable dimensions of DE after applying the tolerance.

Table-1: Allowable Ovality for Push-on-Joint Pipes.

Nominal Diameter DN mm	Allowable Difference Between Minor Axes and DE, Min mm
80-300	1.0
350-600	1.75
700	2.0
4000-800	2.4
900-1000	3.5
1100-1200	4.0
1400 to 1600	4.5

Tolerance on Thickness: The tolerance on the wall thickness (e) and the flange thickness (b) of the pipes shall be as follows:

Dimensions	Tolerance, mm
Wall Thickness (e)	- (1.3 + 0.001 DN)
Flange thickness (b)	+ (2 + 0.05b)

The tolerance given is subject to minimum thickness against Classes K7 and K19 given. No limit for the plus tolerance is specified.

Tolerance on Length: The tolerance on length of pipes shall be as follows:

Type of Casting	Tolerance, mm
Socket and spigot and plain ended pipes	+ 100
Flanged pipes	+ 10

1.12 Coating

1.12.1 Pipes shall be normally delivered internally and externally coated.

1.12.2 Internal Linings: By agreement between manufacturer and the purchaser, the following lining may be applied depending on the internal conditions of use:

- ✓ Portland cement (with or without additives) mortar, as included in Annex A.
- ✓ Blast furnace slag cement mortar as included in Annex A.
- ✓ High alumina (calcium aluminate) cement mortar as included in Annex A.
- ✓ Cement mortar with seal-coat: as included in Annex A.
- ✓ Bituminous paint as included in Annex B.

1.13 Quality Assurance System

The manufacturer shall control the quality of the product during their manufacturing process by a system of process control in order to comply with the technical requirements contained in this standard. Wherever possible, statistical sampling techniques should be used to control the process so that the product is produced within the specified limits.

1.14 Marking

Each pipe shall be marked with the logo of ADC along with month and year of Work Order. Each pipe shall have as cast or stamped or legibly and indelibly painted on it with the following appropriate marks.

a. Indication of the source of manufacture;
b. The nominal diameter;
c. Class reference;
d. The last two digits of the year of manufacturer;
e. The non-standard length of the pipe if specially ordered;
f. Where applicable, an indication of length over which the pipe is suitable for cutting on site; and
g. A short white line at the spigot end of each pipe with push-on joint in sizes DN 700 and above, to indicate the major axis of the spigot.

Marking may be done:

i. on the socket faces of pipe centrifugally cast in metal mould, and
ii. on the outside of the socket or on the barrel of pipe centrifugally cast in sand mould.

BIS certification Marking:

The pipes may also be marked with the Standard Mark:

The use of Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made there under. The details of conditions under which license for the use of Standard Mark may be granted to the manufacturers or producer may be obtained from the Bureau of Indian Standards.

1.15 Jointing

Jointing of DI pipes and fittings shall be done as per the requirements of specifications and as per the relevant IS code. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings/gaskets are used for Jointing these shall conform relevant IS codes.

1.16 Spigot and Socket Pipes

The Spigot and socket pipes and DI fittings shall have push on joints as specified in IS code/ as recommended by manufacturer. The gaskets/sealant used for push on joints/flanged joints shall be suitable for water conveyance. In jointing Ductile iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacturer's recommendations as to the methods and equipment to

be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per relevant IS code is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by engineer.

1.17 Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS:638 of thickness between 1.5 to 3 mm suitable for water conveyance and as specified by manufacturer. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness. Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified. They shall be coated with coal tar epoxy coating after tightening.

1.18 Cleaning of Pipes and Fittings

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by Owner/Engineer to prevent entry of mud or silt etc. If as a result of the removal of any obstructions Owner/Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by Owner / Engineer.

1.19 Specials for Ductile Iron Pipes

This section covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton joints to be used with Ductile Iron pipes with flanged and Tyton jointing system.

1.19.1 Types of specials

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523.

- flanged socket
- flanged spigot
- double socket bends (90^0, 45^0, 22 $1/2^0$, 11 $1/4^0$)
- double socket branch flanged tee
- all socket tee
- double socket taper
- blind flange/dummy flange

1.19.2 Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

1.19.3 Lubricant for ductile iron pipes and specials

1.19.3.1 General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

1.19.3.2 Specification

- The lubricant has to have the following characteristics:
- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non-toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf live not less than 2 years

They shall be conducted in line with the provisions of the IS 9523

1.19.4 Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

1.20 Testing at Work Site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure test and leakage test as per relevant BIS codes. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days, have elapsed. Each section of' the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made plugs inserted after the tests have been completed.

The duration of test shall be 8 hours. No pipe installation shall be accepted until the leakage is less than the number cm3/hr as determined by the formula:

$$QL = \frac{ND \sqrt{P}}{3.3}$$

Where, QL = the allowable leakage in cm3/hr

N = number of joints in the length of the pipeline.

D = diameter in mm, and

P = the average test pressure during the leakage test in kg/cm2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to Owner/Engineer until the leakage is within the specified allowance. Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to

Owner/Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches. After the tests mentioned above are completed to the satisfaction of Owner/Engineer, the backfilling of trenches shall be done as per specifications in layers.

Field Hydrostatic Testing

The entire pipeline shall be subjected to a hydraulic test as follows, to the required test pressure as per Annexure E of IS: 8329 and as per the procedure laid down in IS: 12288. The completed pipeline may be tested either in one length or in sections; the length of section depending upon:

1) availability of suitable water,

2) number of joints to be inspected, and

3) difference in elevation between one part of the pipeline and another

Where the joints are left uncovered until after testing, sufficient material should be backfilled over the centre of each pipe to prevent movement under the test pressure. It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section undertest should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

The test pressure to be applied should be not less than any of the following:

- The maximum pressure, sustained operating
- The maximum static pressure plus 5N/mm2, and
- The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions. The length of this period of time depends on many factors such as slight movement of the pipeline under pressure

whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized up to the full test pressure and the section under test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point. In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipeline because of expansion of water during the high day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much high pressure. However, sufficient care should be taken to prevent floating bulging of the pipeline because of building up of such high pressure during the temperature rise.

If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section undertest should be sub-divided and each part tested separately.

After all sections have been joined together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the maximum sustained operating pressure or the maximum static pressure of the pipeline and, during the test, inspection made of all work which has not been subject to section tests. During the test, the pressure at the lowest point in the pipeline should not exceed the maximum hydraulic field test pressure. It is important to ensure that proper arrangements are made for the disposal of water from the pipeline after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, heavily chlorinated water, some treatment may be necessary before final disposal.

1.21 Measurement

All pipes shall be measured according to the work actually done and no allowance will be made for any waste in cutting to the exact length required. Pipes and fittings shall be described by their internal diameter and length measured in running meters. The

measurement shall be taken along the centre line of pipe excluding fittings which shall be measured separately. The lengths of pipes shall not include the portion of spigots within the sockets of fittings and pipes.

The rate for providing, laying and jointing of DI pipes and fittings shall be deemed to include the cost of jointing material and testing at work site.

Notes

If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified, Contractor shall be held responsible for the same and shall replace the damaged pipeline and retest the same at his own cost of the full satisfaction of Engineer. Water for testing of pipeline shall be arranged by Contractor at his own cost.

Annexure A

CEMENT MORTOR LINING

Materials

Cement: For internal lining of Ductile Iron pipes either blast furnish slag cement / ordinary Portland cement may be used. The type of cement to be used is to be mutually decided between the purchaser and manufacturer. Nominal recommendations are:

Portland cement (as per IS 8112 or IS 455) mortar lining perform rather well and have an expected life of approximately 50 years in soft water with moderate amount of aggressive CO2 and when pH is within 6 to 9. Longer service life can be obtained by increasing the mortar lining thickness.

Where cement mortar lining may be exposed to sulphate attack, ordinary Portland cement should be replaced by sulphate resisting Portland cement (as per IS 12430 or IS 6909). The sulphate concentration limit for sulphate resisting Portland cement is approximately 3000 mg/litre, the same as blast furnace slag cement which naturally possess a good resistance to sulphate attack. For sea water transmission blast furnace slag cement which has C, A content below 3 percent can be used.

High alumina cement (as per IS 6452) mortar lining is suitable for continuous use of pH between 4 and 12 and no severe damage occur after occasional exposure to pH 3 to 4 and 12 to 13.

Sand: The sand used shall have a controlled granulometric distribution from fine to coarser elements; it shall be clean and shall be composed of inert, hard, strong and stable granular particles.

The fine fraction comprising particles passing through a sieve of aperture size 0.125mm shall not be more than 10 percent by mass.

The fraction comprising grains upto a maximum diameter equal to one third of the normal thickness of the mortar lining shall not be less than 50 percent by mass.

The corsest fraction (Comprising particles which do not pass through a sieve of the aperture size closest to half the normal thickness of the mortar lining) shall not exceed 5 percent by mass.

Water: The water used for the preparation of the mortar shall not contain substances deleterious to the mortar nor to the water it is eventually intended to transport in the pipe. The presence of solid mineral particles is, however, admissible provided that these requirements are still fulfilled.

Mortar: The mortar of the lining shall be composed of cement, sand and water.

Additives, which shall be specified, may be used, provided that they do not prejudice the quality of the coating and that of the transported water.

The mortar shall be thoroughly mixed and shall have a consistency which results in a dense and homogeneous lining.

The mortar shall contain by mass at least one part of cement to 3.5 parts of sand.

Application of the lining: The cement mortar lining at work is applied by a centrifugal spinning process or a centrifuged sprinkler or a combination of both methods.

Apart from the inner surface of the joint, the parts of the pipe coming into contact with the transported water shall be entirely covered with mortar.

Once centrifuging is finished, the lining shall be cured at temperatures greater than 4o C. Any loss of water from the mortar by evaporation shall be sufficiently slow so that hardening is not impeded.

Repair of Lining: Repairs to damaged or defective areas are not allowable. If any defects are found in pipe at site contactor shall replace immediately.

For the repair operation, the mortar shall have a suitable consistency, if necessary; additives may be included to obtain good adhesion against the side of the existing undamaged mortar.

Thickness of the lining: The normal thickness of the lining and the minimum permissible mean and local values are given in the Table A.

At the pipe ends, the lining may be reduced to values below the minimum thickness. The length of the chamfer shall be as small as possible but, in any case, shall be less than 50mm.

Determination of lining thickness: The thickness of the lining is checked on the freshly centrifuged mortar by the insertion of a steel pin, or on the hardened mortar by means

of a non-destructive method of measurement. The thickness of the lining shall be measured at both ends of the pipe in at at least one section perpendicular to the pipe axis.

Surface Condition of the Hardened lining: The surface of the cement mortar lining shall be uniformly smooth. Only isolated grains of sand are allowed to appear on the surface of the lining.

The lining shall be such that it cannot be dislodged with pressure of hand and shall be free from corrugations or ridges that could reduce the thickness of the lining to less than the minimum value at one point, as specified in the Table B.

Table-A Thickness of the Lining

DN (mm)	Thickness (mm)		Maximum Crack Width / Radial Displacement
	Nominal Value	Tolerance	
80 to 300	3.0	-1.5	0/8
350 to 600	5.0	-2	1/0
700 to 1200	6.0	-2.5	1/2
400 to 2000	9.0	-3	1/5

Table-B Minimum Bore Clearance Cement

Mortar Lining of Ductile Iron Pipe

DN	Minimum Bore of Cement Mortar Lined Pipe (mm)
80	67.0
100	87.0
150	137.0
200	247.0
250	247.0
300	287.0

On contraction of the lining, the formation of cracks cannot be avoided. These cracks, together with other isolated cracks which may result from manufacturer or may develop during transportation, are acceptable up to a width given in the above.

Seal Coat:

General: When specified the cement lining shall be given a seal-coat of bituminous material or any other epoxy based material compatible with cement mortar lining. Other seal-coat materials may be used, but they shall be agreed on at the time of purchase and shall be specified on the purchase order.

The purpose of seal-coat is to minimize lime leaching of the cement mortar as well as to restrict the unwanted rise in pH value of the transmitted water.

When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

Annexure B

1.0 Bituminous Coating

(a) General

Ductile iron pipes and fittings shall be zinc coated with bitumen over coating, all in accordance with the following Specifications. Buried pipes and fittings shall also have a site or factory applied polythene sleeving. Pipe coatings shall be inspected on site and any damage or defective areas made good to the satisfaction of the Employers Engineer.

(b) Zinc Coating

Zinc coating shall comply with ISO 8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130 g/m^2 as described in Clause 5.2 of ISO 8179.

(c) Bitumen Coating

Bitumen coating shall be of normal thickness 0.07 mm unless otherwise specified. It shall be a cold applied compound complying with the requirements of BS 3416 Type II, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions.

Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

2.0 SPIRALLY WELDED MILD STEEL PIPES

This specification covers the general requirements for design, supply, delivery of spirally welded MS pipe , stacking at site, laying, jointing, testing and commissioning of all spirally welded M.S pipeline, appurtenances, specials etc. above/below ground, including Civil works required for the same. Schedule -B covers the specific requirement for the project.

This specification covers the general requirements for design, supply, fabrication, delivery at site laying, stacking at site, jointing, testing and commissioning of all welded M.S pipeline, appurtenances, specials etc. above/below ground, including Civil works required for the same. Schedule -B covers the specific requirement for the project.

2.1 Applicable codes (Spirally welded M.S. pipes)

The following standards and codes are made a part of the specification. All standards, tentative specifications, codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between this specification and those referred to herein, this specification shall govern.

Code	Description
IS: 2062-2011	Hot Rolled Medium and High Tensile Structural Steel-Specification
IS: 814	Covered Electrodes for manual Metal Arc Welding of carbon and C-Mn steel.
ASME B31.3	Pressure Piping Code for Process Piping
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non-Alloy and Fine Grain Steel. Classification
AWS: A-5.1	Specification for Mild Steel Covered Arc Welding Electrodes.
IS: 3613	Acceptance Tests for Wire Flux combinations for Submerged - arc Welding.
AWS: A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding. IS: 1377 - Technical Supply Conditions for Threaded Fasteners
IS: 1367	Technical Supply Conditions for Threaded Steel Fasteners (Parts 1 to 3).
IS: 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming- specification
IS: 102	Ready Mixed Paint, Brushing, Red Lead, non-setting, Priming.
IS: 816	Code of practice for use of Metal Arc Welding for General Construction in mild steel.
IS: 4353	Submerged Arc Welding of Mild Steel & Low Alloy Steels - Recommendations.
IS: 817	Code of practice for Training and Testing of Metal Arc Welders.
IS: 1182	Recommended practice for Radiographic examination of Fusion - Welded Butt Joints in steel plants
IS: 2595	Code of Practice for Radiographic Testing.
IS: 3658	Code of Practice for Liquid Penetrate Flaw Detection
IS: 5334	Code of practice for Magnetic Particle Flaw Detection of welds.
ASTM E 94	Guide for Radiographic Testing
ASTM E 709	Guide for Magnetic Particle Examination.

ASTM E 165	Test Method for Liquid Penetrate Examination.
IS: 3600	Methods of Testing Fusion Welded Joints and weld metal in steel (Parts 1 to 9)
IS: 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes.
IS: 3589	Seamless or Electrically welded steel pipes for Water Gas and Sewage (168.3 to 2540 Outside Diameter)
IS: 6631	Specification for Steel pipes for Hydraulic Purposes
IS: 7343	Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products
IS: 2598	Safety Code for Industrial Radiographic Practice
IS: 5822	Code of Practice for Laying of Electrically Welded steel pipes for water supply
IS: 1608	Metallic material-tensile testing at ambient temperature
IS: 9595	Metal Arc welding of Carbon and Carbon-Manganese Steels - Recommendations
IS: 2825	Code of unfired Pressure Vessels
IS: 5504	Specification for Spiral Welded pipes
IS: 10748	Hot-rolled Steel Strip for Welded Tubes and Pipes - Specification

2.2 Supplying, Delivery, Lowering, Laying, Jointing of SW MS Pipeline

2.2.1 Scope of Work

Manufacture, supply and delivery of Spirally welded Submerged Arc Welded (SAW) M.S Pipe having bevelled ends from plate or coil conforming to IS-3589 and/or IS-5504 with its latest revision/amendment with inside 406 micron thick solvent free NSF/ANSI 61 approved High build liquid epoxy conforming to the specified thickness & inner diameter of pipe at site with all type of specials, manholes, tees, bends & flanges, lowering, laying and jointing the pipes with welding in prepared trench with required excavation in all strata's, RCC Encasing for the Pipe, breaking the road surface/canal/existing structures & reinstating the same, necessary traffic diversion work, refilling around the MS pipeline RCC Encasing after completion of work, disposal of surplus excavated stuff, including hydro testing etc. complete with all taxes, insurance, freight charges, inspection charges, transportation, etc. complete including all labour, materials and ROU/ROW as per Standards.

Submerged Arc welded Hot finished mild steel Bevelled pipes to be manufactured supplied and delivered under the scope of this contract shall be manufactured in accordance

and conforming to IS-3589 and/or IS-5504. Pipes supplied shall be with inside 406-micron epoxy coating as per detailed technical specification as per DIN-30670, 1991 or latest revision/amendments if any.

Pipe mill shall have valid management system certificates ISO 9001, 14001, 18001 and IS 3589, IS 5504 license for product marking.

2.2.2 Marking

The methods of marking all the pipes to be delivered under scope of contract shall ensure that all the information will remain legible even after transportation storage in open space etc. In general, the legible and marking upon the goods shall indicate the following

Manufacturer's brand name and / or trade mark.

Purchaser's mark as "ADC" be stencilled

Diameter, Length and wall thickness.

Heat No., Pipe No., Pipe Designation

Date of manufacture

Any other important matter that the manufacturer deems fit to be inscribed.

All the MS pipes of diameter up to 2540mm shall be provided with ISI certification mark on each pipe.

2.2.3 Packing and Handling

The materials shall always be packed separately dispatched from manufacturer's works with adequate protective measures to prevent damages and deterioration while in transport or stored at any place. The pack shall always to be so neat and tidy that may withstand any robust and rough handling.

The supplier shall use proper handing instruments / equipment and shall follow to a suitable method of handing of pipes as may be approved by Engineer In-charge, while unloading and stacking materials in the stores.

2.2.4 Workmanship

All pipes with internal solvent free NSF/ANSI 61 approved High build liquid epoxy coating shall be finished and shall conform to detail specifications & relevant IS codes.

2.2.5 Test Certificate

The contractor shall always provide manufacturer's test certificate in accordance with every batch / lot of goods as manufactured and supplied.

2.3 Materials

2.3.1 Steel Plates/H.R. coil

The steel plates for pipes, fittings, specials and stiffeners shall be of mild steel conforming to IS: 2062, Grade-E250 BR or H.R. coil conforming to IS: 10748 grade III.

2.3.2 Welding Consumable

Such as electrodes, filler rods and wires shall conform to IS: 814, IS: 3613, IS: 6419 and IS: 7280.

2.4 Manufacturing

The spirally welded mild steel pipes shall be manufactured from H.R. coils conforming to IS-10748 Grade-III or mild steel plate confirming to IS 2062-2011. The pipes are to be shop or plant manufactured by continuous process in two step methods i.e., by continuous Spiral Submerged Arc Welding (SAW) facility with at least one pass inside and one pass out side welding with online testing sequentially as per terms and conditions as laid down in IS-3589 and/or IS-5504. The pipe shall be manufactured from Fe-410 grade steel.

The steel material viz. MS plate or coils having required thickness (with no negative tolerance) and minimum 1500 mm width with no negative tolerance in trimmed condition having length & width as shown in the schedules of material should have been manufactured and tested under ISI mark scheme or such license under other institution valid for the respective country conforming to IS specification No: IS: 2062-2011 Grade-E250 BR for MS plates and IS 10748 Gr.-III for hot rolled steel coils.

The collection and testing of samples will be in accordance with the following Indian Standard and para testing of samples. Imported steel plates and coils shall not be allowed for manufacturing of pipeline.

Note:

For MS Plate: IS 2062 is to be read as IS: 2062; Gr. E250 BR

For H.R. Coil: IS 10748 is to be read as IS:10748 Gr. III

S. No.	IS No.	Title

1.	228	Method of chemical analysis of steel (Second revision)
2.	1599:1985	Method for Bend test (Second revision)
3.	1608:1995	Mechanical testing of metals- Tensile testing
4.	3803:1984	Steel conversion of elongation value part-I Carbon and low alloy Steel (Second revision)
5.	8910:1978	General Technical delivery requirements for steel and steel product.
6.	9595:1996	Metal arc welding of carbon and carbon manganese steels (First revision) - Recommendation
7.	1730:1989	Dimension for steel plates, sheets, strips & flats for general engineering purposes (second revision)
8.	1852:1985	Rolling & cutting tolerances for Hot re-rolled steel products. (Forth revision)

In addition to above wherever necessary and suggested by inspecting agency, API or other relevant standards will be used for testing and collecting of samples.

Unless otherwise specified, the MS plates supplied under this tender should conform to the applicable requirements of the current addition of the IS specifications No. IS: 2062-2011 Grade-E250 BR killed Quality or equivalent standard and or IS 10748, Gr. III for hot rolled steel coils for manufacturer of spirally welded pipes.

The permissible variations in dimensions & tolerances applicable in length and width of MS plates should be as per IS specification No 1852:1985 as applicable to rectangular, sheared cut MS plates but no negative tolerance in thickness will be acceptable.

The plates/HR coil older than 6 months from the date of manufacturing shall not be allowed to manufacture pipes and these plates/ HR coil shall be free from any cracks, surface flaws, laminations, scares, pits, splits, harmful scratches and other defects.

The MS plates shall be capable of forming operations and should not un-duly loose the specified strength and property during various operations viz. drilling, threading, plugging welding etc. and process adopted for fabrications & erection of pipe line. Also, the plates shall be resistant to cleavage, fractures & effect of ageing.

2.4.1 Technical Advice

The contractor shall be fully responsible for proper liaison with the department to evolve satisfactory welding procedure for fabrication & erection of pipe manufactured from the plates / coil supplied by them. The contractor on receipt of a request from the

dept. shall without any cost to the dept. arrange to furnish manufacturer's technical advice (with up to date instructions Booklet, technical literature etc. regarding any problem concerning fabrication in particular, suitability of welding, consumables, weld grooves, design, heat treatment etc.) such advise shall be rendered till the expiry of contract.

2.4.2 Acceptance of Goods

At the time of delivery of materials, the manufacturer will have to provide test results in accordance with IS specification No. IS: 2062-2011 or equivalent standard of the MS plates or IS: 10748 for hot rolled steel coils supplied along with the challans. The material will not be accepted without test results of the manufacturer. If the test results of the respective lots will be found satisfactory with respect to relevant IS or equivalent standard specification and with no negative tolerance in thickness only then material will be accepted by the department otherwise rejected.

Thus, in case of non-acceptance and return of materials by the department, the department will not be responsible for the cost of materials and its transportation or any other cost.

2.4.3 Inspection, Sampling & Testing

To have the quality assurance of the materials, the contractor shall arrange inspection and testing in consultation with Engineer in charge. He may arrange inspection/testing by him or his representative/consultant/third party inspection agency. The material unless inspected, passed and stamped for acceptance shall not be dispatched. The cost for the inspection and testing shall be borne by the contractor.

2.4.4 Testing of HR Coils

The testing of HR coils shall be carried out by the steel manufacturer as per IS 2062. The steel manufacturer shall submit the Hr coil MTC for review at the pipe manufacturer by client or its representative.

2.4.5 Wall Thickness

The wall thickness of pipes shall be as per the design requirement or minimum mentioned in the tender. No negative tolerance will be allowed, only positive tolerance will be allowed. Thickness of sheet is enclosed.

Diameter in mm	Thickness in mm
1100	10
1400	12
1500	14
1600	14
1800	14
1900	16
2000	16
2400	20
2500	20

2.4.6 Pipe Ends

The pipe shall have bevelled ends to an angle of 30°+5° measured from a line drawn perpendicular to the axis of the pipes. The root face shall be 1.6+0.8 mm. The root face of the bevel may be prepared by hand finishing if required.

2.4.7 Length of Pipes

The random length of pipes shall be 10 to 12 meters. In specific locations, smaller lengths can be accepted as per Engineer-in-charge

2.4.8 Straightness of Pipes

Finished pipes shall not deviate from straightness by more than 0.2% of the total length checking for straightness shall be carried out using as taut string or wire from end to end along the side of the pipe to measure, the greatest deviation.

2.4.9 Testing of Pipes

The main tests among others to be conducted on each pipe shall be as per IS-3589 and/or IS-5504 with its latest version.

2.4.10 Sampling of pipes

The sampling of pipes shall be as in IS:4711 with latest version/ or as directed by the Engineer-in- charge.

2.4.11 Condition of Supply

The pipes with inside solvent free NSF/ANSI 61 approved High build liquid epoxy shall be as per specifications.

2.4.12 Other Tolerances

As per IS-3589 and/or IS-5504 with latest version (Except for wall thickness). M.S. Pipes shall be welded spirally. Before fabrication of pipes and specials / fittings is commenced, the copies of the mill sheets and the manufacturer's test certificates for plates

and other materials required for fabrication shall be submitted by the Contractor to the Engineer In-charge for his approval.

When instructed by the Engineer In-charge, the Contractor shall supply free of charge to the Engineer-in-charge for testing suitable samples of the materials to be used / used in the Works.

2.4.13 Inspection

All materials will be subjected to inspection by the Engineer In-charge, his authorized representative. The inspection charges shall be borne by the Government / Department. However, in any case of re-inspection due to rejection / rework required of inspected goods or inspection could not be carried out due to non-readiness of material called for inspection etc., the additional charges for inspection will be borne by the contractor and are required to be paid directly to the inspection agency. All such incidents will be reported to the Engineer-in-charge in writing within a week.

The Contractor shall notify the Engineer In-charge, in advance of the production of materials and fabrication thereof, in order that the Employer may arrange for mill and shop inspection.

The Engineer In-charge may reject any or all materials or work that does not meet with any of the requirements of this specification. The Contractor shall rectify or replace such rejected material/performed work at his own cost, to the satisfaction of the Engineer In-charge.

The Engineer In-charge shall have free access to those parts of all plants or any other premises and sites that are concerned with the furnishing of materials or the performance of work under this specification. The Contractor shall furnish to the Employer's inspector reasonable facilities and space without charge for inspection, testing and obtaining of any information he desires in respect of the character of material used and the progress and manner of the work.

2.5 Manufacturing of Spirally Welded MS Pipe

2.5.1 General

1. The pipes shall be truly cylindrical, and straight in axis. The ends shall be accurately cut and prepared for field welding. The external circumference of the pipe pieces, which are to be fixed adjacent to flange adapter with fixed outer diameter, shall not deviate from theoretical one by more than 1 mm. To obtain this accuracy the pipe shall be rolled

several times, if necessary, as pipe pieces should be truly cylindrical. The external longitudinal welding of this pipe shall be ground smooth flush with surface to the satisfaction of the Engineer In-charge, for a length of 200 mm. No extra cost shall be charged by the Contractor for this grinding work.

2. Minor repair by welding or otherwise shall be permitted at the discretion of the Engineer In-charge, but such repairs shall be done only after obtaining the previous permission of the Engineer. Any pipe or part thereof which develops injurious defects during shop welding or other operations shall be rejected.

2.5.2 Fabrication

Pipe shall be manufactured by continuous process, Spiral Submerged Arc Welding (SAW) facility with on line testing sequentially, dust free environment, Real time radiography (RTR) of the entire weld length of each pipe, X-ray, Ultrasonic testing, adequate Hydraulic testing, etc.

The contractor shall get the MS pipe fabrication at well established, proven, having adequate test facility, having pipe coating facility (inside-epoxy coating) and executed at least three project and supplied 100 km of pipes with solvent free NSF/ANSI 61 approved High build liquid epoxy coating, having valid factory license. The contractor shall propose such manufacturing unit/s for with credentials of manufacturing unit/s approval by the department prior to placement of order. The department shall not be responsible for non-acceptance of MS pipes manufactured/being manufactured in absence of such approval from the department of particular manufacturing unit/s.

In no case manufacturing/fabrication of MS pipes shall be permitted at site. This manufacturing unit/s should have the following minimum set-up viz.,

- ✓ Continuous Plate bending machines for rolling.
- ✓ By continuous Spiral Submerged Arc Welding (SAW) facility with at least one pass inside and one pass out side welding with online testing sequentially.
- ✓ SAW (Submerged Arc Welding) machine & Automatic welding machines (suitable for circumferential as well as longitudinal welding)- suitable for 3000 mm Dia pipes.
- ✓ Automatic tracking of weld head in weld joint by Laser at forming for SAW weld at final welding station

- ✓ Pipe coating facility (inside-epoxy coating & outside - hot applied 3LPE/polyolefin tape coating) set-up
- ✓ Hydraulic Testing Machines
- ✓ Travelling gantry or crane of suitable capacity
- ✓ Mobile cranes of suitable capacity for loading/unloading of HR/Plates and Pipes.
- ✓ Lathe for machining of the flanges rings, plates etc.
- ✓ Equipment for abrasive/ shot blasting and applying paint by spray gun.
- ✓ Equipment for cold forming of plates up to 25 mm thick to the required curvature
- ✓ Pipe hydro-testing set-up
- ✓ Testing equipment online and off line such as UT/ radiography/ DPT/ Chemical & mechanical laboratory for DT & NDT etc.
- ✓ Real time radiography testing of spirally weld seam prior to Hydro test to ensure the weld soundness and reduce repair work after hydro test.
- ✓ Valid management system certificates ISO 9001, 14001, 18001.
- ✓ Valid IS 3589, IS 5504 license for product marking.
- ✓ Valid license from AERB / BARC for X-ray testing facility.

In addition to above, the details such as company profile, manufacturing experience, order in-hand, client list, quality certifications or other details pertaining to pipes fabrication information as asked by the department.

2.5.3 Cutting plates to size

The plates shall be indented in such length as to have minimum wastage and so as to make the pipe as far as possible with one longitudinal weld joints.

Before cutting, all the edges of the plates shall be cleaned by brushing/grinding on both the sides.

After the plates are cut, the edges shall be made smooth and even by polishing with an electrical or pneumatic grinder to remove all inequalities. Care shall be taken to see that the cut edges of the plate are perfectly straight. Jigs to be used for this purpose shall depend upon the types of cutting machine used. The plates cut to the required shape shall be checked for correctness before they are rolled into pipe drums. If any corrections are required, the Contractor shall do the same by re-cutting, if necessary. If any plate or flat is found to be warped, to have corrugations, the defects shall be removed by putting the plate or flat into a roller press, and no extra payment for this rectification

work shall be made. The laminated or heavily corroded plate shall not be used in the manufacturing of the pipe.

2.5.4 Rolling of Plates

The plates cut to the exact size shall be put into a rolling machine to form a pipe of the required diameter. The Contractor shall adjust the rolling machine so as to give a uniform curvature to the pipe throughout its circumference. The curvature obtained shall be checked by the Contractor's foreman during the process of rolling and if proper curvature is not obtained at any place including the ends, the rolling operation shall be repeated at this stage or even after the longitudinal welding of the drum where directed. Heating of plates to obtain the desired curvature shall not be permitted.

2.5.5 Tacking the Drums

The rolled drums shall be kept on an assembly platform for tacking, care being taken to ensure that the tacked drums have their end faces at right angles to the axis of the pipe. While tacking the drum a gap of 2 mm to 4 mm shall be maintained where hand welding is permitted. However, where the welding is to be done on automatic welding machine, there is no need of maintaining such gap depending on the penetration through complete thickness of the welding required. To achieve this objective, clamp spiders, tightening rings and or any other approved gadgets shall be used. Each such drum, before being taken to the assembly platform, shall be numbered on the inside with oil paint, stating the plate thickness as well.

2.5.6 Assembly of Drums into Pipes

The tacked drums shall then be transported to an assembly platform where they shall be tack-welded together to form suitable pipe-lengths. Plate shall be bent in the maximum possible width to reduce the number of circumferential joints.

The longitudinal joints shall be staggered at 90 deg. The drums when tacked together shall have no circumferential gap when the welding is done on automatic welding machine. But when hand welding is adopted, a gap of 2mm to 4mm shall be maintained to obtain a good butt-welded joint.

The assembly shall be truly cylindrical and without any kinks. The faces shall be at right angles to the axis of the cylinder. A suitable arrangement for testing the correctness of the face shall be provided by the Contractor at the assembly platform.

Factory made spirally welded pipes are also permitted.

2.5.7 Welding

Scope

This specification shall apply to site fabrication of all welded joints in carbon steel (Mild steel), low alloy steel and stainless steel for plant piping systems. Site fabrication also covers any fabrication in a shop set-up at site. The welded joints include the following:

a) All butt welding joints of the longitudinal and circumferential type for attachments in piping, castings and forgings of all components

b) Socket welding and fillet joints

c) All types of branch welds

d) Any other joints not specifically covered above.

Codes and Standards

The welding of all piping systems including equipment, welding consumables, preheating, post-weld heat treatment, other auxiliary functions and welding personnel shall comply with all currently applicable statutes, regulations and safety codes in the locality where the systems are to be installed. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility. Specifically, the latest editions of the codes and standards listed in following paragraphs shall apply:

a) ASME B31.3 - Pressure Piping Code for Process Piping

b) Indian Boiler Regulations (IBR)

c) ASME Boiler and Pressure Vessel Code (BPV Code), Section II Part C - Material Specifications for Welding Rods, Electrodes and Filler Materials

d) ASME Boiler and Pressure Vessel Code (BPV Code), Section V - Non-Destructive Examination

e) ASME Boiler and Pressure Vessel Code (BPV Code), Section IX - Welding and Brazing Qualifications

f) Standards of the Pipe Fabrication Institute

g) BS 2633-Specification for Class I Arc Welding of Ferritic Steel Pipework for Carrying Fluids

The codes and standards listed in are integral part of this specification. In the event of conflict between this specification and the codes and standards, the more stringent shall govern. If no specific requirements are given in this specification, the requirements of the applicable code shall govern.

The following welding processes shall be used for shop-fabricated and field-fabricated piping systems:

Shielded Metal Arc Welding (SMAW)

Gas Tungsten Metal Arc Welding (GTAW)

Welding by oxyacetylene process shall not be used.

All butt welds shall be considered as full penetration welds. Welding from inside of the pipe after back gouging and chipping is not envisaged. However, if the Contractor proposes to use such a method, a detailed written procedure shall be submitted for the Engineer-In-Charge's approval.

All components of a standard shell, either straight or bent etc. shall be welded, by use of automatic arc welding machine by Submerged Arc welding process with alternating current. Manual welding shall not be permitted except for sealing runs/ field weld joints and such other minor works at the discretion of the Engineer In-charge. The strength of the joint shall be at-least equal to that of the parent material.

Welding Qualifications:

Qualification of the welding procedures to be used and the performance of welders and welding operators shall conform to the requirements of the BPV Code, Section IX. For IBR systems, these shall also meet the requirements of IBR.

No production welds shall be undertaken until the qualification requirements are completed to the satisfaction of the ENGINEER-IN-CHARGE.

When impact testing is required by the code or by the specification, these requirements shall be met in qualifying welding procedures.

The CONTRACTOR shall be responsible for qualifying any welding procedure and welders intended to be used. The CONTRACTOR shall submit the Welding Procedure Specification (WPS) for acceptance by the ENGINEER-IN-CHARGE. After approval by the ENGINEER-IN-CHARGE, the procedure qualification test shall be carried out

by the CONTRACTOR, at his own expense, duly witnessed by the ENGINEER-IN-CHARGE. A complete set of test results shall be submitted to the ENGINEER-IN-CHARGE for approval immediately after successful completion of procedure qualification test. All tests as required by the BPV code Section IX or IBR shall be carried out. The WPS shall require re-qualification if any of the essential variables or supplementary variables is altered.

Welders shall be qualified in accordance with BPV Code, Section IX or IBR, as applicable. The qualification shall be carried out in the presence of the ENGINEER-IN-CHARGE. Only those welders who are qualified and approved by the ENGINEER-IN-CHARGE shall be used on the job. For IBR systems, approval of the local IBR inspector shall be obtained by the CONTRACTOR.

Welders shall always keep their identification cards with them and shall produce them on demand. The CONTRACTOR shall issue the identity cards after the same are duly certified by the ENGINEER-IN-CHARGE. Welder, who is not in possession of the identity card, shall not be allowed to work.

The CONTRACTOR shall use forms as per BPV code, section IX, form QW-482, form QW-483 and form QW-484. Other forms are also acceptable subject to approval by the ENGINEER-IN-CHARGE.

Unless agreed otherwise, the CONTRACTOR shall advise the ENGINEER-IN-CHARGE, in writing, at least three (3) weeks before any welder is employed on the work, the names and qualifications of the proposed welders and welding supervisors. It shall be the CONTRACTOR's responsibility to ensure that all welders employed by him or his SUB-CONTRACTORS, on any part of the CONTRACT either in the CONTRACTOR's/his SUB-CONTRACTOR's works or at site are fully qualified as required by the code. Each welder shall qualify for all types of welds, positions and materials or material combinations he may be called upon to weld.

Should the ENGINEER-IN-CHARGE require to test or retest any welder, the CONTRACTOR shall make available, at no extra cost to the ENGINEER-IN-CHARGE, the men, equipment and materials for the tests. The cost of testing the welds shall be borne by the CONTRACTOR.

Welding supervisors shall have qualifications such as engineering degree or engineering diploma in welding technology with adequate knowledge of non-destructive testing and a minimum of five (5) years of experience in supervising welding of pipe joints.

All welding, including the tacking up of all welds shall be carried out by approved welders. Any weld made by other than an approved welder shall be cut out and re-welded.

For purposes of identification and to enable tracing full history of each joint, each welder employed on the work shall be given a designation. The welder's designation and the date on which the joint was made, shall be stamped on the relevant piping and marked on the relevant drawings also. Copies of the drawings so marked shall be furnished to the ENGINEER-IN-CHARGE for record purposes. For austenitic stainless steels, welder's designation shall be applied with water-proof paint that is not detrimental to the pipe. Alternatively, record charts may be used.

For each welder, a record card shall be maintained showing the procedures for which he is qualified. These cards shall note the production welds, the date of the welding done, the type of defects produced and their frequency. The record shall be reviewed once in a week by the ENGINEER-IN-CHARGE and those welders whose work required a disproportionate amount of repair shall be disqualified from welding. Requalification of welders disqualified more than three (3) times shall be entirely at the discretion of the ENGINEER-IN-CHARGE.

The ENGINEER-IN-CHARGE shall have free access to inspect welding or any other related operations at any time and at any stage of fabrication. The ENGINEER-IN-CHARGE may require non-destructive testing of any weld for reasons other than those given in the specification. The responsibility for the cost of such testing shall be mutually decided between the ENGINEER-IN-CHARGE and the CONTRACTOR. The CONTRACTOR shall inform the ENGINEER-IN-CHARGE when the weld preparation and setting up for welding of various members selected by the ENGINEER-IN-CHARGE is in progress so that the ENGINEER-IN-CHARGE can inspect the assembly before welding starts. The responsibilities of the ENGINEER-IN-CHARGE's representative shall in no way reduce the CONTRACTOR's responsibilities to ensure that the work is carried out in accordance with the specification. Any examination by non-

destructive methods on low alloy steels shall be performed after post weld heat treatment. For a welded branch connection, the examination of and any necessary repairs shall be completed before any reinforcing pad is added.

Examination of Welds

Examination refers to the quality control functions performed by the CONTRACTOR during fabrication, erection and testing. As a minimum, the following shall be examined by visual examination:

a. Materials and components to ensure that these are as per the specification and are free from defects. If defects are noticed on "free-issue" items, these shall be brought to the notice of the ENGINEER-IN-CHARGE without delay.
b. Joint preparation and cleanliness
c. Preheating as applicable.
d. Fit-up, joint clearance, and internal alignment prior to joining.
e. Variables specified by the welding procedure, including filler material, position and electrode.
f. Condition of the root pass after cleaning - external and where accessible, internal.
g. Slag removal and weld condition between passes.
h. Appearance of the finished joint Acceptance for the visual examination shall be as per ASME B 31.3 or IBR as applicable.

The contractor shall use radiographic quality electrodes and to be carry-out the welding procedure specification (WPS) and Pre-Qualification Requirement (PQR). For welding the contractor shall ensure use with standard current and arc voltage required for the machine. For this purpose, samples of welded joints shall be prepared and tested in the presence of the Engineer in-charge. The values once determined shall be maintained throughout the work and if any modifications are to be made, a written permission of the Engineer In-charge shall be obtained. In the case of thin sheets, electric arc welding may not give satisfactory results and gas welding shall be resorted to. Gas welding shall be subject to the same specifications and tests as those for electric welds. Welding should be carried out inside as well as outside.

Welder Qualification

The contractor should engage all qualified welder for field welding at least having of 6G level qualification. The contractor should submit such qualified welders list prior taking up welding work.

All welding shall conform to the requirements of IS 4353 latest version

All longitudinal and circumferential joints shall be double welded butt joints. Field joints shall be from outside, with a sealing weld from inside. End preparation for such welding shall conform to IS:2825.

All circumferential welds involving plates of unequal thickness shall be so kept that the inside surfaces of plates match to provide stream lined joints without alteration in the internal diameter. As far as practicable, welding of dissimilar thickness of shells shall be carried out in the shops.

The welding shall be of the best workmanship free from flaws, burns, etc. and the Contractor shall provide for his own electrodes and equipments, ovens to keep the electrodes at the desired temperatures and dry. In order to maintain a good standard in welding, welders shall have to undergo for testing. Such testing shall be organized by the Contractor before they are entrusted with the job. Qualification standard for welding procedures, welders and welding operation shall conform to the requirements of IS:7307 and IS: 7310 (latest) and/or ASME section-IX (latest). Periodical tests as regards their efficiency shall also be taken at intervals of about 6 months and those found inefficient shall be removed from the job. Only those who pass the test shall be posted on the job. If an incompetent welder has already welded some pipes, all welding done by him previously shall be fully checked by X-ray in addition to the regular X-ray inspections. The defects if any shall be set right to the satisfaction of the Engineer Incharge. All such check tests and rectifications of defects shall be entirely at the cost of the Contractor. No pipes or steel sections shall be erected unless the work of the welder concerned has been proved to be satisfactory. Site welds shall be done by specially selected welders.

A record shall be maintained showing the names of welders and operators who have worked on each individual joint. Hand welding shall preferably be carried out by a pair of welders so that, by observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or a pair shall be as far as possible, completed by them in all respects, including sealing run. No helper or other unauthorized person shall

be permitted to do any welding whatsoever. In case of infringement of above, the persons shall be punished as directed by the Engineer In-charge.

The welded joint after welding should not become brittle or sensitive to blows and there should be no loss of toughness due to welding or heat treatment. The material after welding and heat treatment is to be tougher than the base metal and is to retain its original ductility. No allowance will be made for thinning of weld and the weld should in no point be less than the nominal thickness of plate.

Upon receipt of the order and prior to the start of fabrication, the Contractor shall submit to the Engineer In-charge for his approval the “welding procedure" he intends to use in the shop work. Similarly, prior to the start of the field welding, procedure for the field welding must be submitted to the Engineer In-charge for his approval. Manual welding shall be adopted only when machine welding is not possible.

2.5.8 Ultrasonic Test of Welded Joints

Minimum 15% of welded length in each pipe (well distributed along the pipe length) at random shall be subjected to ultrasonic test at factory. The acceptance / rejection criteria shall be as per API 5L (American Petroleum Institute). The ultrasonic test shall be conducted as per relevant ASME code. (American Society of Mechanical Engineering) The person who conducts the test shall have certificate as per ISNT or ASNT Level-2. (American Standards and Testing)

2.5.9 Radiographic test of welded Joints

In case of field joints, minimum 10 % of weld length of each joint at random shall be subjected to radiography test.

In case of shop / plant fabrication of pipes, minimum 200 mm of weld length of each pipe end shall be subjected to radiography test.

In case of failure of joints, the contractor shall be required to carry out radiography of thrice the number of segments failing during the radiography test. Even after such radiography testing, if any one of the segment fails, the contractor shall be required to carry out radiography of full joint.

The weld ripples or weld surface irregularities, on both inside and outside shall be removed by any suitable mechanical process to a degree such that resulting radiographic contact due to any remaining irregularities cannot mark or be confused with that of objectionable defect. The radiograph shall be made in strict accordance with the latest

requirements and as per the latest and most efficient technique either with X-ray or Gamma ray equipment.

The photographs are to be marked in such a way that the corresponding portion of the welded seam can be readily identified. All radiographs will be reviewed by the Engineer to identify the defect and determine those which must be removed. Defects that are not acceptable shall be removed by chipping, machining or flame gouging to sound metal and the resulting cavities shall be welded. After rectification, the joint is to be radiographed again to prove the quality of the repair. The radiographs will be judged as acceptable or unacceptable by the Engineer In-charge based on the latest standards prescribed by Indian Standard specification.

All X-ray shall be made with equipment and by personnel furnished by the Contractor. Films shall be developed within 24 hours of exposure and be readily accessible at all times for inspection by the Engineer In-charge. The Contractor shall provide for the use of the Engineer In-charge suitable X-ray viewing equipment. X-ray films shall be properly maintained by the Contractor and shall be handed over to the department on completion of the Contract. All films shall be identified by the no. and chart prepared indicating location of the joint each X-ray photo represents. In the event of additional radiographic inspections required of any work associated with the pipe erection, such inspection shall be performed by the Radiographer at the discretion of the Engineer In-charge.

The Radiographic / X-ray test facility of the pipe manufacturer shall have valid license / approval from the AERB and in compliance with the requirements of the AERB.

2.5.9.1 Real Time Radiographic Inspection of Weld Seams

The entire weld length of pipes shall be tested by real time radiography (RTR) after the SAW welding and prior to the Hydro test in accordance with the ISO 10893 – 7. All unacceptable defects shall be repaired as per the approved repair procedure to enable to reduce the repair of weld seams after hydro test.

2.5.9.2 Radiographic Inspection

1. General

The Engineer shall assure himself that the welding procedure employed in the construction of pipes has been qualified. The Contractor shall submit evidence to the Engineer In-charge that the requirements have been met. The Contractor shall certify that the welding of pipes has been done only by qualified welders and welding operators and the Engineer In-charge shall ensure himself that only qualified welders and welding operators have been used.

The Contractor shall make available to the Engineer In-charge a certified copy of the records of the qualification tests of each welder and welding operator. The Engineer In-charge shall have the right at any time to call for and witness tests of welding procedure or of the ability of any welder and welding operator.

2. Radiographic Inspection of Welded Joints

All welded joints are to be radio graphed and shall be examined in accordance with:

Code	Description
IS: 2595-1978	Code of Practice for Radiographic Testing
IS:4853-1982	Recommended Practice for Radiographic Inspection of Fusion Welded Butt joints in Steel Pipes
IS:1182-1983	Recommended Practice for Radiographic Examination of Fusion Welded Butt-Joints in steel plates. (second revision)
IS:2598-1966	Safety Code for Industrial Radiographic Practice.

The reinforcement on each side of all butt-welded joints shall not exceed 1.5 mm.

A complete set of radiographs and records as described in IS:2595 Clause 14, for each job shall be retained by the Contractor and kept on file for a period of at least five years.

Radiographers performing radiograph shall be qualified in accordance with SNT-TC-1A. Supplements and Appendices “Recommended Practice for Non-destructive Testing Personnel Qualification and Certification" published by the American Society for Non-destructive testing as applicable for the technique and methods used.

Final acceptance of radiographs shall be based on the ability to see the prescribed penetrometer image and the specified hole.

Sections of welds that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired.

- ✓ any type of crack, or zone of incomplete fusion or penetration,
- ✓ any elongated slag inclusion which has length greater than 6 mm,
- ✓ any group of slag inclusion in line that have an aggregate length greater than thickness in a length of 12 times thickness, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.
- ✓ Rounded indications in excess of that specified by the acceptance standards given earlier

2.5.10 Tolerance

The shell in the completed work shall be substantially round. The difference between maximum and minimum inside diameters at any cross section shall not exceed 1% of the nominal diameter of the cross section under consideration subject to a maximum of 10 mm. Straight pipes shall have their faces perpendicular to the axis of the section with a maximum deviation of 2 mm on either side of the plane. Pipe ends shall be bevelled as per IS-3589 and/or IS-5504.

For the shell thickness, no negative tolerances are acceptable.

2.5.11 Shop Testing

After fabrication, but before application of protective coatings all pipes and specials shall be subjected to a shop hydraulic test. Standard lengths of pipes shall be directly subjected to test and non-standard pipe and elbows can be tested as standard pipe before being cut to size.

The Hydraulic test pressure for individual pipe in the factory shall be as per IS: 3589 (refer latest version).

Prior to testing, the pipe shall be inspected thoroughly by Real Time radiography (RTR) and all the apparent defects in welding such as jumps, porosity etc. shall be repaired by gouge and re-welding.

The hydraulic test shall be carried out under cover at the fabrication shop, in the presence of and to the satisfaction of the Engineer In-charge or the inspection agency appointed by the Employer.

For indicating the pressure inside the pipe an accurate pressure gauge of approved make duly tested and calibrated for the accuracy of readings shall be mounted on one of the closures, which close the pipe ends.

The pressures shall be applied gradually by approved means and shall be maintained for at least 5 seconds or till the inspection of all welded joints is done during which time the pipe shall be hammered throughout its length with sharp blows, by means of a 1 Kg hand hammer.

The pipe shall withstand the test without showing any sign of weakness, leakage, oozing or sweating. If any leak or sweating is observed in the welded joints, the same shall be repaired by gouging and re-welding after dewatering the pipe. The repaired pipe shall be re-tested to conform to the specified pressure.

If any leak or sweating is observed in pipe shell the pipe under test shall be rejected temporarily. The Contractor shall stack such rejected pipes separately in his yard. The Engineer In-charge shall inspect the same and after taking cuts if necessary, shall determine the nature of repairs to be carried out thereon and shall then decide as to how and where they shall be used. No payment shall be made for handling or carrying out repairs, but, payment for the fabrication and hydraulic testing of the pipe shall be released only after acceptance of the pipe with necessary repairs and subsequent testing etc. are carried out by the Contractor to the satisfaction of the Engineer In-charge. The Engineer In-charge shall be supplied with two copies of the results of all the tests carried out.

2.5.12 Submission of Daily Progress Report

The Contractor shall submit to the Engineer In-charge a daily progress report in the Performa approved by the Engineer In-charge, wherein all the details of the work carried out in the factory shall be fully recorded. Similarly, works done in the various units in the factory shall be separately mentioned. The Contractor shall maintain a register of all the finished materials giving dates of carrying out important operations such as testing, transport, etc. The register shall be presented at least once a week to the Engineer In-charge who shall initial the entries after verification.

2.6 Transportation of Pipes, Specials, etc.

All pipes and specials fabricated in the factory and temporarily stacked in the Contractor's yard shall be transported to the site of laying after cleaning them internally etc. The loading in the factory shall be carried out by means of either a crane, gantry or shear legs, so as not to cause any damage to the finished material. Similarly, while unloading and stacking, great care shall be taken to ensure that the material (pipe & special) is not damaged or dented. The contrivances to be used for unloading will be different in different situations and in each case the one approved by the Engineer In-charge shall be adopted. The material stacked at site shall be jointly inspected by the Engineer In-charge and the Contractor and defect or damage noticed shall be repaired to the satisfaction of the Engineer In-charge before payment is admitted.

Props of approved designs shall be fixed to the pipes during transit to avoid undue sagging and consequent distortion. After the pipes are carefully stacked, props may be removed and re-used for subsequent operations. The stacking ground, both in the Contractor's yard and at the site of laying shall be selected in such a way as not to get

waterlogged during monsoon. If this cannot be done, the pipes shall be supported on sleepers to avoid contact with wet earth and subsequent rusting. In order to prevent sagging during transit, savings of steel plates can be utilized by cutting to the required length and tacking the same to the pipe ends, in place of props, if approved by the Engineer In-charge.

As explained in earlier paragraphs, materials such as pipes, tapers, etc. may be transported to the site of laying as soon as the material is finished in all respects with the permission of the Engineer In-charge to avoid congestion in the Contractor's yard. However, materials such as expansion joints, composite bends, 'T' branches and other complicated materials shall be stacked in the Contractor's yard until they are required for laying in the field. In view of this, the work of fabrication of such materials shall be properly synchronized as far as possible with the laying operations.

Fabricated materials such as manhole covers, appurtenances, bolts, nuts, distance pipes, flanges, saddles, collars bypass arrangements etc. shall be transported to the site of laying from the fabrication shop according to the needs of the laying operations only. In regards access roads, the Contractor shall note that access road may lead up to some points on the alignment the Contractor shall have to make his own arrangement for connecting approaches to transport the pipes cross country to the actual site of laying at his own cost. Whatever may be the mode of transport he uses it shall be incumbent on the Contractor to carry and stack the pipes and specials along the alignment as close as possible to the site of laying.

2.7 Procedure for receiving Steel Pipes

2.7.1 General

To ensure that the work of erecting pipes is not held up at any stage and place, the Contractor shall maintain an adequate stock of standard specials, flange rings, plug plates, manhole covers, etc. and short length of smaller diameter pipelines, etc. at site in his field stores, in consultation with the Engineer. Wherever possible, the Contractor shall arrange one full month's requirement of pipes, specials, etc. stacked along the alignment.

2.7.2 Stacking of pipes, etc. and Inspection

The Contractor shall keep in each section a responsible representative to take delivery of the pipes, specials and appurtenances, etc. transported from the fabricating stockyard or received from any other work site to the site of laying and to stack along the route on timber skids. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Suitable gaps in the pipes stacked shall be left at intervals to permit access from one side to the other. The pipes, specials, appurtenances so received on site shall be jointly inspected and defects recorded, if any, such as protrusions, grooves, dents, notches, damage to the internal coating etc. shall be pointed out immediately to the Engineer In-charge at the site and in the acknowledgement challans. Such defects shall be rectified or repaired to the satisfaction of the Engineer In-charge entirely at the Contractor's risk and cost.

2.7.3 Handling of Pipes, Specials, Appurtenances, etc.

It is essential to avoid damage to the pipes, fittings and specials, etc. or their coatings at all stages during handling. The pipes and specials shall be handled in such a manner as not to distort their circularity or cause any damage to their surface treatment. Pipes shall not be thrown down from the trucks nor shall they be dragged or rolled along hard surfaces. Slings of canvas or equally non-abrasive materials of suitable width of special attachment shaped to fit the pipe ends shall be used to lift and lower coated pipes to prevent damage to the coating.

Great care shall be taken in handling the pipe right from the first operation of manufacture until they are laid and jointed. The Contractor will provide temporary props in order to prevent any sagging of the pipes while they are stacked in their yard and while transporting to the site of delivery, i.e. laying. The props shall be retained until the pipes are laid. If at any time these props are found to be dislodged or disturbed, the Contractor shall immediately reinstate them in such a way that the true shape of the pipe shell or specials is maintained to the satisfaction of the Engineer In-charge. No defective or damaged pipe or special shall be allowed to be used in the work without rectification to the satisfaction of the Engineer In-charge. Any damage to the coating shall be repaired by the Contractor at his own cost to the satisfaction of the Engineer In-charge.

2.7.4 Dents

Whenever any dent, i.e. a significant alteration of the curvature of the pipe shell is noticed, the depth of the dent shall be measured between the lowest point of the dent and the pipe shell curvature line. All dents exceeding 2 percent of the outer diameter of the

pipe shall be removed by cutting out a cylindrical portion of the pipe and replacing the same by an undamaged piece of the pipe. The Engineer In-charge may permit insert patching if the diameter of the patch is less than 25 percent of the nominal diameter of the pipe. Repairs by hammering with or without heating shall not be permitted. Any damage to the coating shall also be carefully examined and rectified.

2.7.5 Marking

The component parts of the pipes shall be carefully marked for identification in the field. The marking shall be on the side, which will be the inside of the pipe after bending.

The marking operation shall be conducted with full size rulers and templates. Only blunt nose punches should be used.

The plates used for fabrication of pipes shall be laid out in such a way that when the shells are completed one set of original identification markings for the material will be plainly visible. In case these markings are unavoidably cut out, they shall be accurately transferred by the Contractor to a location where these markings will be visible on the completed work.

After hydraulic tests on the specials and other items, the number of the shell in the line as it will be erected and the direction of flow shall be stamped in a prominent manner on each piece.

A register shall be maintained in suitable proforma giving the following information for each shell tested:

i. Serial No.
ii. Shell No.
iii. Date of test
iv. Thickness and specification of steel
v. Weight of shell tested
vi. Maximum test pressure
vii. Details of test performance
viii. Details of radiographic examination of welds
ix. Name of Engineer's representative witnessing tests

A copy of these details shall be furnished to the owner at free of cost. No separate payment will be made for these markings and the rates for the items concerned shall be deemed to include the cost of such markings.

2.8 Specification for liquid epoxy coating systems for drinking water steel pipelines

Providing & applying internal coating to MS pipe with solvent free NSF / ANSI 61 approved High build liquid epoxy having dry film thickness of minimum 406 microns including scrapping the surface of the pipe. Epoxy coating of supplied pipe shall be carried out at factory, only field joint coating acceptable at site.

2.8.1 Scope

This specification is intended to establish the minimum criteria necessary for selection of the coating material, supply of the materials and equipment, qualification, application, inspection, testing, handling, storage and packaging of the materials that is required for protecting the internal surface of the drinking water carrying pipelines & pipeline components that are coated in factory.

This specification covers chemically cured 2-part epoxy based solvent-free liquid coating material.

The specification has been designed for the said application and material, will be revised periodically if needed, to meet environmental regulations & health-effects and to modify procedures based on technological advances.

This specification makes restrictive amendments/modification to ANSI/AWWA C-210-2015.

2.8.2 References

This specification makes reference to the documents listed below. Unless specified otherwise, the latest editions of these documents including all addenda and revisions shall apply.

Transco specification

- ✓ T/SP/CM1-Technical Specification for internal coating operations for steel line pipe & fittings T/SP/CM2- Technical Specification for internal coating materials for steel line pipe & fittings.
- ✓ ANSI/AWWA specification
- ✓ ANSI/AWWA C210-2015 - Standard for Liquid Epoxy coating systems for the interior and exterior of steel water pipelines

ASTM standards

- ✓ ASTM D4060 - Standard Test Method for Abrasion Resistance of Organic Coatings ASTM D2794 - Standard Test Method for Resistance of Organic Coatings to the effect of Rapid Deformation (Impact)

- ✓ ASTM D2485 - Standard Test Method for Evaluating Coating for High Temperature Service ASTM D4541 - Standard Test Method for Pull-off Strength of Coatings
- ✓ ASTM D1653 - Standard Test Method for Water Vapor Transmission of Organic Coatings ASTM D3363 - Standard Test Method for Film Hardness by Pencil Test
- ✓ ASTM B117 - Standard Process for Operating Salt Spray (fog) Testing ASTM D2486 - Standard Test Method for Scrub Resistance
- ✓ ASTM G8 - Standard Test Method for Cathodic Disbonding of Pipeline Coatings
- ✓ CSA.Z.245.20- Standard Test Method for Cathodic Disbonding of Pipeline Coatings

British Standards

- ✓ BS 3900 - Methods of Test of Paints
- ✓ BS 7079 - Preparation of Steel Substrates before Application

Others

- ✓ SSPC PA 3 – Guide to Safety in Paint Application

2.8.3 Definitions

Applicator: The "Applicator" is the organization responsible to the purchaser for the application of the coating.

Purchaser: The "Purchaser" is the company or the authorized agency that buys the coating or coated pipe.

Supplier: The "Supplier" is the manufacturer and/or distributor of the coating material and its authorized qualified technician.

Inspector: The "Inspector" is the authorized agent appointed by the applicator or the purchaser to carry out inspection of the coating material and the coated product.

Coating Material: "Coating material" indicates the liquid material prior to application on the pipe or substrate.

Coating: "Coating" indicates the film formed by the coating material when applied on the substrate.

Batch: A "Batch" is the quantity of coating material manufactured at one time and identified by a unique batch number.

Note: Other definitions shall be in accordance with the referenced standards.

2.8.4 General Requirements

2.8.4.1 Coating Supplier Information

The coating material supplier shall furnish documents with the following information for each batch of material supplied, to the purchaser and/or applicator.

a. Directions for application and use of the coating materials.
b. Directions for handling and storing of the coating materials.
c. Specification of the basic physical properties and performance test results of the material. These basic physical properties and performance test results shall be within the range permitted in the recommended practice
d. Certification of the specific physical properties for each batch of coating material shipped.

2.8.5 Requirements for Quality

The applicator shall have established within his organization, and shall operate for the contract, a documented quality system that ensures that the requirements of this specification are met in all aspects. The coating material suppliers should have Quality System certifications of ISO 9001-2008, ISO 14001, and OHSAS 18001.

The applicator shall have established quality assurance group within his organization that shall be responsible for reviewing the quality system and ensuring that it is implemented.

The applicator shall submit the procedures, which comprise the quality system, to the purchaser for agreement.

The applicator's quality system shall pay particular attention to the requirements for quality control of suppliers. The applicator shall ensure that requirements of this specification are satisfied by its suppliers and is operating similar quality system in their organization.

The applicator shall, prior to the commencement of work, prepare and issue a quality plan for all of the activities required to satisfy the requirements of this specification. The plan shall be sufficiently detailed to indicate sequentially for each discipline the requisite quality control, inspection, testing and certification activities with reference to the relevant procedures and acceptance standards.

The applicator's quality system and associated procedures may, with due notice, be subjected to formal audits. The appointed representative (s) (by purchaser/ applicator) will monitor quality control implemented by the applicator. These representative(s) will

also witness and accept the inspection, testing and associated work required by this specification.

The applicator's equipment for blast cleaning and coating shall be of such design, manufacture and condition to permit the applicator to comply with the procedures and obtain the results prescribed in this specification.

2.8.6 Compliance

The Applicator shall be responsible for complying with all applicable requirements of ANSI/AWWA C210-2015 and this specification. The purchaser reserves the right to make necessary investigation and in case of doubt, ask the applicator to conduct additional testing, batch sampling and manufacturing inspection, in order to be satisfied of compliance by the applicator. Any material/coating that does not comply with the requirements shall be rejected.

2.8.7 Safety

All necessary precautions should be taken to protect personnel and property from accidents due to falls, hazardous materials, fire, explosion, and other dangers. The methods and practices define in SSPC PA3 shall be followed.

2.8.8 Coating System

2.8.8.1 Two part, chemically cured, Solvent-free Epoxy Lining

Spray applied, impermeable, 100% solids, high build, primer-less, chemically cured epoxy coating. The coating shall be capable of building wet film thickness that can give 406 microns dry film thickness in single coat application.

2.8.9 Shelf life

The component parts shall be stored in unopened original containers at conditions as recommended by the supplier. They shall show no instability or settling beyond a state permitting easy, complete dispersion to a smooth homogenous consistency. When properly mixed and applied, acceptable drying and curing shall result. Shelf life of the material shall be at least 1year from the date of manufacturing.

2.8.10 Physical and Performance Properties

The coating material used shall confirm to the performance standards explained in Table 2. The coating shall be suitable for a maximum in-service temperature of 60˚C.Unless specified otherwise; design life of the internal epoxy coating shall be 40 years.

2.8.11 Drinking Water Approvals

Buried steel pipeline shall be coated internally, with a single coat two part solvent free high build liquid epoxy lining as per AWWA C210-2015 suitable for potable water application. The coating material should have yearly approval and listed by NSF International Standard NSF/ANSI-61 and also should have certification by water regulations advisory scheme (WRAS), UK suitable for contact with wholesome water for domestic purposes having met the requirements of BS6920-1:2000 and/or 2014 'Suitability of non-metallic products for use in contact with water intended for human consumption with regard to their effect on the quality of the water.

In addition to above statements and requirements, applicator need to withdraw samples randomly from the batches used during coating application, the picked samples after consultation with pipeline owner / EPC are to be send to NSF Lab in Michigan, US for testing to conform the compliance of NSF/ ANSI 61 certification. The tests report needs to be submitted to purchaser by applicator.

Coating material should also comply with US FDA 175.300 Leachable and extractible criteria for to be in contact with drinking water, and to be tested by a Government accredited laboratory. Report to be submitted by the coating material manufacturer to applicator and purchaser.

The applicator shall perform all work in accordance with these specifications and the latest pipeline coating practices, and shall complete the work in all respects to the full satisfaction of the purchaser /purchaser's representative

2.8.12 Coating Application

2.8.12.1 General

The pipe coating material shall be used and applied in accordance with the supplier's recommendation, application by hot plural feed air-less spray is preferred.

2.8.12.2 Pipe Surface Preparation

All surfaces should be free from oil, grease and other contamination prior to abrasive blasting.

Surfaces should be blast cleaned to a minimum Sa2½ in accordance with BS7079 Part A1 1989 or equivalent. Prior to blast cleaning any sharp protuberances, surface lamina-

tions, weld spatter, etc. shall be removed by thorough grinding and cleaning. The abrasive used should be capable of producing a minimum profile of 50-90 microns corresponding to 'medium' in accordance with BS7079 Part C4.

All dust, residues and debris left on the surface after the blast cleaning must be removed.

2.8.12.3 Surface Profile

The surface profile (anchor pattern) shall be as recommended by the coating supplier.

2.8.12.4 Profile Determination

Depth of profile shall be determined in the field by using a replica tape, a depth micrometer, or a surface profile comparator.

2.8.12.5 Surface Inspection

The cleaned interior pipe surfaces shall be inspected for conformance to Sec 2.5.2. Surface imperfections such as slivers, scabs, burrs, weld spatter, and gouges, shall be removed by grinding. Inaccessible surface imperfections may dictate that the pipe be rejected.

2.8.12.6 Interior Cleaning

If abrasives or other loose foreign matter has entered the interior of the pipe, then clean, dry and oil-free compressed air shall be used to remove the loose foreign matter in a manner that does not adversely affect the cleaned surface. Alternatively, vacuum cleaning or other methods may be used in place of compressed air.

2.8.13 Coating Application

Blast-cleaned pipe surfaces shall be protected from conditions of high humidity, rainfall, or surface moisture. Pipe shall not be allowed to flash rust before coating.

2.8.13.1 Materials Preparation

Materials preparation shall be in accordance with the supplier’s recommendations.

2.8.13.2 Application Temperature

- ✓ Liquid epoxy coating can be spray coated on the blast cleaned surface, when substrate temperature is in the range of 70C to 500C. If steel temperature is below 70C or above 500C, spray coating shall be stopped, until the substrate (pipe) temperature is brought in the range specified here.
- ✓ Spray coating application shall be performed only when the relative humidity is below 85%. If ambient relative humidity increases above 85% coating process is to be stopped. Applicator is responsible to measure and record relative humidity at every 60 minute interval.

- ✓ Spray coating application to be done, only when steel surface temperature is at least 300C above the dew point of ambient air, so that moisture from ambient air does not condense on the steel surface or coated surface. Applicator shall be responsible to measure and record the dew point of ambient air by using dew point indicator
- ✓ Applicator shall be responsible to use appropriate grade of spray nozzle (23 to 39 thou) and regulator to achieve required tip pressure (about 4000psi), as recommended by the coating material supplier.
- ✓ Both base and activator components need to be preheated (as per recommendation from the supplier), so that material temperature at the spray tip is in the range of 40˚C to 65˚C, again it depends on fan width during application which can be established during application.

2.8.13.3 Application of Coating Material

The epoxy coating system shall be applied as recommended by the coating manufacturer. If more than one coat is applied, the second coat shall be applied within the time limits, surface conditions, and temperature recommended by the supplier. If the period between the coats is exceeded, then a repair procedure shall be obtained from the coating material supplier and its recommendations to be followed.

2.8.14 Coating Repair and Touch Up

Defective coating shall be repaired in accordance with the following sections.

Accessible areas of pipe requiring coating repairs shall be cleaned to remove debris and damaged coating using surface grinders or other means acceptable to the purchaser. The adjacent coating shall be feathered by sanding, grinding or other methods approved by the purchaser. Accumulated debris shall be removed by vacuum, blowing with dry air or wiping with clean rag.

Areas not accessible for coating repair, such as interior surfaces of small diameter pipe, shall be reprocessed and recoated.

Repairs shall be electrically inspected using a holiday detector.

2.8.15 Field Joints

2.8.15.1 Preparation

The weld joints shall be cleaned to be free from mud, oil, grease, welding flux, weld spatter, and other foreign contaminants. The cleaned metal surfaces of the weld joint shall then be abrasive blasted, or abraded to provide a surface in compliance with Sec

1.8.12 The adjacent coating shall be feathered by abrading the coating surface for a distance of 50-70mm.

2.8.15.2 Coating

The coating system shall be applied to the weld joint in accordance with Sec 1.8.12

2.8.15.3 Inspection

After curing, the coating system shall be electrically inspected using a holiday detector.

2.8.16 Inspection

The coating system shall be inspected for adhesion to the steel and between coats, thickness, blisters, cracks, bubbles, under-film voids, holidays, pinholes, discontinuities, and mechanical damage. All imperfections shall be identified and marked with for repair.

After curing but prior to installation, the coating system applied to the pipe shall tested for holidays according to the procedures and using the high voltage settlings outlined in NACE RP0188 for the specified thickness. Any holidays indicated by the detector shall be identified and marked for repair.

2.8.17 Coating Qualification Testing

General

The coating system shall be qualified for production by coating applicator by testing laboratory coated test specimen for each applicable test (see clause 7.3) and by meeting the acceptance criteria as applicable. The applicator shall submit all test reports to the purchaser for review and approval. The coating shall be re - qualified where there is a change in one or more of the following:

a) Supplier
b) Coating formulation, and
c) Location of manufacture

Preparation of Test Panels

Prepare 4 in x 6 in x 1/8 in steel panels by blast cleaning one side in accordance with Sec 2.5.2. Apply the coating without primer at the specified thickness and by the method recommended by the supplier. Cure the coating according to the supplier`s recommendations.

Coating Qualification Testing Requirements

Cure Test

The coating supplier shall be consulted to ascertain the proper cure time of the coating prior to testing. The cure test, whether performed on the coating system applied to the test panels prepared as in Sec 7.2 or on the pipe in the shop or field, shall be performed in accordance with solvent rub procedures as outlined in ASTM D4752 (Solvent Rub Test), ASTM 3363 (Pencil Hardness) or both as required by purchaser. The coating system that has not been cured in accordance with the manufacturer's written instructions may be rejected.

Adhesion Test

The adhesion or bond of the coating to the steel and the intercoat adhesion of succeeding coats after curing shall be determined in the field after curing by making a V-shaped cut through the coating with a sharp knife. The adhesion will be considered satisfactory if the film can't be peeled by the knife either from the steel or between coats for a maximum distance of 3.2mm from the intersection of the cut lines forming the "V". Forcible rupture of the coating that leaves potions of the film adhering tightly to the metal shall not be cause for rejection. The adhesion of the coating to the test panel can also be performed in the laboratory in accordance with ASTM D4541. The test can also be performed in the field under the conditions set forth in the ASTM procedure.

Thickness Test

The thickness of each coat and of the final cured coating system shall be determined in accordance with SSPC PA2.

QUALITY CONTROL TESTING

Applicator shall establish and maintain quality assurance system as are necessary to ensure that goals or services supplied, comply in all respects with the requirements of this specification. The quality assurance plan shall include following tests for quality control:

Surface Preparation Stage

The standard of finish for cleaned pipe shall conform to near white metal finish to Sa2 ½ of Swedish Standard SIS 055900 latest edition. Surface of pipe after abrasive shot/grit blasting shall have an anchor pattern (surface profile measured from peak to trough) of 50 to 90 microns (Rz) inclusive. This shall be measured for each pipe by a

suitable instrument such as stylus gauge. In addition, the pipe surface after blast cleaning shall be checked for the degree of cleanliness (Say 2 ½) and degree of dust and shape of profile

All pipes shall be preheated to a temperature of 55˚C to 65˚C, prior to abrasive blast cleaning. The pipe surface shall be maintained at a temperature of at least 3˚C above dew point of the ambient air. At no time, the blast cleaning be performed when the relative humidity exceeds 85%. The applicator shall measure the ambient conditions at regular intervals during blast cleaning and coating operations and keep records of prevailing temperature, humidity and dew point of the air.

Application Stage

Wet Film thickness shall be checked at 3' O clock, 6' O clock" and 12' O clock positions at both the pipe ends. It is suggested to maintain appropriate wet film thickness (~ 506 μ) to ensure a minimum dry film thickness of 406μ.

Visual Assessment: No runs, sags, or bubbling

About10 minutes of spinning to be carried out to avoid sagging.

Surface hardness to be measured after full cure.

The internal epoxy lining shall consist of resin (epoxy) & hardener (curing agent), mixed in the ratio as recommended by the supplier and applied to a dry film thickness (DFT) of minimum 406μ. Physical properties of the internal lining shall be as per Table-1

During PQT the coated specimens cut from coated pipes are to be tested as per AWWA C 210-2015 compliance requirement.

Prior to regular production coating, supplier needs to submit their quality assurance plan for approval from purchaser for the process and tests are to be carried out. At no point, the DFT of cured coating should not be less than 406 μ while maximum can be up to 606 μ.

Table-1 Physical Properties of the Coating

Property	Requirement	Test Method
Long term contact with	No effects for human	NSF / ANSI -61

potable water	consumption as certified by NSF International	
Thickness (applied min)	406µ	SSPC-PA 2
Thickness deviation (min)	- 0 / + 200µ	SSPC-PA 2
Dielectric strength (min)	450 V/mil (15 V/µm)	ASTM D149
Hardness Shore D	85 (min)	ASTM D2240
Adhesion to Steel (min)	1500 psi	ASTM D4541
Tabor Abrasion	1560 cycles / mil	ASTM D4060
Compressive strength	70 MPa	ASTM C109

Check for Touch Dry after 24 hours

Dry Film thickness: DFT should be measured after full cure.

Wet Sponge Holiday Detection: ISO 15741 method to be used for holiday detection. Depending upon actual Dry Film Thickness, Holiday Voltage to be set as per ISO 15741 requirements of Wet Sponge Test. All detected holidays need to be repaired.

2.8.18 Rejection

Pipe

The purchaser may reject pipe if the surface condition does not comply with the requirements of this specification.

Coating Material

The coating material may be rejected if the coating materials does not comply with the requirements specified in Table 1 & 2.

2.8.19 Packaging, Handling, Stacking & Storage

Coated pipe and other article shall be packaged, handled and stored in a manner that will minimize damage. Pipe or coating damaged in handling or other operations shall be repaired in accordance with the procedure mentioned in this specification.

All coating materials shall be supplied to the job site in the supplier's original, unopened containers. Each container shall be plainly marked with the name and address of the supplier, type of material, batch or lot number, date of manufacturing, storage conditions and information as required by federal, provincial and state laws.

Stacking of coated pipes shall be in accordance with industry-accepted safety practices and in accordance with purchaser's instructions.

Table 2 - Physical & Performance Properties of Liquid Epoxy Coating

S No	PROPERTY	TEST METHOD	SPECIFICATION
1	**PHYSICAL PROPERTIES**		
	Total Solid Content (by Volume), %	API 5L2	100
	Specific Gravity (Mix), gm/cc	ASTM D1475	Min -1.40
	V.O.C. (as supplied)		NIL
	Film Thickness, Microns		406 - 1000Microns in Single Coat
	Note: The thickness should be agreed between the specifier & manufacturer dependent on operational performance criteria		
	Theoretical Coverage	API 5 L2	Min 2 Sq meter per litre @ 500u DFT
	Thermal stability of cured coating	Supplier's Method	65^0C in contact with water.
	Application Method	Hot Plural Feed Air-less Spray	Uniform thickness of coating
	Mixing Ratio (v/v) Part-A: Part-B	Supplier's Method	As per Manufacturer product recommendation
2	**DRYING PROPERTIES @ 20 ℃**		
	Touch Dry	API 5L2	4 Hrs Max
	Hard Dry	API 5L2	6 Hrs Max
	Full Cure	API 5L2	7 Days Max
3	**PERFORMANCE PROPERTIES (500-600 Micron DFT)**		
	Abrasion Resistance (1 kg load, 1000 Cycles,	ASTM D4060	
	Impact Resistance	ASTM G14	> 5 Joule
	Dry Heat Resistance, ℃	ASTM D2485	80
	Pencil Hardness	ASTM D3363	3H Min
	Shore D Hardness	ASTM D2240	Minimum 78
	Water Vapor Permeability, perm.cm	ASTM D1653	3.75×10^{-6}
	Direct Pull Adhesion, Grit-blasted Steel, PSI	ASTM D4541	Minimum 10MPa
	Cathodic Disbondment, mm	ASTM G8	6 Max
	Salt Fog Resistance, Cycles	ASTM B117	Minimum 5000Hrs should Pass
	Scratch Resistance, 2.5Kg load	BS 3900 part E2	No failure
	Humidity Resistance, Hrs	BS 3900 part F2	5000 Min
	Cathodic Disbondment Resistance- 28 Days / 1.5V / 3% NaCl/ 65 ± 2 ^{0}C	CSA.Z.245.20	≤ 13.5 mm
	Hot Water Soak Adhesion at 65 ^{0}C	CSA.Z.245.20	Rating 1-3

	Water Vapor Permeability Gm.mm/m2/24hrs -	ASTM D 1653	2.5 Max

2.9 Outside Coating – For underground pipe upto 1500mm diameter SWMS pipe 3 LPE outside coating shall be provided and above 1500mm diameter pipe polyolefin tape outside coating shall be provided by the bidder:
For Over ground pipe outside coating shall be of 2 layer Epoxy Paint over a coat of primer.

3 Layer Polyethylene

2.9.1 Scope

This Specification defines the minimum requirements for the application of three- layer polyethylene coating to the external surface of steel pipes.

For the factory applied coating the system shall comprise of a layer of fusion bonded epoxy (FBE), overlaid with adhesive with an outer layer for high density polyethylene (HDPE).

2.9.2 Codes and Standards

This latest edition of the following codes and standards shall establish the minimum standards for the work

Codes and Standards

Codes	Standards
ANSI/AWWA C213	Standard for Fusion-bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
ASTM D149	Standard test method for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies.
ASTM D257	Standard Test methods for dc resistance or conductance of insulating materials.
ASTM D570	Standard test method for water absorption of plastics
ASTM D638	Standard test method for tensile properties of plastics
ASTM D746	Standard test method for brittleness temperature of plastics and elastomers by impact.
ASTM D790	Standard test method for flexural properties of unreinforced and reinforced plastics and electrical insulating materials
ASTM D1238	Standard test method for melt flow rates of thermoplastics by extrusion plastometer.
ASTM D1505	Standard test method for Density of plastics by the Density-Gradient Technique.
ASTM D1525	Standard test method for Vicat softening temperature of plastics.
ASTM D1531	Standard test methods for relative permittivity (dielectric constant) and dissipation factor by fluid displacement procedures.

ASTM D1603	Standard test method for carbon black content in olefin in define plastics
ASTM D1928	Standard practice for preparation of compression- molded polyethylene test sheets and test specimens.
ASTM D2240	Standard test method for rubber property - durometer hardness.
ASTM D3417	Standard test method for enthalpies of fusion and crystallization of polymers by differential scanning calorimetry (dsc)
ASTM D4703	Standard test practice for compression Molding Thermoplastic Materials into Test Specimen, Plaques or Sheets.
ASTM F372	Standard test method for water vapour transmission rate of flexible barrier materials using an infrared detection technique
AWWA C 200-97	Steel water pipe line
ASTM G8	Standard test method for Cathodic Disbonding of pipeline Coatings.
CAN/CSA Z 245:1	Internal fusion bond epoxy coating / lining of steel pipes
DIN 30670	Polyethylene Coatings of Steel pipes and Fittings – Requirements and Testing.
DIN EN ISO 9001 2000	Quality management systems – Requirements
DIN EN ISO 8501-1	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - Part 1 : Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
DIN EN ISO 8502-2	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness – Part 2 : Laboratory determination of chloride on cleaned surfaces.
DIN EN ISO 8502-3	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 3 : Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)
DIN EN ISO 8502-4	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 4 : Guidance on the estimation of the probability of condensation prior to paint application.
DIN EN ISO 8502-9	Preparation of steel substrates before application of paints and related products – Tests for the assessment of surface cleanliness – Part 9 : Field method for the conductometric determination of water-soluble salts.
DIN EN ISO 8503-1	Preparation of steel surfaces before application of paints and related products. Method for the grading of surface profile of abrasivety blast cleaned steel using a comparator (1995)
DIN EN ISO 8503-1	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast cleaned surfaces.

DIN EN ISO 8503-2	Preparation of steel substrates before application of paints and related products - Surface roughness characteristics of blast-cleaned steel substrates - Part 2: Method for the grading of surface profile of abrasive blast-cleaned steel - comparator procedure.
ISO 8502-5	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness - Part 5: Measurement of chloride on steel surfaces prepared for painting (ion detection tube method)
NACE RP0490	Holiday Detection of Fusion-Bonded Epoxy External Pipeline Coatings of 250 to 760mm (10 to 30 mils)
NACE RP-01-75	Recommended practice: control of International corrosion in steel pipe line system.
SIS 05-5900	Preparation of steel substrates before application of paints and related products - visual assessment of surface cleanliness - PT 1: rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous.

2.9.3 General

2.9.3.1 Environmental Conditions

The environmental conditions operating conditions, product data, etc. under which the pipes shall operates and defined in Documents. Scope of Work, Project Design Data and Site Conditions and Specification for Pipeline construction.

2.9.3.2 Abbreviations

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
DIN	German Standards Institute
ISO	International Organisation for Standardisation
NACE	National Association of Corrosion Engineers
NPS	Nominal Pipe Size
MPI	Magnetic Particle Inspection
UT	Ultrasonic Testing
SIS	Swiss standard
AWWA	American Water Works Association

2.9.4 Handling of Coating Materials

2.9.4.1 General

Materials shall be handled and stored in accordance with the material manufacturer's recommendations, which shall be available for review by the Engineer In-charge at the

Contractor's premises. Materials shall be stored in temperature controlled environment until required for use.

Coating materials shall be segregated by type and batch during storage and handling. Materials from damaged containers shall be rejected unless otherwise agreed with the Engineer In-charge.

As a minimum, all packages of the coating materials shall be marked with the following data:

a. Name of manufacturer
b. Complete material identification – trade name, chemical name and
c. type of product details
d. Batch number
e. Date of manufacture
f. Place of manufacture
g. Shelf life/expiry date (if appropriate)
h. Health and safety, and environmental instructions
i. Hazard Warnings
j. Storage instructions
k. Quantity
l. Manufacturing Standard

Any material not labelled with the above information shall not be used.

2.9.4.2 Abrasive Grit

The abrasive shall be steel grit, also in combination with steel shot of the required grade to achieve the specified surface profile. The use of sand is not permitted.

Blasting abrasives shall be kept dry, clean and free from contamination. When recovered metallic grit systems are used, a stabilized working mix of blast cleaning material shall be established. This mix shall be maintained throughout the entire course of the production, by frequent small additions from fresh or cleaned stock at a rate sufficient to refurnish consumption. Blasting and other dust producing areas shall be kept separate from coating application areas. The surface cleaning shall be degree of cleanliness as per SA 2.5 & ISO 8502-3.

2.9.4.3 Fusion Bonded Epoxy (FBE) Powder

The FBE powder selected shall be suitable for use at the design temperatures in the proposed environment and be suitable for a three-layer polyethylene coating system.

The FBE shall be endorsed by the contractor of the adhesive and Polyethylene as being compatible with these products under the specified service conditions.

Each batch of FBE shall be accompanied by a certificate stating the following tests have been carried out on every batch and results are in accordance with the coating material manufacturer's product specifications;

- ✓ Gel Time
- ✓ Moisture content
- ✓ Particle size distribution
- ✓ Density
- ✓ Infrared Scan
- ✓ Thermal analysis

2.9.4.4 Adhesive

The adhesive selected shall be completely suitable for use at the design temperatures in the proposed environment and be suitable for a three-layer polyethylene coating system. Each batch of adhesive shall be accompanied by a certificate stating the following tests have been carried out on every batch and results are in accordance with the coating material manufacturer's product specifications:

- ✓ Adhesion
- ✓ Density
- ✓ Melt flow index

2.9.4.5 Polyethylene

The polyethylene selected shall be high density meeting to Class B of ISO 21809-1 and shall be completely suitable for use at the design temperatures in the described environment. The polyethylene shall be suitable for a three-layer polyethylene can be stabilized against UV-rays by incorporation of minimum 2% well dispersed Carbon black of particle size 10-25 nm.

Each polyethylene batch shall be accompanied by a certificate stating the following tests (as per below table) have been carried out on every batch and results are in accordance with the coating material manufacturer's product specification:

2.9.4.6 Properties of Epoxy Powder and Adhesive

i. The Contractor shall choose such a brand of epoxy powder and adhesive that will achieve the functional requirement and properties of coating system as specified in this specification. In addition, the coating material manufacturer shall also furnish Infra-red

Scan for each batch of epoxy powder. The coating materials manufacturer shall issue test certificates as per EN 10204, 3.1 for each batch of materials supplied to the contractor and the same shall be submitted to the department for approval prior to their use. Epoxy powder properties shall be as per CSA Z245.20.98 (latest version). The colour of epoxy powder shall be either green or dark red or any other colour approved by the department except grey colour. Copolymer grafted adhesive shall have the following properties.

S. No.	Properties	Unit	Requirement	Test Method
a.	Melt Flow Rate (190°C/2.16 kg)	g/10 minutes	1.0 minute	ASTM D 1238
b.	Vicat Softening Point	°C	100 min	ASTM D 1525
c.	Specific Gravity	-	0.926 min	ASTM D 792

ii. Properties of Polyethylene compound

S. No	Properties	Unit	Requirement	Test Method
a.	Melt Flow Rate (190°C/2.16 kg)	g/10 minutes	1.0 minute	ASTM D 1238
b.	Vicat Softening Point	°C	100 min	ASTM D 1525
c.	Specific Gravity	-	0.926 min	ASTM D 792

S. No	Properties	Unit	Requirement	Test Method
a.	Tensile Strength @ + 25 °C	N/mm2	17 min	ASTM D638
b.	Melt Flow Rate (190°C / 2.16 kg)	g/10 minutes	0.25	ASTM D 1238 or DIN 53735
c.	Specific Gravity + 25°C	-	0.926 min. (MDPE) 0.941 min.(HDPE)	ASTM D 792
d.	Hardness @ + 25°C	Shore D	50 min.	ASTM D 2240
e.	Water Absorptions, 24 hours @ +25°C	%	0.05 max.	ASTM D 570
f.	Volume Resistivity @ + 25 °C	Ohm-cm	1015 min.	ASTM D 257

g.	Dielectric with-stand, 1000 Volt/sec rise @ + 25°C	Volts/mm	30,000 min.	ASTM D 149
h.	Vicat Softening Point	°C	110 min.	ASTM D 1525
i.	Elongation	%	600 min.	ASTM D 638
j.	Oxidative Induc-tion Time in Oxy-gen at 220°C, Aluminum pan, no screen	Minutes	10 min.	ASTM D 3895
k.	Environmental Stress Crack Re-sistance (ESCR) (for F50)	Hours	300	ASTM D 1693
	- Medium Den-sity, Condition "C"		300	
	- High Density, Condition "B"			
l.	Carbon Black Content	%	2 min.	ASTM D 1603

iii. In addition to vendor's certificate, the contractor shall draw samples from each batch of epoxy, adhesive and polyethylene in the presence of department's representative and the test for the following properties at the coating yard at least one week prior to its use, to establish compliance with the Manufacturer's test certificates.

a. Epoxy Powder: Gel Time, Cure Time, Moisture content, Thermal Characteristics (Tg1, Tg2, ΔH).
b. Adhesive: Specific gravity, Melt Flow Rate, Vicat Softening Point.
c. Polyethylene: Melt Flow Rat, Specific Gravity, Vicat Softening Point, Moisture content, Oxidative Induction Time.

In Case of the failure of any of the above tests in a batch, that batch of material shall be tested for all other tests required as per this specification including the tests which failed. If all tests pass, the batch shall be accepted for coating. If any of the tests fail, entire batch of material shall be rejected and shall not be used for the coating.

iv. The Contractor shall ensure that all coating materials are properly stored in accordance with the Manufacturer's recommendation at all times, to prevent damage and deterioration in quality prior to use.

v. Properties of coating System

S. No.	Properties	Unit	Requirement	Test Method
a.	Bond Strength (using Type 2 test i.e. Dyna-mometer) Assembly @ 23°C @ 80°C	Kg/cm	15 min 5 min	ISO 21809-1
b.	Impact Strength (Mon. of 30 impacts on body along the length. No breakdown allowed when tested at 25 Kv)	Joules per mm of coating thickness	7 min	DIN 30670
c.	Indentation Hardness @ 23 +/- 2°C @ 70 +/- 2°C	mm	 0.2 max 0.3 max	DIN 30670
d.	Elongation at Failure	%	400 min	DIN 30670
e.	Coating Resistivity (*)	Ohm-m2	108 min.	DIN 30670
f.	Heat Ageing (*)	-	Melt Flow rate shall	
g.	Light Ageing (*)	-	not deviate by more than 35% of original value	DIN 30670
h.	Cathodic Dis-bond-ment -@ 23°C after 28 days, -1.5 V -@ 65°C after 24 hrs, -3.5 V -@ 80°C after 28 days, -1.5 V	Min. radius of Disbondment in mm (**)	7 max 7 max 15 max	Annex H; ISO 21809-1
i.	Degree of Cure of Epoxy - Percentage Cure, ΔH - Δtg	%°C	95 +3/-2	CSA Z 245.20 – 98 (***)

(*) Test carried out in an independent laboratory of national / international recognition of PE top coat is also acceptable.

(**) Disbondment shall be equivalent circle radius of total unsealed area as per ASTM G42.

(***) Temperature to which the test specimens are to be heated during cyclic heating shall however be as per the recommendations of epoxy powder manufacturer.

2.9.5 Acceptance of Pipe Materials

2.9.5.1 Identification and Tracking

Upon receipt at the coating factory, the Contractor shall record the following pipe information: The unique pipe identification number, measured length, and measured weight (both to be found stencilled in paint on one end or the pipe).

This data shall be used as a basis for monitoring pipe from the time of receipt until the delivery of coated pipe.

The Contractor shall identify (or maintain identification of) every coated item, by using a weatherproof mark on the inside of the pipe and on the outside of the coated item. The pipe identification shall be the unique pipe identification number (the number required by the applicable pipes specification). The contractor may use additional tracking numbers at his discretion but these shall relate simply to the unique pipe number in the QC documentation.

Pipe tracking shall be carried out in accordance with approved procedures.

2.9.5.2 Preliminary Inspection

The Contractor shall carry out visual inspection of all pipes.

The Contractor shall record all external damage on pipes against the unique item serial number. This damage shall be brought to the attention of the Engineer In-charge and the Pipe shall not be coated without prior release by Engineer In-charge.

Bevel protectors at each end of every pipe joint shall not be removed unless showing signs of damage or if removal is required to facilitate surface preparation, or they would be damaged by coating operations. If the protectors are removed the conditions of the bevel shall be recorded against the pipe serial number and any damage shall be brought to the attention of the Engineer In-charge.

2.9.5.3 Damage to Pipe and Pipe Ends and Repair

No repair work shall proceed until a written procedure has been prepared by the Pipe Coating Contractor and approved by the Engineer In-charge.

Minor damage to pipe and pipe ends/bevels, identified either at time of receipt or after abrasive blasting shall be repaired by grinding. The number of such damages shall be not more than 3 per pipe. Repair by grinding on the pipe or pipe ends/ bevels outside diameter shall not reduce

the wall thickness to less than the minimum requirements of the line pipe specification, when measured using ultrasonic thickness measurement equipment.

All other damage to pipe ends/bevels shall be advised to the Engineer In-charge for review. Subject to Engineer's approval, these defects may be repaired by removal of damaged pipe material and re-bevelling. No welding on the pipe surface shall be allowed.

Pipe identification numbers shall be preserved during repair. Any reduction in pipe lengths shall be recorded in the relevant forms and files.

2.9.6 Prior to Coating Application

2.9.6.1 Stages

- The principle stages of pipe coating shall be as follows:
- Solvent cleaning followed by steam or hot bath cleaning (if required)
- Abrasive blasting
- Application of fusion bond epoxy (FBE) layer
- Application of adhesive layer
- Application of polyethylene layer

2.9.6.2 Cleaning Prior to Abrasive Blasting

All surface contaminants such as oil, grease, tar, salt, or other contaminants on the pipe shall be removed by solvent cleaning followed by steam or hot bath cleaning, in accordance with a procedure approved by the Engineer In-charge.

Following the steam or hot bath cleaning the pipe shall be tested for salt and chloride contamination in accordance with the requirements of DIN EN ISO:8502-2, DIN EN ISO: 8502-5, DIN EN ISO 8502-9.

The removal of hydrocarbon contamination shall be confirmed by a water spray test, where a fine spray is applied to the surface and uniform wetting confirms the removal. This check shall be performed before and after blasting, as a pre- qualification test and as a minimum, once per 100 items during production, or when necessary.

Items found to be contaminated shall be cleaned as above and re-blasted if testing after blasting establishes that salt, chloride or hydrocarbon contamination is still present. The remainder of the batch concerned shall all be checked individually.

All water used for rinsing or cleaning purposes shall be potable with less than 200 ppm total dissolved solids and 50 ppm chlorides.

2.9.6.3 Abrasive Blasting

Blasting and other dust producing areas shall be separate from coating application areas.

After cleaning and prior to abrasive blasting the pipe lengths shall be free from moisture, dust, grease and free from other foreign materials.

Abrasive and dust, which entered the inside of the pipe during blasting operation, shall be removed by suitable means.

Weld joints, sharp-edge projections, weld spatter and slag etc. shall be dressed prior to blast cleaning.

Using dry blasting techniques only, the exterior surface of the pipe joints shall be abrasively cleaned to remove all mill scale, and other impurities from the surface.

No blast cleaning shall take place when the prevailing relative humidity is higher than 85 percent unless pipe is preheated to at least 3ºC above the dew point.

Twice per shift, samples of the abrasives mixture shall be removed from the hopper and checked for hydrocarbon contamination. The sample shall be placed in a beaker to which deionized water is added. The beaker shall then be sealed and shaken vigorously. Once the grit has settled the surface of the water shall be examined for signs of hydrocarbon contamination. If any signs are found all the abrasive in the hopper shall be rejected and not re-used.

Additionally, abrasive materials shall be checked at least once per shift to ensure that only uncontaminated angular grit with an acceptable size distribution is used. As a minimum, the following shall be carried out.

- Correct abrasive size distribution shall be carried out by sieve analysis.
- Placing a sample of abrasive on a clean, dry sheet of absorbent paper to determine water contamination.

The surface of the pipes shall be blasted until a finish of Grade 2.5 to DIN EN ISO 8501-1 is attained. The surface profile shall be between 50 to 100 microns, measured in accordance with DIN EN ISO 8503-2. Profile measurements shall be made with a Keane Tator Profile Comparator, Testex Press –O-Film or other Engineer In-charge approved method suitable for the abrasive being used.

Following abrasive blasting, the surface shall not be contaminated with dirt, dust, metal particles, hydrocarbons, water, chlorides, sulphates or any other foreign matter, which would be detrimental to the coating.

Prior to the coating application, the exterior surface shall be thoroughly inspected under adequate lighting. Any damage such as surface imperfections, slivers, scabs, burrs, gouges, or sharp-edged defects, shall be repaired in accordance with this specification. Pipes that have damage repaired by grinding and have ground areas greater than 50 mm diameter shall be re-blasted to meet the requirements of the clauses above. After grinding or mechanical repairs, the wall thickness shall be ultrasonically examined and compared with the minimum requirements of the applicable code / standard.

Any dust or loose residue that has accumulated during blasting and/ or grinding operations shall be removed by the use of clean compressed air or by vacuum extraction. Alternative methods for removing dust and lint shall require approval of the Engineer In-charge.

The elapsed time between the start of blasting and the heating of pipe shall be indicated in the application procedure submitted by the Contractor and shall be reflected on his plant scheme.

The total elapsed time between the start of blasting of any pipe and the heating of that pipe to the specified temperature shall not exceed the following time- humidity table:

PERCENT RELATIVE HUMIDITY	ELAPSED TIME (HOURS)
85	0.5
80	1.0
70	2.0
60	2.0

Any pipe surface not processed within the above time-humidity table shall be completely re-cleaned and re-blasted before coating.

The maximum time limit between blasting and coating for humidity below 60% shall be 4 hours.

2.9.7 Coating Application

2.9.7.1 General

The application of the coating shall be in accordance with the material manufacturer recommendations and the procedure outlined below.

The Contractor shall perform coating Procedure Qualification Testing (PQT) prior to commencing production or on his own risk at the start of production in accordance with this specification.

Prior to start-up of the coating process the powder application and recovery systems shall be thoroughly cleaned to remove any powder other than that is use, minimum once per day and the collected powder shall be disposed off.

2.9.7.2 FBE Layer

The FBE shall be applied to a minimum thickness of 200 microns.

The pipe shall be uniformly preheated in accordance with the FBE manufacturer's instructions. This temperature shall have been confirmed during PQT. The surface temperature shall not exceed 260ºC in accordance with AWWA C213, section 4.4.3.1 Preheating".

Pipe temperature shall be checked periodically using pyrometer. The pyrometer shall be checked for error not less than every four hours against a calibrated temperature measuring instrument.

The coating shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potential.

The use of reclaimed FBE powder is only permitted if the reclaimed powder is screened to remove foreign or deleterious material before being reintroduced into the powder application system.

The clean reclaimed powder upto a maximum of 20% shall be introduced back into the fresh virgin material by means of proportional weight.

During application, the bevelled ends and pipe bore shall be protected against mechanical damage and from contamination with coating material.

2.9.7.3 Adhesive Layer

The adhesive shall be applied to a thickness of 200 microns.

The adhesive layer shall be applied before gel time of the FBE has expired. Application of the adhesive shall not be permitted after the FBE has fully cured. The Contractor shall establish to the satisfaction of the Engineer In-charge that the adhesive is applied within gel time window of the FBE and at the temperature recommended by the adhesive manufacturer. The Contractor shall state the proposed minimum and maximum time interval between FBE and adhesive applications at the proposed pre-heat temperature.

2.9.7.4 Polyethylene Layer/Cutback

The polyethylene layer shall be applied to a minimum thickness as per DIN 30670 over the pipe body and to a minimum of 90% body thickness over the production welds.

PIPE DN	TOTAL THICKNESS OF POLYETHYLENE COATING
> DN 100 ≤ DN 250	2.7 mm
> DN 250 < DN 500	2.9 mm
≥ DN 500 < DN 800	3.2 mm
≥ DN 800	3.7 mm

The thickness may be less than the minimum thickness locally as long as these local areas do not exceed 5cm2 per 1m length of pipe and the difference between the actual thickness and the minimum thickness is not greater than 10%.

Inspection of Thickness:

- Inspection of thickness shall be as per Annexure A (normative) of DIN 30670.
- A polyethylene layer cutback of 150 mm (±20mm) shall be provided at pipe ends.
- The polyethylene shall be applied over the adhesive within the time limits established during pre-production testing.
- The coating shall be cooled to below 60°C before handling.
- The ends of the coating shall be chamfered and bevelled to less than 30º.
- Immediately after the coating is fully cured, pipe identification marks shall be re-applied to the coated pipe using a method approved by Engineer In-charge

2.9.8 Inspection, Testing and Certification

2.9.8.1 General

In order to demonstrate that the manufacturer's proposed coating procedure is capable of meeting the specification, the Contractor shall undertake coating procedure qualification testing (PQT) prior to commencing production, or at his own risk at the start of production. The Contractor shall also be required to test the finished coating during production to demonstrate continued compliance with this specification. Details of all inspections and testing shall be fully documented in accordance with this section.

All states of the surface preparation, coating and testing shall be subject to 100% inspection by the Contractor. The Engineer In-charge shall be informed at least two weeks prior to the start of surface preparation to allow scheduling of inspection supervision work

2.9.8.2 Coating Procedure Qualification Testing (PQT)

Prior to commencing or at the start of full production five pipe of each diameter coated with FBE only and five pipes of each diameter with the full coating system shall be selected for PQT. All coating shall be in accordance with the coating procedure specifications and shall be witnessed by the Engineer In-charge or its representative.

The produced pipes will not be released until the successful results of the PQT can be provided. In case of long-term tests, the PQT report shall be updated once the results can be provided. Any failure in meeting the specified acceptance criteria for the PQT will result in rejection of the coated pipes. Engineer In-charge shall approve any remedial action, repairs or re-use.

The test methods for all tests required for PQT on the FBE and the complete coating system shall be performed in the same manner as the production tests described in this specification.

Pipes selected for PQT testing shall pass all the criteria containing in 1.9.8.3 before production commences.

Any change in the coating material or coating procedure shall require approval from Engineer In-charge.

If any of the tests fails to meet the minimum acceptance criteria defined in this specification, then the pre-qualification pipes shall be rejected. Further pipes may be prepared and coated using revised procedures and further tests performed. Once acceptable results are obtained and approved by Engineer In-charge, the Contractor's quality plan and procedures shall be revised, and submitted to the Engineer In-charge for approval. All items coated using the rejected procedures shall be striped and recoated to the revised procedures.

2.9.8.3 PQT Inspection and Test Summary

Inspection and testing summary for procedure qualification test (PQT) for three-layer coating system for each pipe diameter:

Property	Acceptable Values	Frequency of Tests
On Arrival Pipe Damage	Minor damage/grinding <3 Per Pipe	Each Pipe
After Cleaning Chloride Oil Salt	 2 mg/cm2 No contamination 3 mg/cm2	Each Pipe
After Abrasive Blasting Cleanliness Profile	 SA 2.5 acc to ISO 8501 50 – 100 um No contamination	Each Pipe Each Pipe Each Pipe

Contamination		
Visual Inspection Holidays Thickness Adhesion	No surface defects No holidays Min/Max see Clause 2.9.7.2 See Clause 2.9.7.3	Each Pipe Each Pipe 10 per pipe 2 per pipe
Holidays Visual Inspection Coating Bare steel at pipe ends Production FBE PE cut backs	No surface defects 120+10/-0 mm width 10 to 40 mm width, Chamfered 150 ±20 mm bevel <30º	Each Pipe Each Pipe Each Pipe Each Pipe
Adhesion Peel Test	> 100 N/cm at 20 °C +5° > 50 N/cm at 50 °C +5°	2 per Pipe 2 per Pipe
Impact Resistance	See Clause 2.9.8.4d	1 per pipe
% Elongation at Failure	See Clause 2.9.8.4f	2 per pipe
Cathodic Disbondment	See Clause 2.9.8.4h	2 per pipe
DIN 30670	See Clause 2.9.8.4g	1 per pipe

2.9.8.4 Production Testing

a. Production testing shall be performed at the frequency shown below:

Property	Acceptable Values	Frequency of Tests
On Arrival Pipe Damage	Minor damage/grinding <3 Per Pipe	Each Pipe
After Cleaning Chloride Oil Salt	 2 mg/cm2 No contamination 3 mg/cm2	Each Pipe
After Abrasive Blasting Cleanliness Profile Contamination Pipe damage	 SA 2.5 acc to ISO 8501 50 – 100 um No contamination See clause 2.9.5	Each Pipe 20 Each Pipe 20
FBE Layer Visual Inspection Holidays Thickness Adhesion	No surface defects No holidays Min/Max see Clause 2.9.7.2 See clause 2.9.7.3	Each Pipe Each Pipe 10 per pipe 2 per pipe

Holidays Visual Inspection Coating Bare steel at pipe ends Production FBE PE cut backs	No surface defects 120+10/-0 mm width 10 to 40 mm width, Chamfered 150 ±20 mm bevel <30°	Each Pipe Each Pipe Each Pipe Each Pipe
Adhesion Peel Test	> 150 N/cm at 20° C +5°	1 Pipe per 25 2 per Pipe
Cathodic Disbondment at Room Temperature	See Clause 2.9.8.4h	First pipe, last pipe and at intervals of every 500 pipes

The frequency of tests shown in the table above will be for normal production operations. This frequency of tests is subject to change at the discretion of the Engineer In-charge as a result of change of materials or consistent poor production performance.

b. Holiday Detection

FBE Layer

The FBE coating shall be 100 % holiday tested with a pulse type DC holiday detector equipped with audible signaling device. The test shall be carried out in accordance with NACE RP0490 or equivalent.

Final Coating

Each fully coated pipe shall be inspected for holidays over 100 percent of its coated surface using a high voltage DC detector.

The detector shall be a type, which maintains complete contact with the coating. It may be either constant or pulsed voltage type. If constant voltage type, holiday detection shall be carried out on a dry coating. The operating voltage between electrode and pipe shall be checked at least twice per working shift, and shall be maintained at 10 kilovolt/mm of coating thickness. The Contractor shall demonstrate to the Engineer In-charge that the setting of the detector is satisfactory for detecting pinhole defects. This setting shall be checked once every two hours. The correct travel speed shall be determined by consistent detection of an artificial pinhole made in a good coating sample but shall not exceed 300 mm/s.

All holidays and other detects shall be marked for subsequent repair and re-testing. On retesting, no holidays shall be permitted in the final coating.

The number of holidays for each pipe length shall be recorded. Coated pipe having holidays in excess of 1 per 1 square meter shall be stripped and re-coated.

If there is an excess occurrence of holidays on successive pipes, the Contractor shall immediately stop the coating operation to determine the cause and remedy it.

c. Adhesion (Peel) Test

FBE Layer:

With a sharp narrow bladed knife, two incisions (approximately 13 mm long) shall be made, in the form of an X. through to the metal substrate. At the intersection of the X. an attempt shall be made to force the lining from the steel substrate with the knife point. The point of the knife shall be inserted horizontally i,e., the flat of the blade under the lining at the point of intersection of the X such that the blade point is on the metal surface. Using a levering action, the flat point shall be forced away from the steel in an attempt to pry off the coating. Refusal of the lining to disbond from the substrate shall be recorded as a pass. A pass shall also be recorded where the lining fails cohesively. Partial or complete adhesive failure between the lining and the substrate shall be recorded as a failure. Disbondment at the point of the intersection is common due to the action of marking the 'X' cut. Therefore for 1 mm away from the tip of the intersection any disbandment shall be ignored.

Final Coating:

The adhesion for the complete coating shall be determined in accordance with the requirements for bond strength in DIN 30670. The relevant test temperature and acceptance criteria for these tests shall be as detailed in procedure qualification and production testing of this specification. Automatic chart recording equipment shall be used and the average peeling force shall be recorded.

The failure mode shall be recorded. The failure should occur at the adhesive/polyethylene interface or adhesive/FBE interface or cohesively in the polyethylene layer. If failure should occur at the FBE/steel interface this will be considered a total failure of the system.

d. Impact Test

A sample or coated pipe shall be impact tested in accordance with the procedures and acceptance criteria of DIN 30670.

e. Resistance to Indentation Test (Indentation Hardness)

Once per shift (and when the FBE or polyethylene batch is changed), the indentation hardness of two coated samples shall be measured (at 20○C ± 5°C and 70ºC ± 2ºC) in accordance with DIN 30670.

Indentation depth shall not exceed 0.2mm at 20°C ± 5°C or 0.3mm at 70°C ± 2ºC.

f. Percentage Elongation at Failure

This test shall be conducted in accordance with DIN 30670 on each of the full system pre-qualification pipes, but at least the coating of three pipes shall be tested for elongation at failure, from which five test pieces shall be taken. The percentage elongation at failure shall be at least 400% on each of the full system pre-qualification pipes, 2 samples per pipe to the requirements of DIN 30670.

g. Other DIN 30670 Tests

The Contractor shall demonstrate, for the same system to be applied for this order, attainment of DIN 30670 requirements for Coating Resistivity, to Thermal Ageing and Light Ageing as required by DIN 30670.

h. Cathodic Disbondment Test

Cathodic Disbondment testing shell be conducted:

as a pre-qualification test - 24 hours duration at 65 ± 2°C as a pre-qualification test - 28 days duration at 23 ± 2°C

as a production test - 24 hours duration, at the frequency of one test per 50 coated pipes at 65 ± 2°C

The test requirements shall be in accordance with ISO 21809-1.

The final unsealed diameter (including the initial holiday diameter of 6.35 mm) shall not exceed 15 mm. This shall apply to both, the 28-day test at 23 ± 2°C and the 2 days test at 65 ± 2°C.

The Contractor may propose alternative cathodic disbondment test standards provided the essential requirements of this specification are retained. Any such alternatives shall be submitted to the Engineer In-charge for review and approval.

Every 24 hours the applied voltage and current flow shall be recorded. Any drift from the specified voltage setting shall be corrected.

i. Destructive Tests

A sufficient length of production pipe shall be cold cut to provide the required number of samples for conducting the coating destructive tests listed in this specification.

Items that fail individual tests and that cannot be repaired in accordance with this specification shall be rejected. Subject to the approval of Engineer In-charge, the rejected coating shall be stripped and the joint shall be re-blasted and coated in the manner specified for new pipe in this specification.

Where a test relates to a quantity of coated items, e.g. 1 per 50 items or 1 per 100 items etc., the quantity or items represented by the item tested (e.g. 50 or 100) shall be considered to be a batch.

If a test on an item in a batch fails then this item shall be rejected and two further items shall be randomly selected from the batch for repeat testing. If either of these tests fails then the whole batch shall be quarantined for review by Engineer In-charge. The cause of failure shall be established and reported to the Engineer In-charge and if deemed necessary by the Engineer the coating procedure shall be amended and re-qualified. The Engineer In-charge will decide whether the whole batch is rejected and sent for re-blasting and re-coating or whether acceptance may be on the basis of acceptable tests carried out on individual items.

j. Coating Repairs

The Contractor shall submit detailed coating repair procedures for approval by Engineer in-charge. These shall include procedures for repair or 'pin-hole', 'small area' and 'large area' defects. The minimum and maximum areas for which each type of repair is applicable shall be stated taking into consideration the below mentioned requirements.

The maximum number of coating defects allowable, before a joint of pipe shall be classed as rejected and recoated, shall not exceed 1 per 1 square metre (exclusive of damage caused by testing).

- Repair areas of sizes < 5 mm^2

Pinhole damage shall be repaired by cleaning with an emery cloth followed by application of a two (2) pack epoxy repay repair kit or an approved hot melt mastic smoothed flush with the polyethylene surface. If the mastic is used, it shall be spread with the aid of a hot air or a propane torch.

- Repair areas of sizes < 5 mm^2 upto < 250 mm^2

The area shall be swabbed with solvent and abraided with an emery cloth to ensure that the surrounding polyethylene is well bonded, the surface shall be roughened for a distance of at least 25mm beyond the damage area. An approved hot melt mastic shall be applied to the damage area and smoothed flush. The mastic and surrounding area shall be warmed with hot air or propane torch until the surrounding polyethylene has as slight sheen. An approved polyethylene patch material shall be applied overlapping the damage but not overlapping the pre-abraided areas. Torch heat and smoothing pressure shall be applied to fuse the patch and ensure that no blisters are formed.

- Repair areas of sizes 250 mm^2 upto 625 mm^2

Heat shrink-wrapping pipe sleeves shall be used for repair according to the following procedure:

Thoroughly clean the area to be coated.

Bevel the extremities of the mill-coating with a rasp.

Pre-heat the area to be coated to a temperature of approximately 110-140°C.

Install the sleeve over the area to be coated.

Warm the shrink sleeve to a temperature above 150°C with a propane torch or a warm-air ring.

- Repair areas of sizes exceeding 625 mm^2

No single defect shall exceed an area or 625 mm2. Pipes with a coating defect exceeding 625 mm2 shall be cause for rejection and shall be subsequently rejections and recoated. All rejections shall be recorded.

Repairs shall provide a finished coating equal in effectiveness to that of the parent coating. The limit of the repair area shall be revised.

Each repaired area shall be holiday inspected as described in this specification.

The Pipe Coating Contractor shall submit coating stripping procedure for pipes rejected for coating quality. The rejected coating may be stripped by heating in an oven. Under these circumstances, the temperature of the pipe joint shall not be allowed to rise above 400°C.

k. Handling, Transport and Storage Rules

The contractor shall be responsible for any damage occurring to the pipes from unloading to reloading on the relevant transportation means.

- The contractor shall consequently:

- inspect the bare pipes upon delivery to check that they have suffered no previous damage,
- take all necessary precautionary measures to prevent any deterioration during the following operations:
- handling,
- transfer to storage yards.
- storage,
- loading of pipes for shipment.

All repairs and inspections shall be carried-out at the contractor's expense.

l. Handling

The pipes shall be handled without causing damage to the pipe bevels and coating.

Direct contact steel or hamp slings or with any material whose shape or nature may deteriorate the pipe coating shall be strictly prohibited. Polyamide slings or hooks fitted with thermoplastic protection may be used.

Use of electromagnetic device is recommended.

m. Transfer to storage yard

During transport of pipes to the storage yard of the contractor, the latter shall take all their required measures to avoid pipe and coating damage.

n. Storage yard of the contractor

Stockpiling of coated pipes shall be made so as to avoid any deterioration of coating. Coated pipes, when non-concrete weight coated, shall be protected against ultraviolet rays action in particular.

o. Pipe loading for shipment

When loading the coated pipes for shipment, the contractor shall take all necessary measures to avoid the deterioration of pipes and coating during handling and transport.

p. Repair of Coating

The contractor shall submit to Department, its methods and materials proposed to be used for executing a coating repair and shall receive approval from the department prior to use. In open storage the repair materials must be able to withstand a temperature of at least (+) 80°C without impairing its serviceability and properties. The contractor shall furnish manufacturer's test certificates for the repair materials clearly establishing the compliance of the repair materials with the applicable coating requirements indicated in this specification.

All pipe coating plan, shall have sound external with no holiday or porosity on 100% of the surface.

Defects, repairs and acceptability criteria shall be as follows:

Pipes showing pororsity or very small damage not picked up during holiday test and having a surface less than 0.5 cm2 or linear damage (cut) of not less than 3 mm shall be repaired bystick using material of same quality.

Damages caused to coating by handling such as scratches, cuts, dents, gouges, not picked up during holiday test, having a total reduced thickness on damaged portion not less than 2 mm and an area not exceeding 20cm2 shall be rebuild as per approved method and without exposing to bare metal.

Defects of size exceeding the above and mentioned area of or holidays of width less than 300mm shall be repaired as per approved method by exposing the bare metal surface.

Defect exceeding the above and in number not exceeding 2 per pipe and their length not exceeding 500 mm shall be repaired as per approved method.

Pipes with bigger damage shall be stripped and recoated.

In case of coating defect close to coating cut back, the contractor shall remove the coating throughout the entire circumference of the pipe down to the steel surface and increase the coating cut back length. Now, if the coating cut back exceeds by 30 mm than the specified cut back length, then the coating shall be repaired as per approved method thereby making up the coating cut back length as per specification.

In case the defect exceeds 70 mm from the original coating cut back length, the entire coating shall be removed and the pipe shall be recycled through the entire coating procedure.

Irrespective of type of repair, the maximum number of repair of coating shall be as follows:

- ✓ Holiday repair of size ≤ 100cm^2 attributable to process of coating application shall be maximum one number per pipe.
- ✓ In addition to the above, defects to be repaired as per approved method shall be maximum 2 (two) per pipe.

Defects exceeding the above limits shall cause pipe coating rejection, stripping and recoating.

The above is exclusive of the repairs warranted due to testing as this specification.

All repairs carried out to the coating for whatever reason shall be to the account to the contractor.

Cosmetic damages occurring in the polyethylene layer only need not be repaired by exposing up to steel surface, as deemed fit by the department Engineer. In any case, the contractor shall establish his material, methods and procedure of repair that result in an acceptable quality of product by testing and shall receive approval from department prior to use.

Testing of repairs shall be in the same form as testing coating. All repairs shall result in a coating thickness not less than the parent coating thickness. The contractor shall test repairs to coating as and when required by department.

Repair Material:

Heat Shrink Sleeves - Material to be qualified by the material manufacturer and approved by department.

As applied coating system for repair shall comply the requirements of ISO 21809-1/DIN 30670 except as modified below:

i. Cathodic Disbondment Resistance at Tmax i.e. 80°C shall be 15 mm when tested as per ISO 21809-1. Test shall be carried out at (+) 80°C.

ii. Peel Strength shall be as follows

Peel Strength		Unit	Requirement for Class-B (minimum)
To Pipe Surface	@ 23 ±2 ºC	N/mm	15
	@ Tmax	N/mm	3
To Factory Coating	@ 23 ±2 ºC	N/mm	15
	@ Tmax	N/mm	3

Any combination of epoxy, adhesive and polyethylene shall be tested and certified by an internationally recognized agency.

In case the contractor proposed coating material other than above mentioned combination of epoxy, adhesive and polyethylene, coating procedure and qualification need to be carried out by an internationally recognized agency by the coating material Manufacturer.

All materials to be used shall be supplied in sealed, damage free containers and shall be suitable marked with the following minimum information:

a. Name of the Manufacturer
b. Type of Materials
c. Batch Number

d. Place and Date of Manufacture
e. Shelf Life/Expiry Date (if Applicable)
f. Quantity

All materials noted to be without above identification shall be deemed suspect and shall be rejected by the department. Such materials shall not be used for coating and shall be removed from site and replaced by the contractor at his expense.

LOFC: List of Operation of Fabrication and Control

Each LOFC must contain the following information as a minimum (all clearly marked and separated):

a. Company name and references relating to the order;

b. All technical and other information required in order to define the items covered.

- ✓ The area of application will be limited to that item or those items considered in fabrication and control as a natural unity.
- ✓ Details of plants, layout, capacity, production rate, testing equipment, yard facility.

c. A numerical sequence of operations with description will be built-up in a logical way of work progress.

- ✓ The first operation will be the control over the incoming material(s) and documents.
- ✓ The last operation will be the control over the final documentation.

The following operations have to be included (not limited to):

- ✓ Procedure prior to the commencement of production shall be approved by the department
- ✓ Each step which call for own quality control (eventually QA);
- ✓ Each applicable examination as part of this specification;
- ✓ Document control-stamping and final documentation.

d. Each operation will be followed by the applicable specification or procedure number (with the latest revision).

e. Columns to be provided for possible interventions of:

- ✓ the manufacture's fabrication control;
- ✓ the manufacturer's quality control (eventually QA);
- ✓ inspection Agency
- ✓ and place of intervention if not by the manufacturer.

The interventions will be indicated per operations with H or w and/or R.

H = hold point - no further steps may be undertaken before the intervention of the designated responsible takes place.

W = witness point - the designated responsible has to be notified of the operation in advance, but production will continue whether the intervention took place or not.

R = point for which a control report or a recording has to be made.

The manufacturer will rill in his own H, W and R points. The inspection Agency will do the same in its designated column, but this will not implicate a relaxation or waiving of the requirements of the manufacturer's controls.

Each intervention has to be signed and dated by person acting as controller. Only the original documents will be presented for this purpose.

One column to be provided for report or record number (point marked R) and one for the review or these documents by the Inspection Agency.

Two extra columns may give reference to non-conformity report if any and the resolution give to it.

Completion of the LOFC does not automatically rise to a release of the material or it must be stipulated otherwise in the contract.

The steps indicated in the LOFC must be executed following the sequence as stipulated in LOFC.

2.10 EXTERNAL COATING - Polyolefin Tape Coating

General

Buried steel pipeline shall be coated externally, with prefabricated polyolefin tape coating as per AWWA C 214-14. The Contractor shall perform all work in accordance with these specifications and the latest pipeline coating practices, and shall complete the work in all respects to the full satisfaction of the Owner/Owner’s representative. The entire coating operation starting from cleaning and surface preparation till coating shall be performed under the supervision of skilled personnel who are well conversant with the work. Pipes which have been cleaned and primed, or cleaned, primed and coated, without having been inspected and approved shall be rejected.

This specification is not intended to be all inclusive and the use of guidelines set forth here does not relieve the Contractor of his responsibility for the quality and performance of the applied coating system, and to supply coating material capable of performing its intended service.

All steel special sections, connections and fittings to be used for underground steel pipeline shall be coated with cold applied tape consisting of liquid adhesive and prefabricated tape as described in AWWA C 209 and using Visco Elastic material as per ISO 21809 - 3 (2016) with PE outer wrap only.

Referenced Standards:

The following standards (latest revision) referenced below are a part of this specification. In case of conflict between this specification and the referenced standards, this specification shall apply.

ANSI/AWWA C214: Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines

ANSI/AWWA C604: Installation of Buried Steel Water Pipe

ANSI /ASTM D149: Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

ANSI/ASTM D570: Standard Test Method for Water Absorption of Plastics

ANSI/ASTM D4218: Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.

ASTM D1000 : Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications

ASTM E96: Standard Test Methods for Water Vapor Transmission of Materials

ASTM G8: Standard Test Method for Cathodic Disbonding of Pipeline Coatings

ASTM Gl4: Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

ASTM G17: Standard Test Method for Penetration Resistance of Pipeline Coatings (Blunt Rod)

ANSI/AWWA C209: Standard for cold applied tape coatings for the exterior of special sections, connections and fittings for steel water pipelines.

ANSI /AWWA C210: Liquid Epoxy Coating systems for Exterior and Interior of Steel Water Pipelines

ANSI/AWWA C 216: Standard for Heat – Shrinkable cross-linked Polyolefin coatings for exterior of special sections, connections and fittings of steel water pipelines.

NACE RP-O2-74: High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

SSPC-PA 2: Measurement of Dry Paint Thickness with Magnetic Gauges

SSPC-SP l: Solvent Cleaning

SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning

Tape Coating Systems for the Exterior of Steel Water Pipelines

General:

The buried steel pipeline shall be protected with cold applied tape protective coating conforming to AWWA C214-14 (Cold Applied Tape Coating Systems for Exterior of Steel Water Pipelines).

Protective coating shall consist of a coating system consisting of primer, inner tape wrap and outer wraps.

Work or material that fails to conform to this standard may be rejected at any time before final acceptance

Coating system:

The pre-fabricated polyolefin tape coating system shall consist of the following layers to provide an applied coating system thickness of 80 mils (2mm) on the exterior of the steel pipes.

- ✓ A liquid adhesive layer.
- ✓ An inner-layer tape for corrosion protection.
- ✓ An intermediate-layer tape for mechanical protection.
- ✓ An outer-layer tape for mechanical and UV protection.

The inner-layer tape and outer-layer tape shall be made of prefabricated tapes in rolls.

Liquid Adhesive layer:

The liquid adhesive layer shall consist of a mixture of suitable rubber and synthetic compounds and solvent. The liquid adhesive layer shall be spray applied to the abrasive blasted prepared pipe surface before application of the inner-layer tape. The function of the liquid adhesive is to provide a bonding medium between the pipe surface and the inner-layer tape.

The liquid adhesive shall be supplied by the manufacturer that supplies the inner-layer tape. The liquid adhesive shall not settle in the container forming a cake or sludge that cannot be easily mixed by hand or mechanical agitation and it shall have good machine-application properties.

Table-I Physical Properties of the Liquid Adhesive

Property	Requirement		
	Minimum	**Maximum**	**Test Method (Ref AWWA C214-14)**
Width deviation	-5% or -1/4 in. (-6 mm) whichever is smaller	+5%	Sec. 5.2.3
Nominal thickness 20mil (0.508 mm)	19 mil (0.48 mm)		Sec. 5.2.4
Ratio of adhesive to total in-ner- layer tape thickness, t	40% of total t	60% of total t	Sec, 5.2.4
Adhesion to prepared steel	15.9 lb/in. width (2.8 N/mm width)	-	Sec. 5.2.5
Water absorption (24 h)	-	0.2% by wt	Sec. 5.2.6
Water-vapor transmission	-	0.10 g/(h.m2)	Sec. 5.2.7
Insulation resistance	500,000 megaohms		Sec. 5.2.9
Tensile strength	30 lb / in width (5.3 N/mm width)		Sec. 5.2.10
Elongation	300%		Sec. 5.2.11
Non-polyolefinic Material Percent by Weight	-	3.5%	Sec. 5.2.12

Inner-layer tape:

The inner-layer tape shall be a two-layer tape consisting of a polyolefin backing layer with a laminated butyl-based adhesive layer. The inner tape shall be compatible with the liquid adhesive. The manufacturer shall certify that the backing material shall be polyolefin only, containing not more than 3.5 percent, by weight, of non-polyolefinic material consisting of carbon black and antioxidants. The inner-layer tape shall be applied after the liquid adhesive and before the outer-layer tape.

The backing and adhesive shall be made from materials that provide high electrical resistivity, resistance to corrosive environments, low moisture absorption and permeability, and shall provide an effective bond to a primed steel surface. The inner-layer tape shall be of material that will resist excessive mechanical damage during normal application operations and shall be sufficiently pliable for the intended use. The inner-layer tape shall withstand, without tearing, the tensile force necessary to obtain a tightly wrapped inner coating free of voids. The inner-layer tape shall be supplied in roll form wound on hollow cores with a minimum inside diameter of 75mm.

To ensure a proper smooth coating, the inner-layer tape shall be provided in standard widths as per manufacturer recommendations consistent with the pipe diameter. Width shall be approved by Employer's representative.

Table-2: Physical Properties of Inner Layer Tape

Color	Base	Weight			Flash Point
Black	Rubber and Synthetic Resins	Flammable	-	6 - 8 lb/gal (0.72 – 0.965g/l)	-10oF(17oC) or greater
		Nonflamma-ble	-	10 - 12 lb/gal (1.20 – 1.44 kg/l)	none

Intermediate- layer tape / Outer-layer tape:

The intermediate -layer tape / outer-layer tape shall be a two-layer tape consisting of a poly-olefin backing layer with a laminated butyl adhesive layer. The manufacturer shall certify that the backing material shall be polyolefin only containing not more than 7.0 percent, by weight, of non-polyolefinic material consisting of pigments, antioxidants and stabilizers. The interme-diate -layer shall be compatible with the inner-layer tape and the outer-layer tape shall be com-patible with the intermediate-layer tape. The primary function of the intermediate - layer tape is to provide mechanical protection to the inner-layer tape and of outer-layer tape to provide mechanical and outdoor weathering (UV) protection to the tape system, and secondarily, to contribute to the overall corrosion-protection properties of the system. The outer-layer tape backing shall be compounded so that it will be resistant to outdoor weathering. To distinguish the intermediate- layer tape from outer-layer tape the colors of the two layers shall be different. The intermediate- layer tape color shall be grey and the outer-layer tape color shall be white. The outer-layer tape should be of suitable quality for the local environment, as follows:

Storage Temperature	: 0 to 50^0C.
Over-ground Condition	: 0 to 60^0C.
Under-ground Condition	: 7^0C to 35^0C.
Ultraviolet-ray Protection	: Required in outer layer.

Materials used in the intermediate-layer & outer-layer tape shall have high electrical resistivity, low moisture absorption and permeability, and shall provide mechanical protection during handling and outdoor storage. The intermediate - layer & outer-layer tapes shall be sufficiently pliable for normal application operations and shall form an effective bond to the inner-layer / intermediate-tape layers. The intermediate- layer & outer-layer tape shall be supplied in roll form wound on hollow cores with a minimum inside diameter of 75mm.

Dimensions: The intermediate- layer tape & outer-layer tape shall be provided in standard widths and lengths. The width of the intermediate - layer & outer-layer tape shall be at least equal to that of the inner-layer tape.

Table-3 Physical Property of Intermediate Layer Tape & Outer Layer Tape

Property	Requirement		
	Minimum	**Maximum**	**Test Method (Ref AWWA C214-14)**
Width deviation	-5% or -1/4 in. (-6 mm) whichever is smaller	+5%	Sec. 5.2.3
Nominal thickness 30mil (0.762 mm)	28.5 mil (.724 mm)	-	Sec. 5.2.4
Adhesion to Inner layer Dielectric Strength	3.71 lb /in. width (0.65 N/mm width) 450 V/mil	-	Sec. 5.2.5 Sec. 5.2.8
Tensile strength	40 lb/in width (7.0 N/mm Width)	-	Sec. 5.2.10
Elongation	300%	-	Sec. 5.2.11
Non polyole finic Material Percent by Weight	-	7.0%	Sec. 5.2.12

Coating-system Thickness:

The installed coating system thickness shall not be less than 80 mils (2mm) and shall comprise of the following.

- ✓ A liquid adhesive layer (50-75 microns)
- ✓ An inner-layer tape (Nominal 20 mils i.e. 0.50mm)
- ✓ An intermediate tape (Nominal 30 mils i.e. 0.75mm)
- ✓ An outer-layer tape (Nominal 30 mils i.e. 0.75mm)

The properties of the complete coating system shall conform to the following requirements.

Table-4 Physical Properties of Total System

Property	Requirement		
	Minimum	**Maximum**	**Test Method (Ref AWWA C214-07)**
Thickness			
80 mil, nominal	73 mil (1,854 μm)	-	Sec.5.5.4
Dielectric strength	12000V		Sec. 5.3.6
Impact resistance	25 lb * in. (2.8 N*m)		Sec. 5.2.13
Penetration/deformation resistance	-	25% with no holiday at 220C	Sec. 5.2.14
Cathodic Disbondment	-	12mm	Sec 5.2.15

Coating Application:

General:

The coating application shall be a continuous operation starting with properly abrasive blasted pipe surface. Longitudinal & spiral welds of the pipe shall not exceed a height of 3/32 inch (2.4mm) above the pipe surface and shall be ground flush a full 18 inch (450mm) along the length of the pipe from both ends prior to the coating process.

Four steps, which shall be performed consecutively, shall consist of

(1) liquid adhesive application;

(2) application of the inner-layer tape directly onto the prepared pipe surface;

(3) application of the intermediate-layer tape directly on top of the inner-layer tape and

(4) application of outer-layer tape directly on top of the intermediate-layer tape.

Pipe preparation:

Metal surface condition:

Bare pipe shall be free from mud, mill scale, mill lacquer, wax, coal tar, asphalt, oil, grease, or any other foreign material. Before blast cleaning, surfaces shall be inspected and pre-cleaned according to SSPC-SP 1 to remove oil, grease, and loosely adhering deposits. Visible oil and grease spots shall be removed using a solvent. Only solvents that do not leave a residue shall be used. Preheating to remove oil, grease, and mill scale may be used provided that all pipe is preheated in a uniform manner to avoid distortion.

After drying and removing all loosely adhering foreign materials, the pipe surface shall be cleaned by blasting with grit or steel shots to achieve a surface preparation at least equal to that

specified in SSPC: SP6/NACE3. The blast anchor pattern or profile depth shall be 1.5 mil to 3 mils (38 μm to 75 μm) measured in accordance with ASTM D-4417.

For consistent surface finish, a stabilized working mix shall be maintained in abrasive recycling blasting machines by frequent small additions of new grit, shot infrequent large editions shall be avoided. The abrasive working mix, abrasive recycling blasting machines shall be maintained clean of contaminants by continuous effective operation of blasting machine scalping and air-wash separators.

The cleaned exterior pipe surface shall be in inspected for adequate surface preparation. Surface imperfections, such as slivers, scabs, burrs, weld spatter, and gouges, shall be removed by hand filing or grinding if necessary to prevent holidays.

Blast-cleaned pipe surfaces shall be protected from conditions of high humidity, rainfall, or surface moisture. No pipe shall be allowed to flash rust before coating. To ensure a dry pipe surface at the time of liquid adhesive application, the minimum steel substrate temperature shall be 30°C and at least 3°C above the dew point.

Coating Application:

Liquid adhesive application:

The liquid adhesive shall be applied in a uniform thin film at the coverage rate recommended by the manufacturer. The liquid adhesive shall be thoroughly and continuously mixed and agitated during application to prevent settling. The liquid adhesive shall be applied to the entire exterior surface of the pipe by spray to cover the entire exterior surface of the pipe.

The liquid adhesive coat shall be uniform and free from floods, runs, sags, drips, or bare spots. The liquid-adhesive-coated pipe surface shall be free of any foreign substances, such as sand, grease, oil, grit, rust particles, or dirt.

Before applying the inner-layer tape, the liquid adhesive layer shall be allowed to touch dry in accordance with the manufacturer's recommendation.

Application of inner-layer tape:

The inner-layer tape shall be applied directly onto the prepared pipe surface using mechanical constant-tension coating equipment. The inner layer tape shall be spirally applied with neck down tension as recommended by manufacturer. When applied to spirally welded pipe, the direction of the tape spiral shall be generally parallel to the weld spiral. The minimum overlap shall not be less than 25 mm. When a new roll of tape is started, the ends shall be overlapped at least 150 mm measured circumferentially.

Application of Intermediate-layer tape:

The intermediate-layer tape shall be applied over the inner-layer tape using the same type of mechanical equipment used to apply the inner-layer tape. The intermediate- layer tape shall be spirally applied with neck down tension as recommended by manufacturer. The overlap of the intermediate -layer tape shall not coincide with the overlap of the inner-layer tape. The minimum overlap shall not be less than 25 mm. When a new roll of tape is started, the ends shall be overlapped at least 150 mm measured circumferentially. The intermediate-layer tape shall be applied at a minimum roll body temperature of 21°C or as recommended by the tape manufacturer.

Application of outer-layer tape:

The outer-layer tape shall be applied over the intermediate-layer tape using the same type of mechanical equipment used to apply the inner and intermediate layer tapes. The outer layer tape shall be spirally applied with neck down tension as recommended by manufacturer. The overlap of the outer-layer tape shall not coincide with the overlap of the intermediate-layer tape. The minimum overlap shall not be less than 25 mm. When a new roll of tape is started, the ends shall be overlapped at least 150 mm measured circumferentially. The outer-layer tape shall be applied at a minimum roll temperature of 21°C or as recommended by the tape manufacturer.

Cutbacks

Coating cutbacks shall be 150 mm + 0 / - 25 mm.

Material acceptance, inspection and testing:

Material Acceptance

Proposed coating materials shall be approved by the Owner / Owner's representative.

The recommendations of the manufacturer regarding coating process, repairs, etc, shall also be provided by the contactor. The manufacturer should give guarantee to supply of the required quantity as per the project time schedule and take responsibility for supervising the coating application, repair works if required. Supporting documents shall be provided for the same.

When the material is supplied, acceptance of the material shall be based on submission of certificate of conformance of the coating system to AWWA C214-14 standard and properties specified in this specification superseding AWWA C 214-14 along with manufacturing acceptance test certificates for various lots as per manufacturer's quality assurance and quality control requirements.

Coating application inspection:

The entire coating operation by the Contractor will be supervised by qualified experts from the manufacturer. The CV of the manufacturer's expert shall be approved by the Owner / Owner's representative. All coating work will be done in the presence of the Owner / Owner's representative. All lots shall be inspected at SGS/BV lab – Globally.

Coated-Pipe Tests:

Thickness:

The thickness of the coating system shall be checked in accordance with SSPC-PA 2. The thickness shall be in accordance with the values given in the Table III and shall be checked at a frequency specified by the Owner / Owner's representative.

Holiday Testing:

Each coated pipe section shall be electrically tested for flaws in the coating using a suitable holiday detector approved by the Owner / Owner's representative. The detector shall impress a minimum of 6,000 V. Reference should be made to NACE RP-02-74. The electrical inspection shall take place on the inner-layer tape before the intermediate -layer tape is applied. If a holiday is detected, it shall be repaired as per specifications.

Peel strength:

The peel strength of the inner-layer tape to steel shall be checked in accordance with ASTM D-1000. The average value below the limits stated in the Table I shall constitute a failure of the system to meet the adhesion requirement. The peel test shall be conducted at a frequency specified by the Owner/Owner's representative.

Field procedures:

At all times during construction of the pipeline, the Contractor shall use caution to prevent damage to the protective coating on the pipe. No metal tools or heavy objects shall be permitted to unnecessarily contact the finished coating. Workmen shall not be permitted to walk on the coating except when necessary. In these cases, they shall wear shoes with rubber or composition soles and heels or other suitable footwear that will not damage the coating. Any damage to the pipe or the protective coating from any cause during the installation of the pipeline shall be repaired.

Coating repair in field:

All holidays visually or electrically discovered either at the coating plant or in the field shall be repaired by peeling back and removing the outer, intermediate and inner layers from the damaged area. The exposed areas shall then be coated with liquid adhesive and either (1) a length of inner-layer tapes shall be wrapped around the pipe to cover the defective area; or (2) a patch of inner-layer tape shall be applied directly to the defective area as specified by the Owner / Owner's representative. The minimum over-lap at the damaged area shall be 100 mm all around. The repaired area shall be tested with a holiday detector as per specifications after the repair is completed. If holidays are not found, the repaired area shall be covered with the intermediate - layer & outer-layer tape with a minimum over-lap of 100 mm beyond the inner-tape patch, Or as per the repair method recommended by the manufacturer of the tape.

Hoisting:

Pipe shall be hoisted using only wide-belt nylon slings or the equivalent. The use of caliper clamps, metal chains, cables, tongs, or other equipment likely to cause damage to the coating shall not be acceptable, nor shall dragging of the pipe be permitted. The Contractor shall allow inspection of the coating on the underside of the pipe while the pipe is suspended from the slings.

Shipping, handling and storage:

Coated pipe shall be handled, stored and shipped in a manner that will prevent damage to the coating.

Pipe also shall be handled and stored in a manner to prevent damage to pipe walls and ends.

Pipe or coating damaged in handling or other operations shall be repaired. Handling during the period of coating also shall be such as to avoid damage to the coating. Thermal expansion is a characteristic of the coating that may cause uneven areas on the coated pipe surface, but does not adversely affect the coating system's performance. These areas do not require any repair.

Stacking:

Sufficient spacers or padding shall be used to prevent damage to the pipe and coating.

Shipping:

Pipe shall be transported from the coating yard to the jobsite using sufficient shoring or ton-nage, padding and banding to adequately protect the pipe and its coating.

Loading:

Pipe shall be loaded for shipping in compliance with existing shipping standards and regulations.

Trench-side Storage:

Pipe stored along the trench side shall be suitably supported off the ground to avoid damage to the coating.

2.11 Specification for External Coating for Special Sections, Connections & Fittings of Buried Steel Pipelines for Water - Polyolefin Tape Coating

General:

Special sections, miter bends, tees, connections, fittings in buried steel pipeline network shall be coated externally, with prefabricated polyolefin tape coating as per AWWA C 209 Protective coating shall consist of a coating system consisting of primer, inner - layer tape and outer-layer tape or using Self - Healing Monolithic Polymer Wrap (Visco Elastic) material conforming to ISO 21809 with PE backed outer tape.

Referenced Standards:

The following standards (latest revision) referenced below are a part of this specification. In case of conflict between this specification and the referenced standards, this specification shall apply.

ANSI/AWWA C 216: Standard for Heat - Shrinkable Cross-linked Polyolefin coatings for exterior of special sections, connections and fittings of steel water pipelines.

ANSI/AWWA C214: Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines

AWWA Manual M11: Steel Pipe – A Guide for Design and Installation

ANSI /ASTM D149: Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

ANSI/ASTM D257: Standard Test Method for DC Resistance or Conductance of Insulating Materials.

ANSI/ASTM D570: Standard Test Method for Water Absorption of Plastics

ANSI/ASTM D638: Standard Test Method for Tensile Properties of Plastics.

ASTM D1000 : Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications.

ASTM D1002 : Standard Test Method for Apparent Shear Strength of Single Lap Adhesively Bonded Metal Specimens by Tension Loading.

ASTM E96: Standard Test Methods for Water Vapor Transmission of Materials

ASTM G14: Standard Test Method for Impact Resistance of Pipeline Coatings (Falling Weight Test)

ASTM G17: Standard Test Method for Penetration Resistance of Pipeline Coatings (Blunt Rod)

ANSI/AWWA C209: Standard for cold applied tape coatings for the exterior of special sections, connections and fittings for steel water pipelines.

NACE RP-O2-74: High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning.

ISO 21809-3-2016

Coating system:

The pre-fabricated polyolefin tape coating system shall consist of the following layers to provide an applied coating system thickness of 100 mils (2.5mm) on the exterior of the special sections of steel pipes.

- A liquid adhesive layer.
- An inner-layer tape for corrosion protection having thickness of 30mils and applied with 50% overlap
- An outer-layer tape for mechanical and UV protection having thickness of 20mils and applied with 50% overlap.

Liquid Adhesive layer:

The liquid adhesive layer shall consist of a mixture of suitable rubber and synthetic compounds and solvent. The liquid adhesive layer shall be brush applied to the abrasive blasted prepared pipe surface before application of the inner-layer tape.

Table-I Physical Properties of the Liquid Adhesive

Color	Base	Weight			Flash Point
Black	Rubber and Synthetic Resins	Flammable	-	6-8 lb/gal (0.72 – 0.965g/l)	-10oF(17oC) or greater
		Non-flammable	-	10 – 12 lb/gal (1.20 – 1.44 kg/l)	none

Inner-layer tape:

The inner-layer tape shall be a two-layer tape consisting of a polyolefin backing layer with a laminated butyl-based adhesive layer. The thickness of the inner tape shall be 30mils. To ensure a proper smooth coating by hand or by manual hand wrapping machine, the inner-layer tape shall be provided in standard widths of 4" or 6" as per manufacturer recommendations consistent with the pipe diameter.

Outer-layer tape:

The outer-layer tape shall be a two-layer tape consisting of a polyolefin backing layer with a laminated butyl adhesive layer. The outer-layer should be of suitable quality for the local environment. The thickness of the outer-layer tape shall be 20mils. To ensure a proper smooth coating by hand or by manual hand wrapping machine, the outer-layer tape shall be provided in standard widths of 4" or 6" as per manufacturer recommendations consistent with the pipe diameter.

Coating-system Thickness:

The installed coating system thickness shall not be less than 100 mils (2.5mm) and shall comprise of the following.

i. A liquid adhesive layer (50-75 microns)
ii. An inner-layer tape (Nominal 30 mils i.e. 0.75mm) applied with 50% overlap
iii. An outer-layer tape (Nominal 20 mils i.e. 0.50mm) applied with 50% overlap

The properties of the tape & coating system shall conform to the following requirements.

Table 2 - Physical Properties of Total System

Property	Requirement		
	Minimum	**Maximum**	**Test Method (Ref AWWA C214/209-07)**
Thickness			
100 mil, nominal	95 mil (2,413 μm)	105 mil (2,267 μm)	
Dielectric strength	12000V		Sec. 5.2.8 AWWA C214
Impact resistance	25 lb * in. (2.8 N*m)		Sec. 5.2.13 AWWA C214
Penetration/deformation resistance	25% with no holiday at 72 0F (220C)		Sec. 5.2.14 AWWA C214
Water-vapor transmission	0.25 perms [1.44ng/ (Pa.s.m2)]		Sec 5.2.7 AWWA C209

Insulation resistance	500,000 mega ohms (min)		Sec 5.2.9 AWWA C209
Adhesion to Primed Steel	228 oz/inch (2500 N/m width)		Sec 5.2.4 AWWA C214

Coating Repair:

Damages, Flawed areas, holidays, or mislaps to coatings applied to special sections, connections, and fittings from any cause during installation and before final acceptance shall be repaired by peeling back and removing the tape layers from the affected area. The repair area shall be brushed with a primer, then a patch of tape covering a minimum of 4 inch (100mm) around the affected area shall be applied by wrapping it around the pipe or by applying a patch of tape as specified by the purchaser. After the repair is completed, the repaired area shall be tested with a holiday detector.

Backfilling shall be conducted at all times in such a manner to avoid abrasion or other damage to the coating. Unless otherwise specified, the following requirements shall be met:

Where the trench traverses rocky ground containing hard objects that could penetrate the protective coating, unless otherwise specified, a layer of screened earth, sand, or rounded river gravel no less than 6 inch (152 mm) thick with a maximum particle size of 20mm shall be placed in the bottom of the trench before installation of the coated item. Other bedding material acceptable to the purchaser may be used in place of the earth, sand, or rounded river gravel. Placement of backfill around the exterior of the coated item shall be done only in the manner approved by the purchaser after final inspection and acceptance of the exterior coating. If rocks, concrete chunks, or other hard objects are present in the backfill material along any section of the pipeline, screened backfill or other approved materials shall be placed around the coated item. When screened backfill is used, it shall be placed around the coated item to a minimum depth of 152 mm before backfilling the remainder of the trench. Compaction of bedding and backfill in the trench shall be done according to the best industry practices and ensures the full integrity of the pipeline and coating.

INSPECTION:

Careful inspection of the coating shall include visual observation.

The coating shall be checked for any holidays using 12 kV holiday detector.

All holidays and all damages to coating shall be clearly marked and repaired immediately. The repair shall be carried out by filling the damaged area with patch of tape and then wrapping the tapes around the circumference to extend 100 mm beyond the damage.

During the procedure qualification, peel test shall be carried out using hand peel test gauge. The peel test shall be conducted on a strip 25 X 200mm long. The minimum peel value to be recorded.

2.12 Coating of Field Joint, Special Sections & Connections Fittings of Steel Pipelines for Water (3 Layer Poly Ethylene)

2.12.1 Scope

This specification establishes the minimum requirements of materials, equipment and installation of field joint anti-corrosion coating of buried onshore pipelines factory coated with three-layer polyethylene coating, by heat shrink wrap around sleeves conforming to ISO 21809-3 Second Edition 2016 – "External coatings for buried or submerged pipelines used in pipeline transportation systems" and the requirements of this specification. Unless modified/replaced by this specification, all the requirements of ISO 21809-3 shall remain fully applicable and complied with.

This specification shall be read in conjunction with the conditions of all specifications and documents included in the Contract between Company and Contractor. Unless specified otherwise, all sections of this specification shall apply to all specifications referred in this specification.

2.12.2 Reference Documents

Reference has also been made to the latest edition (edition enforce at the time of issue of enquiry) of the following standards, codes and specifications:

a. ISO 8502-3 : Preparation of Steel Substrates before Application of Paints and Related Products - Part 3 - Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape)

b. ISO 8503-1 : Part 1: Specification and definitions for ISO surface profile comparator for the assessment of abrasive blast cleaned surfaces.

c. ISO 8503-4 : Part 4: Methods for calibration of ISO surface profile comparator and for the determination of surface profile-Stylus instrument procedure

d. SIS 055900 : Pictorial Surface Preparation Standard for Painting Steel surfaces.

e. SSPC-SP1: Steel Structure Painting Council.

In case of conflict between the requirements of this specification and that of above referred documents, the requirements of this specification shall govern.

The contractor shall be familiar with the requirements of these documents and shall make them readily available at the site to all personnel concerned with carrying out the works specified in this specification.

2.12.3 Materials and Equipment

2.12.3.1 Field Joint Coating Material:

Field joint anti-corrosion coating material shall be heat shrinkable wraparound sleeve suitable for a maximum operating temperature of (+) 80°C (Tmax) and shall conform to ISO 21809-3; 2016 Table 17 Type 14B-2. In addition, the field joint anti-corrosion coating shall comply the requirements specified in this specification.

a. Heat shrinkable wrap around sleeves:

Heat shrinkable wraparound sleeve shall consist of radiation cross-linked, thermally stabilized, ultraviolet resistant semi-rigid polyolefin backing with a uniform thickness of high shear strength thermoplastic/co-polymer hot melt adhesive. The joint coating system shall consist of a solvent free epoxy primer applied to the pipe surface prior to sleeve application. The sleeve shall be supplied in pre-cut sizes to suit the pipe diameter and the requirements of overlap.

The total thickness of heat shrinkable wraparound sleeve in the "As Applied" condition shall be as follows:

Pipe Size (Specified Outside Diameter)	Thickness (mm)		
	On Pipe Body		On Weld Bead
	Average	Min.	(Min.)
<30" (762.0mm)	2.0	1.8	1.6
>32" (813.0mm)	3.0	2.7	2.5

The heat shrink wraparound sleeve shall have the required adhesive properties when applied on various commercial pipe-coating materials and shall be equivalent product to 3LPE main-line coating. The pre-heat and application temperatures required for the application of the shrink sleeve shall not cause loss of functional properties of the pipe coating.

The Contractor shall propose the manufacturer's details, heat shrinkable sleeve details/ properties and the specific grade of field joint coating system meeting the requirements of this specification.

2.12.3.2 Functional Requirements of Field Joint Coating

As applied field joint coating system shall comply the requirements of ISO 21809-3; 2016 Table 17

Contractor shall obtain prior approval from Employer regarding the Manufacturer of the joint coating material and the specific grade of the joint coating system. Complete technical details along with test certificates complying with the requirements shall be submitted to Employer for this purpose. The Contractor shall furnish test certificates from an independent test laboratory for all the properties required for the specified field joint coating and the requirements of this specification.

Functional Properties of Joint Coating System (As supplied)

As applied field joint coating system shall comply the requirements of ISO 21809-3, Table 17 except as modified below:

i. Cathodic Disbondment Resistance at Tmax i.e. 80°C shall be 10 mm .

ii. Peel Strength shall be as follows:

Peel Strength		Unit	Requirement for 14 B-2 (minimum)
To Pipe Surface	@ 23ºC	N/mm	15
	@ Tmax	N/mm	3
To Factory Coating	@ 23ºC	N/mm	15
	@ Tmax	N/mm	3

Contractor shall obtain prior approval from the department regarding the Manufacturer of the joint coating material and the specific grade of the joint coating system. Complete technical details along with test certificates complying with the requirements of this specification shall be submitted to Employer for this purpose.

2.12.3.3 Cut back

Cut back length of the pre-coated pipes shall be 150mm +20, - 0mm.

2.12.3.4 Field joint coating system

Field joint coating system shall be of suitable width considering an overlap to the factory coated pipe coating by minimum 50 mm on each side 3 LPE coated pipes.

2.12.4 Application Procedure

2.12.4.1 General

a. The application procedure shall be in accordance with manufacturer's instructions and the minimum requirements specified below whichever are the most stringent and shall be demonstrated to and approved by the department. The contractor's expert shall supervise

the application and shall be available at site upon request during qualification of application procedure and during construction at Contractor's cost.

b. Operators for coating application shall be given necessary instructions and training before start of work, by the Contractor. To verify and qualify the application procedures, all coating applied during the qualification test shall be removed for destructive testing as detailed subsequently in this specification. Contractor shall only utilize those operators who have been approved/ pre- qualified by the field joint coating manufacturer.

c. Oil, grease and salt shall be removed from steel surface by wiping with rags soaked with suitable solvents such as naphtha or benzene. Kerosene shall not be used for this purpose. Solvent cleaning procedure according to SSPC-SP1 shall be followed.

d. Each field joint shall be blast cleaned using a closed cycle blasting unit or open expandable blasting equipment. With the first equipment type, steel or chilled shot and iron grit shall be used and Garnet material with the second one (in case the authority having jurisdiction have no objection, the contractor may adopt sand blasting instead of garnet material). During blast cleaning the pipe surface temperature shall be simultaneously more than 5°C and more than 3°C above ambient Dew Point, while the ambient Relative Humidity shall not be greater than 85%. Prior to surface cleaning the surfaces shall be completely dry. The surface shall be cleaned to a grade Sa 2½ in accordance with Swedish Standard SIS-055900 with a roughness profile of 50-70 microns. Surface roughness profile shall be measured using an approved profile comparator in accordance with ISO 8503-1 and shall be calibrated prior to the start of the work in accordance with ISO 8503 or ISO 8503-4. The blast cleanliness shall be checked on every joint and the roughness profile shall be checked 1 every 10 joints.

   Dust, grit or foreign matter shall be removed from the cleaned surface by an industrial vacuum cleaner. The dust contamination allowed shall be of a rating max 2 as per ISO 8502-3. The frequency of checking for dust contamination shall be 1 every 10 joints.

   Blast cleaned field joint shall be coated with 2-4 hours according to the conditions below:

   - ✓ Relative Humidity (RH) >80% - 2 hours
   - ✓ Relative Humidity (RH) 70-80% - 3 hours
   - ✓ Relative Humidity (RH) <70% - 4 hours

   Pipes delayed beyond this point or pipes showing any visible rust stain, shall be blast cleaned again.

e. The field joint surface shall be inspected immediately after blast cleaning and any feature of the steel surface such as weld spatter, scabs, laminations or other imperfections considered injurious to the coating integrity, made visible during blast cleaning, shall be reported to the Company Representative and on permission from Company Representative, such defects shall be removed by filling or grinding. Pipes affected in this manner shall be then re-blast cleaned if the defective area is larger than 50mm in diameter.
f. The ends of existing pipe protective coating shall be inspected and chamfered. Unbounded portions of the coating shall be removed and then suitably trimmed. Portions where parent coating is removed shall be thoroughly cleaned as specified. The adjacent chamfered areas of the line pipe coating shall be cleaned and abraded, to expose a clean uniform fresh surface of uncontaminated factory applied coating.
g. All steel joint surfaces shall be thoroughly examined before the application of the coating in order to ensure the surfaces are free of oil, grease, rust, mud, earth or any other foreign matter. All these substances shall be removed before coating, to the procedures herein described.
h. Protection coating shall be applied on the joints immediately after the completion of cleaning operation.

2.12.4.2 Application Procedure for Heat Shrink Wraparound/Sleeves

In addition to the requirements stated above, following shall be complied with:

a. The wraparound sleeve shall be of a size such that a minimum overlap of 50mm is ensured (after shrinking) on both sides of the yard applied corrosion coating of pipes.
b. In the cases where carrier pipe is installed by direct boring/jacking, the overlap on the mill coating for the leading edges of the joints shall be minimum 200mm. When this extra overlap is achieved by providing an additional patch of heat shrink tape/ wraparound, it shall be applied in such a manner that the square edge of the patch on the joint coating is in the direction opposite to the direction of boring/ jacking.
c. Before centering the wraparound sleeve, the bare steel surface shall be preheated either with a torch moved back and forth over the surface or by induction heating. The minimum pre-heat temperature shall be as recommended by manufacturer and shall be checked by means of contact type temperature-recording thermometer (Digital Pyrometer with flat probe type contact). Temperature indicating crayons shall not be used. Pre-heat temperature shall be checked on every joint. Care shall be taken to ensure that the entire circumference

of the pipe is heated evenly. Temperature measuring instruments shall be calibrated immediately before the start of the works and thereafter at intervals recommended by the manufacturer of the instrument.

d. Upon pre-heating, the pipe surface shall be applied with two pack epoxy primer of wet film thickness 250 microns or as per manufacturer's recommendation whichever is higher, to cover the exposed bare metal of the welded field joint and 10mm min. onto the adjacent pipe coating if recommended by the manufacturer. The wet film thickness of the primer shall be checked on every joint with a wet film thickness gauge prior to installation of sleeve. Thickness gauge shall be calibrated once per shift.
e. After application of epoxy primer, the wraparound sleeve shall be entirely wrapped around the pipe, epoxy has to be forced cured using direct low flame before wrapping of sleeve and shall be as per manufacture recommendation. To ensure the corrosion protection layer is uniformly applied the Dry Film thickness of the epoxy needs to be checked in every 1 of 50 joints. Sleeve shall be positioned such that the closure patch is located to one side of the pipe in 10 or 2 O'clock position, with the edge of the undergoing layer facing upward and an overlap of min. 50mm. Gently heat by appropriate torch the backing and the adhesive of the closure and press it firmly into place.
f. A heat shrinking procedure shall be applied to shrink the sleeve in such a manner to start shrinkage of the sleeve beginning from the centre of the sleeve and heat circumferentially around the pipe. Continue heating from the centre towards one end of the sleeve until recovery is completed. In a similar manner, heat and shrink the remaining side. Shrinking has been completed when the adhesive begins to ooze at the sleeve edges all around the circumference.

The complete shrinking of the entire sleeves shall be obtained without undue heating of the existing pipe coating and providing due bonding between pipe, sleeve and pipe coating. The installed sleeve shall not be disturbed until the adhesive has solidified.

2.12.4.3 Joint Coating Application

Joint Coating Application shall be done under supervision of the contractor's personnel during the field trial demonstration and testing work. Presence of manufacturer's representative is a mandatory requirement and contractor shall be required to furnish specific commitment to this.

Minimum 50 (fifty) field joint coating to be carried out under supervision of the joint coating supplier's representative. Application procedure and environment protection methodology demonstrated at the time of field trial shall be strictly followed during the entire work.

2.12.5 Repairs

a. If a field joint is detected to be unacceptable after testing as per relevant QA section of this specification the Contractor shall, at his own cost:
   - ✓ Determine the cause of the faulty results of the field coating.
   - ✓ Mobilise the expert of manufacturer, if required.
   - ✓ Test to the complete satisfaction of Company, already completed field coatings.
   - ✓ Stop the field coating works until remedial measures are taken against the causes of such faults, to the entire satisfaction of the Company.

b. Contractor shall replace all joint coating found or expected to be unacceptable as per relevant section of this specification.

c. Contractor shall, at his own cost, repair all areas where the coating has been removed for testing by the Company.

d. After the coating work on welded joints and repairs to the coating have been completed the coating as a whole shall be tested with a spark-tester before lowering or jacking the pipeline.

e. Employer shall be entitled to check the coating on buried pipelines or parts of pipelines with equipment such as the "Pearson Meter" and the resistance meter. If coating defects are established, the Contractor shall be responsible for excavation at such points, repairing the coating, spark testing and backfilling the excavations without extra charge.

2.12.6 Documentation

a. Prior to procurement of coating materials, Contractor shall furnish the following information for qualification of the Manufacturer and material.

i. Complete information of the Joint Coating Material along with descriptive technical catalogues.

ii. Test certificates and results of previously conducted tests, for all properties listed in this specification shall be submitted to the Engineer in Charge.

iii. Reference list of previous supplies, in last 5 years, of the similar material indicating the project details such as diameter, quantity, operating temperature, year of supply, project name, contact person and feedback on performance.

Once the Employer's approval has been given, any change in material or Manufacturer shall be notified to Employer, whose approval in writing of all changes shall be obtained before the materials are manufactured.

b. Prior to shipment of materials from the Manufacturer's Works, Contractor shall furnish the following documents:

- ✓ Test certificates/results as per Manufacturer's Quality Control Procedure for each batch of material.
- ✓ Specific application instructions with pictorial illustrations.
- ✓ Specific storage and handling instructions.

c. All documents shall be in English language only.

2.13 Lowering, laying & jointing of pipe

2.13.1 General

The pipeline shall be buried with minimum cover of 1.2 m at top, however pipeline shall be laid as per detailed Engineering approved by Engineer In-charge. In case required cover is more than 1.20m, contractor has to laid the pipeline accordingly.

Erection of fabricated shells shall be carried out by the Contractor who shall equip himself, at his cost, with all necessary tools, machinery, labour etc. required for the purpose.

2.13.2 Welding

Except for routine welding of joints, no other work shall be done in the absence of Contractor's engineer, either during the daytime or at night.

Chipping shall not be kept in arrears for more than 15 joints.

Saddle pieces shall be fixed in position after checking bolts holes, by means of templates. These works shall be done together with the pipe laying work, if pipeline is to be laid above ground in unavoidable circumstances.

2.13.3 Temperature

The components of the pipeline such as base plates, top plates and pedestals have been so designed that the centres of the plates and pedestals shall coincide at the Mean Temperature (30^{o}).

For this reason, all works such as fixing flanges, base plate etc. in true alignment, and in correct position and tack welding pipes shall be done at the mean temperature.

For ascertaining the temperature, the Contractor shall provide mercury cups and fix them to the pipe shell from outside and shall also provide thermometers of the required type and range. No extra payment shall be made for this.

2.13.4 Saddle Supports

Unless otherwise specified pipeline shall be underground. However, at unavoidable reaches it shall be on R.C.C. saddles spaced as per design. The material and construction of R.C.C./Steel structures such as saddles, anchor blocks, crossings etc. associated with the work of pipe line shall conform with the relevant I.S. codes, good engineering practice and as directed by the Engineer In-charge. The pipes to be laid on saddle supports shall be erected at mean temperature. Saddle supports shall either be sliding type or fixed type. For both the types of supports a 10mm thick double plate shall be welded to the part circumference of the pipeline that will make contact with the saddle and another similar plate shall also be embedded in the concrete saddle with necessary arrangement to facilitate welding it to the double plate welded to the pipe, in case of fixed support. In case of sliding support, the pipe shall be allowed to slide freely over the plate embedded in the saddle. Alternatively, to achieve fixity, the pipe shall be anchored by providing suitable anchor block. The rate for laying the pipe on saddle support shall include for laying, aligning, tack welding, provision of rigging screws with screw eyes etc., complete.

In addition to above, the pipe shall be held in position on saddles with two numbers 50mm x 8mm thick holding down traps fixed to the saddles with holding down bolts and nuts which shall be paid separately under relevant item of bill of quantities.

2.13.5 Erection of Pipes

The erection shall be true to position, lines and grade as shown in the drawings or as modified by the Engineer In-charge. The Contractor shall provide at his cost necessary saddles, pads, spider etc., all necessary instruments and other materials and labour required for proper erection of pipes in position and for the Engineer in checking the correctness of the erection.

Alignment of sections at edges to be butt welded shall be such that the maximum offset is not greater than the values given below:

Thickness 't' mm	Offset in Longitudinal joints (mm)	Offset in Girth joints (mm)
Up to 12	0.25 t	0.25 t
12 to 20	3 mm	0.25 t

20 to 40	3 mm	5 mm
40 to 50	3 mm	1/8 t
Over 50	Lesser of 0.0625 t or 10 mm	Lesser of 0.125 t or 20 mm

The best of welders as selected from their work in the Contractor's workshop shall be selected for in-situ welding of the pipes. The relevant provision under welding such as qualification standard for welding procedures, tests on welder's work and removal of defects etc., shall also apply to in-situ welding.

2.13.6 General Sequence of Operations

Before commencing the work of pipe laying, the Contractor shall study the L-section of the pipeline for the section concerned. He shall also study the details of laying i.e. underground or aboveground. The underground pipeline shall be laid on sand cushioning/ bedding as shown on the drawing. The difference in depth due to uneven excavations shall be made up by sand cushioning.

Pipe laying shall generally start from the fixity points on either side, the expansion joints if required for pipeline aboveground being provided last. Fixing points are at all anchor blocks. Where such blocks are not required for long lengths, fixity shall be achieved by fixing the pipeline to the special type of R.C.C. or steel saddles as directed. The distance between successive fixity points shall not exceed 300 m.

Anchor blocks shall be constructed before commencing the pipe laying work in any section. The construction of the blocks shall be carried out in 3 stages: In the first stage, the lower part up to 150 mm below the invert of the pipeline including concrete chairs to support it shall be constructed; in the second stage, the pipeline on this part of the block shall be laid; and lastly, the remaining block around and over the pipeline shall be constructed. Necessary curing to concrete shall be carried out for 14 days or as instructed Engineer in charge.

The fixity saddles and ordinary saddles if the pipeline is aboveground shall be cast-at least 3 weeks before the pipeline is laid on them. After all saddles between successive fixity points have been cast, a line plan showing the actual position thereof shall be prepared, after taking levels and measuring distances. In case of any errors in casting the pedestals, corrections shall be applied. The pipe laying work shall then start from the fixity points and shall proceed towards the expansion joints. The method of jointing the pipes and erecting them on previously

cast R.C.C. saddles shall be determined by the Contractor depending upon the type of plant equipment and personnel available with them.

The pipe stacking shall be assembled in position on the saddles either by the cranes, portable gantries, shear legs or any other equipment approved by the Engineer In-charge. Normally, not more than two pipes shall be aligned, tacked and kept in position on temporary supports. The Contractor shall not proceed with further work, until the circumferential joints of these pipes are fully welded. During assembly, the pipeline shall be supported on wooden sleepers and wedges, with the free end of the pipeline held in position by slings to avoid deflection due to temperature variations during the day. In general, the assembly of pipe stacking and one run of welding shall be done during the day time while full welding including the external gouging and sealing runs shall be done after 5 p.m. or so. The Contractor shall maintain the continuity of the work by adding two more pipes on the second day in a similar manner, after full welding of the previous joints is completed during the night. While this new work is being done, the Contractor shall proceed with the work of providing permanent supports for the pipeline assembled and welded previously.

2.13.7 Fixing Expansion Joint

The work of laying pipeline in aboveground, laying starts from the fixity points and proceeds towards the expansion joints. It shall be continued until the gap between the pipe ends is less than the lengths of the expansion joint plus pipe strake length. At this stage, the exact gap between the pipe ends shall be measured at mean temperature of that locality. Let it be `X'. Similarly, the exact length of the pipe strake and the expansion joint bought at site shall be measured at the same temperature let these be `Y' and `Z' respectively. Normally, the length of the expansion joint (`Z') is standard.

✓ Case when `Y' plus `Z' is more than `X' or equal to `X' (i.e. fixing of expansion joint without strip)

At mean temperature, the exact gap between pipes shall be measured. Free ends of pipes shall be brought in a correct line and level; lateral movement, if any, shall be corrected. Then the gap between the free ends shall be made equal to the exact length of the expansion joint by cutting one of the pipe ends. Choice of the end to be cut must be made from the point of view of bringing the expansion joint to a central position.

The expansion joints are normally supplied without packing. The normal length of the expansion joint shall be reduced by about 100 mm by cutting the inside locks and inserting the inner

strake by means of turnbuckles. At mean temperature, this expansion joint shall be inserted inside the gap (care being taken to keep the tapered portion on the down-stream side), and both ends shall be tack welded to the pipe ends, after pulling the expansion joint. (Tacks of these two joints shall be of longer length, approximately 100 mm long).

Welding of these two joints of the expansion joints shall be started only after it is ascertained by taking observations that the expansion joint is functioning properly. The procedure to be followed for taking observations is given in below observations.

✓ **Case when `Y' plus `Z' is less than `X' (i.e. fixing of expansion joints with strap)**

The expansion joint shall be laid in locked position. Before laying the pipes adjacent to the expansion joint, the exact gap between the pipes shall be calculated by taking measurements of the first pipe (upstream of the expansion joint), and the second pipe (downstream of the expansion joint) at Mean Temperature.

If the gap is less than 100 mm, the second pipe shall be cut to make the desired gap of at least 100 mm. If the gap is more than 200 mm, suitable distance piece of not less than 700 mm shall be inserted after cutting necessary length of the first pipe.

The second pipe shall then be laid in position. Then a strap of length equal to three times the gap length shall be welded to the pipe, overlapping the second pipe by the gap length. The other end of the strip shall be kept free.

At mean temperature, the other end of the strap shall be tacked to the first pipe, after checking of the line and level. Simultaneously, all the locks of the expansion joint shall be removed and chipped off properly.

Welding of the joints between the strap and the first pipe shall be started only after observations are over and it is ascertained that the expansion joint is functioning properly.

Observations

Before fixing the expansion joint, two mercury cups - one on the left and the other on the right side - shall be fixed on the pipe near the upstream side of the expansion joint.

Immediately after the expansion joint in case (a) above or the strap in case (b) above is tack welded, observations for total expansion or contraction shall be started and continued for 48 hours round the clock. Similarly, the central and end fixity pedestals shall be kept constantly under observation.

The expansion and contraction shall be measured by making a temporary marking on the inner strake (on the upstream side) and measuring the distance between this mark and the edge of the gland of the expansion joint.

The observations shall be recorded in the following proforma;

Reading No.	Time	Pipe Temp on Up-stream side	Pipe Temp on down-stream side	Atmos-pheric Tempera-ture	Dist. between edge of gland and marking
1	2	3	4	5	6

2.14 Specials

2.14.1 General

Specials, such as tees, Y-pieces, bends (single or composite), tapers, etc. shall necessarily be made from same pipe as used in straight reach shall be fabricated as per standards and tested and laid in the same manner as the pipes. Small branches, single piece bends, etc. may be fabricated at site, care being taken to ensure that the fabricated fittings have at least the same strength as the pipeline to which they are to be jointed.

2.14.2 Bends

Bends shall be fabricated taking into account the vertical and horizontal angles for each case.

The bends shall have welded joints and the upstream and downstream ends of each bend shall have a straight piece of variable lengths as required.

Bends shall be designed with suitable deflection angle between segments.

When the point of intersection of a horizontal angle coincides with that of a vertical angle, or when these points can be made to coincide, a single combined or compound bend shall be used, designed to accommodate both the angles. The combined bend should have a pipe angle equal to the developed angle, arrived at from appropriate formula.

All joints in bends shall be thermally stress relieved as specified.

Details of thrust collars anchor bolts, holding down straps, saddle plates should be furnished together with full specifications in Contractor's fabrication drawing.

Coating on bends has to be as per ISO 21809-1 (for 3 LPE coating)

2.14.3 Closing or Make up sections

Closing or make up sections shall be furnished at appropriate locations on the line to permit field adjustments in pipeline length to compensate for shrinkage in field welded joints, differences between actual and theoretical lengths and discrepancies in measurements.

2.14.4 Heads

Test heads may be ellipsoidal, standard dished as per ASME code or hemispherical heads. They shall be welded in the shop and removed after the test. Allowance should be made in the length of the pipe section receiving the test head for the welding and removal of the head and preparation of the plate edges for the final weld after testing.

The rate quoted for the hydraulic test shall be deemed to cover the cost of such installations.

2.14.5 Flanges

Flanges shall be provided at the end of pipes or special where, butterfly, air valve, scour valve, sluice valves, blank flanges, tapers, etc. have to be introduced. The flanges received from the manufacturers will have necessary bolt holes drilled. The Contractor shall assemble the flanges in the exact position by marginal cutting, if necessary, so as to get the desired position of the valves, etc. either vertical or horizontal and shall then fully weld the flanges from both sides in such a way that no part of the welding protrudes beyond the face of the flanges. In case the welding protrudes beyond the flanges and if the Engineer orders that such protrusions shall be removed, the Contractor shall file or chip them off. If required and when ordered by the Engineer In-charge, the Contractor shall provide and weld gusset stiffeners, as directed on site. The drilling pattern shall be matching with the drilling pattern of flanges of valves.

2.14.6 Blank Flanges

Blank flanges shall be provided at all ends left unattended for the temporary closure of work and also for commissioning a section of the pipeline or for testing the pipeline laid. For temporary closures, non-pressure blank flanges consisting of mild steel plates, tack welded at the pipe ends may be used. For pipes subjected to pressures, the blank flanges or domes suitably designed as per Engineer's requirements shall be provided.

2.14.7 Stiffener Rings

The Contractor shall provide stiffener rings wherever required by design. The Contractor shall weld the same to the pipes with one circumferential run on each side. All fillet welds shall have a throat thickness of not less than 0.7 times the width of welding.

2.15 Field Hydraulic Test

The entire pipeline shall be subjected to a hydraulic test as follows, to the required test pressure as per Clause 11 of IS: 5822.

Hydrostatic test for the buried pipeline to be conducted for 1.5 times of working pressure (i.e. 1.5 * 50 = 75 m or 7.5 kg/cm2)

Water shall not spout, ooze or sweat either through joints-welded or bolted or the body of the pipe. If any leakage noticed shall be repaired by the Contractor, which shall include coating and repairing of the damaged portion. Repairs and replacements and further testing including the cost of the plates and other raw materials shall be carried out by the Contractor at his own cost. If any leakages are observed during the defects liability period due to defective workmanship or material supplied by the Contractor, he shall repair the same to the entire satisfaction of the Employer, at his own cost.

After completion of field hydraulic test as specified above and if no leakage is found in the entire pipeline/joints and all welded portion, then this may be considered as field hydraulic test.

2.16 Progress in laying

The contractor shall submit a detailed bar chart for manufacturing and laying of the pipeline. While preparing this bar chart, the contractor shall plan all activities such that the laying of pipes shall closely follow the manufacturing schedule and no pipes shall remain stacked in factory or at site for a period more than one month.

2.16.1 Lowering and Jointing

The pipe shall be lowered into the trenches by removing only one or two struts at a time. It shall be seen that no part of the shoring is disturbed or damaged and, if necessary, additional temporary struts may be fixed during the lowering operations. It shall also be necessary to see that the coating of pipe is not damaged in any way during the lowering and assembling. After the pipe is lowered into the trench, it shall be laid in correct line and level by using the levelling instruments, sight rails, theodolite, etc. Care shall be taken to see that the longitudinal joints of two consecutive pipes at each circumferential joints are staggered by 90°. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4mm. If necessary, a marginal cut may be taken to ensure a close fit of the pipe faces. For this purpose, only experienced cutters who can make uniform and straight cuts shall be permitted to cut the faces of the pipes. No extra payment shall be made for such marginal cutting. There shall be no lateral displacement between the pipe faces to be joined. If necessary, spiders from inside and tightening rings from outside shall be used to bring the two ends in perfect contact

and alignment. It may also be necessary to use jacks for this purpose. In no case shall hammering or longitudinal slitting be permitted. When the pipe is properly assembled and checked for correct line and level, it shall be firmly supported on wooden beams and wedges and tack welded. Some portion of the trench may be refilled at this stage so as to prevent the pipeline from losing its alignment. The tack welded circumferential joints shall then be welded fully. Only experienced welders, who shall be tested from time to time shall be permitted to carry out the welding work.

On completion of the pipe jointing and external protection, the trench and the welding pits shall be cleaned. The welding pit shall be filled and compacted in 150mm layers with the bedding material.

Backfilling shall be carried out as detailed here under.

Providing Steel Props inside the Pipeline (Dia. 1200 mm and above).

It is necessary that the roundness of the pipes is maintained circular. To achieve the same, steel adjustable screw type props of screw or similar approved make consisting of minimum six (three on each side) legs shall be fixed inside the pipe. The deflection of the pipe should be limited to 1% of the average diameter. In no case shall the limit be exceeded, even under the full load, in case of pipes laid underground. The design and drawings of the props that the Contractor intends to use should be got approved by the Engineer In-charge before starting the work. While laying the pipes underground. In case the Engineer In-charge finds it necessary, they will have to be fixed in any position. The props should be kept in position at least for three days after the encasing of the pipe in that section is completed or till refilling is done to the full height of fill over the pipe in case the pipes are not encased. The props shall be removed only after obtaining permission from the Engineer In-charge. The height of earth fill over the pipe top shall normally be such as to avoid floatation under submerged conditions and to have a minimum earth cushion of about 1.20 metres over the pipe whichever is greater. It is also necessary that, in case of buried pipe, adequate side supports from the backfilled materials is developed to keep the diametrical deflection within the specified limits. Backfilling of the excavated trenches, particularly below the pipe and along the sides shall, therefore, have to be done with proper care and compaction as desired. No extra payment will be made for the above work.

2.16.1.1 Precautions against Floatation

When the pipeline laid underground or above ground in a long narrow cutting gets submerged in water collected in the trench of cutting it is subjected to an uplift pressure due to buoyancy and is likely to float if completely or partly empty. In the design of pipelines, provision is to be made to safeguard against floatation providing sufficient overburden or by providing sufficient dead weight by means of blocks, etc. Factor of safety for calculations for check against floating shall be taken as 1.2.

In the case of works extending over one or more monsoon seasons, however, special care and precautions are necessary during the progress of work on this account. The Contractor shall close down pipe laying operations well in time for the monsoon. The work of providing blocks, refilling the earth to the required level, compacting the same, etc. shall always be done as soon as the pipeline in the cutting has been laid.

The Contractor shall see that the water shall not be allowed to accumulate in open trenches. Where work is in an incomplete stage, precautionary work, such as blank-flanging in the open ends of the pipeline and filling the pipeline with water etc. shall be taken up as directed by the Engineer In-charge.

Such works shall be to the Contractor's account and no separate payment shall be made for the same. The Contractor's rate for pipe laying shall be deemed to include such precautionary measures against floatation.

Protection of the pipeline against floatation during the Contract Period shall be the responsibility of the Contractor. Should any section of the pipeline float due to his negligence, etc. the entire cost of laying it again to the correct line and level shall be to his account.

Pipeline will be laid by the contractor as per the drawings provided by the Client.

Alignment of pipeline may require to be changed on same route due to any obstructs or service lines. No extra payment made to contractor.

All necessary actions required for diversion of the traffic on State high way, or any other routes are to arrange by the contractor at his own cost as per the requirement of the traffic rules and approval from concerned competent authority.

During the execution of work any damage occurred to the private/Govt. property is to be reimbursed by the contractor to the owner.

2.17 Specification for External Field Girth Weld Joint Coating for Buried Steel Pipelines for Water Coated with Cold Applied Tape System

General:

All girth weld joints of buried steel pipeline shall be coated externally with pre-fabricated heat shrinkable cross-linked polyolefin coatings as per AWWA C216-07. The Contractor shall perform all work in accordance with these specifications and the latest pipeline coating practices, and shall complete work in all respects to the full satisfaction of the Owner / Owner's representative. The entire field joint coating operation starting from cleaning and surface preparation till coating shall be performed under the supervision of skilled personnel who are well conversant with the work.

This specification is not intended to be all inclusive and the use of guidelines set forth here does not relieve the Contractor of his responsibility for the quality and performance of the applied coating system, and to supply coating material capable of performing its intended service

Referenced Standards:

The following standards (latest revision) referenced below are a part of this specification. In case of conflict between this specification and the referenced standards, this specification shall apply.

ANSI/AWWA C 216: Standard for Heat - Shrinkable Cross-linked Polyolefin coatings for exterior of special sections, connections and fittings of steel water pipelines.

ANSI/AWWA C214: Standard for Tape Coating Systems for the Exterior of Steel Water Pipelines

ANSI /ASTM D149: Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.

ANSI/ASTM D257: Standard Test Method for DC Resistance or Conductance of Insulating Materials.

ANSI/ASTM D570: Standard Test Method for Water Absorption of Plastics

ANSI/ASTM D638: Standard Test Method for Tensile Properties of Plastics.

ASTM D1000 : Standard Test Method for Pressure-Sensitive Adhesive-Coated Tapes Used for Electrical and Electronic Applications.

ASTM D1002 : Standard Test Method for Apparent Shear Strength of Single Lap Adhesively Bonded Metal Specimens by Tension Loading.

ASTM E96: Standard Test Methods for Water Vapor Transmission of Materials

ASTM G14: Standard Test Method for Impact Resistance of Pipeline Coatings

(Falling Weight Test)

ASTM G17: Standard Test Method for Penetration Resistance of Pipeline Coatings (Blunt Rod)

ANSI/AWWA C209: Standard for cold applied tape coatings for the exterior of special sections, connections and fittings for steel water pipelines.

NACE RP-O2-74: High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning.

Heat Shrinkable joint coating system:

General:

Heat shrinkable joint coating system shall consist of material fabricated from cross-linked polyolefin backing, coated with a protective, heat-activated adhesive. The heat activated adhesive can be of modified butyl rubber based or modified asphalt based. After installation, the heat shrinkable coating shall conform to all surface contours of the pipe. Heat shrinkable sleeve will be of wrap around design and shall be provided with a separate closure patch to secure the overlap of the heat shrinkable sleeve during the shrinking process.

Dimensions:

The manufacturer shall provide pre-cut heat shrinkable sleeves to suit the diameter of the steel pipe. The width of the sleeve shall meet the requirement of the coating cut back and shall overlap the main line coating by 100mm on either side. For coating cut back of mainline coating 150+ 0 /-25 mm, width of sleeve shall be 600mm.

Thickness:

The applied thickness of the heat shrinkable sleeve on the steel pipe body shall match the thickness of the main line coating and the thickness on the apex of circumferential girth weld seam shall not be less than 75% of the thickness of the heat shrinkable sleeve on the steel pipe body. Applied thickness of the heat shrinkable sleeve shall be minimum 2.0 mm on the steel pipe body and on the apex of circumferential girth weld shall be minimum 1.5 mm.

Table-I Physical and performance requirements for heat shrinkable coatings:

Property	Requirement	Test Method (Ref. AWWA C216)
Width deviation (min)	+0.25 inch (6mm)	Sec.5.3.1
Thickness (as applied min)	2.0 mm	Sec. 5.3.2
Water-vapor transmission	0.03 g/h/m2	Sec 5.3.3

Dielectric strength (min)	400 V/mil (15 V/µm)	Sec 5.3.4
Volume resistivity (min)	1014 ohm-centimeter	Sec. 5.3.5
Adhesion to Steel (min)	15 lb/in width	Sec. 5.3.6
Lap shear (min)	12 psi 83(kPa)	Sec. 5.3.7
Heat shock (test for cross linking of backing)	No visual cracking, flowing, or dripping	Sec. 5.3.8
Tensile strength	2,200 psi (15.2 Mpa)	Sec. 5.3.9
Elongation	400%	Sec. 5.3.10
Impact resistance	25 in-lb (282 cm-N)	Sec. 5.3.11

Heat Shrinkable joint coating application:

Surface preparation:

Bare surface:

Bare surface shall be free from mud, mill scale, lacquer, wax, paint, coal tar, asphalt, oil, grease, or any other foreign material. Before blast cleaning, surfaces shall be inspected and, if required, pre-cleaned according to SSPC-SP1 to remove oil, grease, and loosely adhering deposits.

Welds shall be cleaned of all welding slag, spatter and scale and shall be allowed to cool before the coating is applied. Sharp edges or burns that could puncture or cut the coating shall be removed by grinding or filling.

Blast cleaning:

All metal surfaces shall be blast cleaned to achieve a surface preparation equivalent to SSPC-SP 6/NACE No.3. Anchor profile shall be minimum 50 microns.

Protection from moisture:

Blast-cleaned surface shall be protected from conditions of high humidity, rainfall or surface moisture and shall not be allowed to flash rust before the coating is applied. If rust occurs, the surface must be prepared again by blast cleaning in the mill or shop or by either blast cleaning or wire-brush cleaning in the field. At the time of coating/adhesive application the steel sub-strate shall be at least 3°C above the dew point.

Application of heat shrink sleeve:

The application of heat shrink sleeve shall be in accordance with the manufacturer's recom-mendation and the procedures outlined below. The procedure shall be submitted to owner for approval before start of work.

Heat shrink sleeve shall be clean, free from dust and dirt, moisture and chemical contamination up to and during the time of application.

Pipe surface shall be pre-heated to a temperature of 600C using LPG gas torches.

Heat shrink sleeve shall then be wrapped loosely around the pre-heated pipe, centering it over the exposed weld area and evenly overlapping the adjacent pipe coating by 100mm. The closure patch shall be positioned off to one side of the pipe in 10 o'clock or 2 o'clock position. Closure patch shall be pressed into position and using a LPG torch with the flame adjusted according to the manufacturer's instructions, the closure patch shall be heated evenly until the pattern of the reinforcement fabric is visible. Any wrinkles or entrapped air in the closure patch shall then be smothed out using a gloved hand and or rollers.

LPG torches shall then be used to heat circumferentially around the joint heating from the centre of the joint outwards, on one end of the joint only. When one end of the joint is fully shrunk the other end shall be heated in the same manner. When fully shrunk adhesive flow shall be visible at both ends of the sleeve and the dimples on the backing vanish.

After the joint sleeve is fully shrunk onto the field joint and while the sleeve is still warm and soft, any wrinkles, creases or air bubbles shall be smoothed out with a gloved hand or small roller. Sleeves showing signs of overheating or uneven shrinkage shall be removed and the cleaning and surface preparation repeated for a new heat shrink.

Material acceptance, inspection and testing:

Material acceptance:

Proposed coating materials shall be approved by the Owner / Owner's representative. The heat shrink sleeve manufacturer proposed by the Contractor shall have supplied coating material for a single water pipeline project with pipe diameter ≥ 2000mm and a length of minimum 100 Kms in the last seven years globally. The Work completion certificates from End User & coating applicator will be submitted by the Contractor while submitting credentials of the proposed sleeve manufacturer to the Owner / Owner's representative for approval.

The recommendations of the manufacturer regarding coating process, repairs, etc, shall also be provided by the contactor. The manufacturer should give guarantee to supply of the required quantity as per the project time schedule and take responsibility for supervising the coating application, repair works and should have technical support team available in owners country. Supporting documents shall be provided for the same.

When the material is supplied, acceptance of the material shall be based on submission of certificate of conformance of the coating system to AWWA C216-07 standard and properties specified in this specification along with manufacturing acceptance test certificates for various lots as per manufacturer's quality assurance and quality control requirements.

Field joint coating application inspection:

The entire field joint coating operation by the Contractor will be supervised by qualified experts from the manufacturer. The CV of the manufacturer's expert shall be approved by the Owner/Owner's representative. All field joint coating work will be done in the presence of the Owner/Owner's representative.

Thickness:

The thickness of the field joint coating system shall be checked in accordance with SSPC-PA 2. The thickness shall be in accordance with the values given in the Table I and shall be checked at a frequency specified by the Owner / Owner's representative.

Holiday testing:

Each field joint coating shall be electrically tested for flaws in the coating using a suitable holiday detector approved by the Owner / Owner's representative. The detector shall impress a minimum of 12,000 V. Reference should be made to NACE RP-02-74. If a holiday is detected, it shall be repaired as per specifications.

Peel strength:

The peel strength of the heat shrinkable sleeves shall be checked in accordance with ASTM D-1000. The average value below the limits stated in the Table I shall constitute a failure of the heat shrinkable sleeve to meet the adhesion requirement. The peel test shall be conducted at a frequency specified by the Owner / Owner's representative

Field procedures:

At all times during construction of the pipeline, the Contractor shall use caution to prevent damage to the heat shrinkable field joint coating on the pipe. No metal tools or heavy objects shall be permitted to unnecessarily contact the finished coating. Workmen shall not be permitted to walk on the coating except when necessary. In these cases, they shall wear shoes with rubber or composition soles and heels or other suitable footwear that will not damage the coating.

Coating repair in field:

All holidays visually or electrically discovered and heat shrink sleeves damaged during peel test shall be repaired using heat applied polyethylene adhesive lined repair patch. The patch shall be applied as per manufacturer's recommendation.

EXCAVATION

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided. The excavation shall include excavation in earth and murrum and others shall be carried out to the correct levels required and specified and no clearance, plus or minus (ie. no overcuts), shall be permitted as per the authority.

Road crossing with the trench less technology / HDD (Horizontal directional drilling): Trench-less technology tunneling work include the laying by hydraulic jacking and smooth controlled pushing method in all types of soils including hard rock true to the alignment and gradient under running traffic condition as per standards including carrying out the survey work at the site for determining underground cable trenches like telephone, fiber optic cables , water supply pipes , irrigation pipes and resistivity test for finding the soil strata using necessary equipments for completeness of works mobilizing of the machineries and specialized crews at construction site etc, complete in all respects including the excavation of the driven pit and exit pit with proper protection with shoring sheets and ISMB (providing and casting MS cutting edges for front shield and construction thrust bed at designated level as directed by the engineer, necessary dewatering and providing the concrete foundation at the base of the driven pit, crane for holding the pipe and any other machinery, tools , tackle required, construction of the temporary works as per the requirement and approval of the concerned authorities and engineering in charge, as per the scope of work defined.

2.18 Back filling of trenches

On completion of the pipe laying operations in any section, for a length of about 100m and while further work is still in progress, refilling of trenches shall be started by the Contractor with a view of restricting the length of open trenches. Pipe laying shall closely follow the progress of Trench Excavation and the Contractor shall not permit unreasonably excessive lengths

of trench excavation to remain open while awaiting testing of the pipeline. If the Engineer considers that the Contractor is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trenches. Backfilling shall be carried out from bottom of pipe to 30 cm. above top of pipe with useful excavated soil which do not damage the pipe surface. In case of any damage to external surface (of pipe/joint/specials etc.), the damages shall be rectified by the contractor at no extra cost. In case of failure in attending satisfactory repairs, entire pipe/specials shall be replaced with new one at no extra cost. Filling from bottom of pipe line up to centreline shall be done in layers not exceeding 225mm and compacted to 85 percent of the maximum dry density by hand compaction as per part VII of IS:2720. Filling from centre line of the pipe to a level 300mm above the top of pipe shall be done by hand or approved mechanical methods in layer of 225mm as per IS 3114. Care shall be taken during backfilling, not to injure or disturb the pipes, joints or coating. Filling shall be carried out simultaneously on both sides of the pipes so that unequal pressure does not occur. Walking or working on the completed pipeline unless the trench has been filled to height of at least 30 cm over the top of the pipe except as may be necessary for tamping etc., during backfilling work.

Soil of excavated stuff which is to be used for refilling / backfilling work shall be got tested for all chemical tests including SO3 %, sulphate as SO3 2:1 water soil extract as per I.S. 456:2000. No swelling soils shall be used for backfilling work. For the purpose of back filling requirements of I.S. 3114:1994 shall be satisfied.

As per approval by EIC suitable material in backfilling may be use in lieu of earth, sand, or rounded river-run gravel / crushed sand.

The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place. No extra payment will be made for material brought from outside. Backfill material shall be properly consolidated by watering and ramming, taking due care so that no damage is caused to the pipes.

To prevent buckling of pipe shell diameters 1200 mm and above, pipes shall be strutted from inside while the work of refilling is in progress, for which no separate payment shall be made. Strutting shall be done by means of strong spiders having at least 6 arms which shall be sufficiently stiff to resist all deformation. Spiders shall be provided at a maximum interval of 4 m.

If suitable material sand for back filling is not available from excavated stuff, it shall be brought from borrow area for which no extra payment shall be made.

The Engineer shall, at all times, have powers to decide which portion of the excavated materials shall be for filling and in which portion of the site and in what manner it shall be so used.

If any material remains as surplus it shall be disposed of as directed by the Engineer In-charge, which includes loading, unloading, transporting and spreading as directed. Contractor has to make his own arrangement for disposal of surplus earth. Contractor has to identify and arrange for dumping zone to dispose of the excess excavated stuff. No extra payment for such arrangement shall be paid. If the Contractor fails to remove the earth from site within 7 days after the period specified in a written notice, the Engineer may arrange to carry out such work at the Contractor's risk and cost or may impose such fine for such omission as he may deem fit. Particular care shall be taken to keep the trench dry during the entire refilling operation.

If suitable material / Sand for refilling is not available from excavation the Contractor shall bring selected material of approved quality as directed by the Engineer In-charge. No extra payment will be made for material brought from outside.

No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or the approval of the Engineer In-charge has been obtained.

Subsidence in filling in: Should any subsidence take place either in the filling of the trenches or near about it up to completion of the Contract Works. The Contractor shall make good the same at his own cost or the Engineer may make good the same in any way and with any material that he may think proper, at the expense of the Contractor. The Engineer In-charge may also, if he anticipates occurrence of any subsidence, employ persons to give him timely notice of the necessity of making good the same, and the expenses on this account shall be charged to the Contractor.

2.19 Distance indicators and Markings

The Contractor shall supply and fix indicators at all points of change of direction, at all valves and at every one kilometre intervals along the buried pipe line. Indicators shall consist of 10 cm x 10 cm pre-cast concrete posts 1.25-metre-long, set 0.75 metre into the ground and painted white above ground level. The description shall be written in blue at one face of the pre-cast post.

In case of the pipeline laid above ground details such as chainage, Invert levels of pipe, appurtenance number, pedestal/saddle number, culvert number, anchor/thrust block number etc.,

shall be suitably marked either on the pipeline or the supporting structure etc., in distinct colour. The Contractor shall include the cost of this in his rates for the other items.

2.20 Responsibility of Contractor

The following responsibilities are under the scope of contractor

- ✓ Procurement of pipeline
- ✓ Stacking/storing of pipeline
- ✓ Remove of rust on Internal surface and external surface (BS-105 with A&C 2) before lowering
- ✓ Excavation
- ✓ Lifting/Shifting of pipeline from yard (stacking place) to laying place.
- ✓ Lowering and laying of pipeline
- ✓ Welding and jointing of pipeline
- ✓ Closing of pipe ends
- ✓ Backfilling
- ✓ Compacting and testing.

3. APPURTENANCES

3.1 Scope of Work

This chapter describes the minimum requirements for the provision of valves & valve chambers. Prior to the procurement of valves, the Contractor shall obtain the Engineer in charge's approval for the QAP, Data sheet & drawings. General applicable Standards to be applied to the Works under this Section shall be Indian Standards and British Standards or other approved International Standard.

3.2 General

DI Resilient seated sluice valves shall be used as scour valves at following locations as mentioned in the Schedule – B, Table-4 of water supply scope. Shop inspection, Pressure testing of valves, Material testing at manufacturer's testing facility in presence of EIC/Representative of EIC followed by a certificate from the manufacturer's shop testing shall be provided for review by the Engineer in charge. Before delivery to Site all working surfaces shall be thoroughly cleaned and if metal protected with grease. The initial charges of oil, grease and similar materials necessary for the correct setting to work and operation of valves and penstocks shall be provided by the Contractor. Packing must be sufficient to ensure complete protection of the fitting during transit and storage and all valves are to have their openings sealed until installation.

3.3 Installation

All valves, operators and appurtenances shall be installed in accordance with the manufacturer's recommendations and as per the specifications laid for pipe laying, and to the locations indicated on the drawings. The installation shall be true to alignment and rigidly supported. As soon as installation and operating conditions permit, all valves and appurtenances shall be given a field test to be witnessed by the Engineer in charge to demonstrate that they meet all requirements and operating conditions.

Valves shall be rated for PN 16 as minimum working pressure unless elsewhere defined as per the requirement or in tender document.

3.4 Flanges

Valves shall be flanged and the flange face at right angles to the valve centerline. Backside of valve flanges shall be machined or spot faced for proper seating of the head and nut. Flanges

shall be machined on faces and edges to IS 6392 or BS 4504 for PN 16 nominal pressure rating unless otherwise required. Flange drilling shall conform to IS 1538.

3.5 Operation

Scour valves shall be provided with extension spindle by contractor with supports for operation from operating level / ground level. All valves shall be protected against corrosion. Provision for indicator tags shall be made for identification / location of valves. Marking shall be either cast on the bonnet or the body and shall show the following:

- Manufacturer's name or mark
- Year of valve casting
- Size of valve
- Designation of working pressure
- Number of turns to open, with the direction of closing clearly indicated on the hand wheel or body as appropriate.

Nuts and bolts shall be of the best quality bright steel, machined on the shank and under the head and nut. Nuts and bolts shall be ISI Marked conform to IS 1363 and IS 1367, unless otherwise specified. Nuts and bolts shall be hot dip galvanized or shall be chromium plated.

3.6 Construction of Scour Valve

The valve shall be constructed as per the arrangement drawing provided in the drawings and the GFC drawing shall be provided by the contractor before installation/construction for approval of EIC.

Sluice Valves

3.6.1 Constructional Features

The valves shall be resilient seated, bubble-tight, straight and pocket less body passage, inside stem screw and electrostatic epoxy powder (EP-P) coated INSIDE AND OUTSIDE. The face to face dimensions shall conform to provisions of IS 14846/EN 558-1, Basic series F4/BS 5163. All tests shall be carried out as per these standards.

Valves shall be of non-rising spindle type except for the bypass valves. The spindles shall be of such lengths that when the valves are closed the bottom ends of the spindles engage fully in the spindle nuts. The spindle collars of thrust plates shall be concentric and machined, suitable for the specified test pressure. The thickness and bearing of the nut shoulders shall be adequate to resist operating thrusts. Spindles shall be greased and supplied with a cap top. Valve shafts

shall be a one-piece unit extending completely through the valve disc, or of the 'stub shaft' type, which comprise two separate shafts inserted into the valve disc hub. Valves of 400 mm and above shall be provided with thrust bearing arrangement/Gear Arrangement for ease of operation.

Valve of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N.

Valves spindles and hand wheels shall be positioned to give good access for operational personnel. Hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.
Valves shall have two positions marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

The valves shall be so designed that the gates may be removed without removing the bodies from the connecting pipe work. The gate guides shall be cast integrally with the valve bodies and be of adequate strength and of sufficient length to guide the gates throughout their full length of travel. In the fully open positions, the gates shall be fully withdrawn well clear of the stream and the spindles shall not protrude into the bores of the valves.

All Sluice valves shall be open end tested. The Contractor shall provide test certificates for materials, strength and leakage in accordance with BS 5163 / IS 750/International reputed Standards.

3.6.2 Materials of Construction

Item	Material of Construction
Body, Dome	Spheroidal Graphite Iron IS 1865 Gr 400/12 or Gr500/7 Ductile Iron DIN 1693-GGG40 / GGG50
Wedge	Spheroidal Graphite Iron IS 1865 Gr 400/12 or Gr500/7 Ductile Iron DIN 1693-GGG40 / GGG50 Rubber Vulcanized with EPDM/
Spindle / Stem	SS: IS 6603 04 Cr17 Ni 12 M0 2 / AISI 316/SS 420

Bonnet Gasket	EPDM
Internal Fasteners	Stainless steel SS316
Nuts, bolts & washers for pipe flanges	High tensile steel Hot dip galvanized
Coating	Internal and external with powder or liquid food grade Fusion Bonded Epoxy(FBE) coating with minimum dry film thickness of 250 microns Or Thermoplastic-Powder Coating Internal/External min 250 microns

4. PLB HDPE Duct

Optical Fiber Cables should be pulled though Permanently Lubricated HDPE Duct of 40 mm/33 mm size conforming to the specifications as per TEC GR No. TEC/GR/TX/CDS-008/03/MAR-11 with latest Amendments. The Ducts shall be Orange in colour and have the identification markings as per TEC GR.

4.1 Laying of PLB HDPE Duct

Purpose of PLB HDPE duct is for laying of optical fibre cables, networking/interconnect of all accessories i.e., valves, control valves & WDC control management to C3 located at WTP near Undavalli. PLB Duct shall be laid along with MS/DI K9 Pipes with minimum clearance from the pipe line. Prior to the procurement of ducts, the Contractor shall obtain the Engineer in charge's approval for the QAP & Data sheet. The L-Section should show the water supply profile, bends and appurtenances ie., Air valve, Scour valve, Isolation valve details (X, Y, Z Coordinates), PLB HDPE duct profile for approval of Engineer-in-Charge.

4.2 PLB HDPE Duct Accessories

a. Push fit Coupler

Push Fit couplers shall be used for coupling PLB HDPE ducts/coils. The specifications of the couplers shall be as per TEC GR no TEC/GR/TX/CDS-008/03/Mar11 with latest amendment.

b. PP Rope

Should confirm to TEC GR No. TEC/GR/TX/CDS-008/03/MAR-11 with latest Amendments. However, this is optional and EMPLOYERs may use the same on need basis. The PP rope can be ordered along with the PLB duct as required. In this case PP rope is drawn through the HDPE/PLB pipes/coils and safely tied to the end caps at either ends with hooks to facilitate pulling of the OF cables at a later stage. The duct shall be supplied with pre-

installed rope when so ordered by the purchasing authority. The rope shall be polypropylene, 4 mm in diameter for 40mm/33mm ducts and confirm to IS: 5175, with a minimum slackness of 2%.

c. End Cap

End Cap shall be used for sealing the ends of the empty ducts, prior to installation of the OF Cable and shall be fitted immediately after laying the duct to prevent the entry of any dirt, water, moisture, insects/rodents etc. It should confirm to TEC GR No. TEC/GR/TX/CDS-008/03/MAR-11 with latest amendments. The ends of the PLB HDPE ducts/coils laid in the manholes should be closed with End Caps. The End Caps used should be suitable for closing 40mm/33mm PLB HDPE ducts/coils. A suitable arrangement should be provided in the End Cap to tie PP Rope.

d. Cable sealing Plug

This shall be used to seal the end of the ducts perfectly, after the OF cable is pulled in the duct. For pulling the cable through the ducts, it is necessary to provide man holes at that location and also at bends and corners wherever required. The ends of the PLB HDPE ducts/coils are closed with Cable Sealing Plugs. The End Plugs used should be suitable for closing 40mm/33mm PLB HDPE ducts/coils. The Cable sealing plug shall confirm to TEC GR No. TEC/GR/TX/CDS-008/03/MAR-11 with latest amendments.

Annexure – I (D)

Recycled Water Supply

1.0 Reuse Water Supply Network

Standards and Specifications for the Design and Construction of Recycled Water Supply Network are given in this section.

2.0 Applicable Codes & Standards

The manufacturing, testing, supplying, jointing, and testing at work sites of pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern. However, other codes as approved by Employers Engineer but not specifically mentioned below pertaining to the use of DI and HDPE Pipes shall form part of these specifications.

DI Pipes

Code	Description
IS: 8329	Specification for Centrifugally Cast (spun) Ductile Iron pressure pipes for water, gas and sewage specification.
IS: 5382	Specification for Rubber sealing ring for gas mains, water mains and sewers
IS: 638	Sheet rubber jointing and rubber insertion jointing.
IS: 1387	General requirements for supply of metallurgical materials.
IS: 1500	Methods for Brinell hardness test for metallic materials.
IS: 9524	Ductile Iron fittings for pressure pipes for water, gas and sewage.
IS: 12820	Dimensional requirement of rubber gaskets for mechanical Joints and push on joints for use with cast Iron pipes and fittings for carrying water, gas and sewage.
ISO:4179	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining - General requirements.
ISO:2531	Ductile iron pipes, fitting and accessories for pressure pipe lines. Code of Practice
IS: 12288	Code of practice for use & laying of Ductile iron pipes.

IS: 13382	Cast iron specials for mechanical and push-on-flexible joints for pressure pipe lines for water, gas and sewage.

HDPE Pipes;

Code No.	Description
IS 4984 – 1995	High Density Polyethylene Pipes for Water Supply Specification.
IS 2530: 1963	Methods of test for polyethylene moulding materials and polyethylene compounds
IS 4905: 1968	Methods for random sampling
IS 8360 (part- I): 1977	Specification for Fabricated High-Density Polyethylene Fittings for Potable Water Supplies – General Requirements
IS 8360 (part-II):1977	Specification for Fabricated High-Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Tee
IS 8360(part-III):1977	Specification for Fabricated High-Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Bends
IS 7634 (part-I):1975	Code of Practice for Plastic Pipe Work for Potable Water Supplies – Choice of Materials and General Recommendations
IS 7634 (part-II):1975	Code of Practice for Plastic Pipe Work for Potable Water Supplies – Laying and Joining Polyethylene (PE) Pipes
IS 8008 (part-I): 2003	Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies –Specification – General Requirements for fittings
IS 8008 (part-II):2003	Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies – Specification – Specific Requirements for 90 Deg. Bend.
IS 8008(Part III):2003	Specification for injection moulded HDPE fittings for potable water supplies: Part 3 Specification for 90-degree tees
IS 8008(Part IV):2003	Specification for injection moulded HDPE fittings for potable water supplies: Part 4 Specific requirements for reducers
IS 8008(Part VI):2003	Specification for injection moulded HDPE fittings for potable water supplies: Part 6 Specific requirements for pipe ends

IS 8008(Part IX):2003	Injection moulded/machined high density polyethylene (HDPE) fittings for potable water supplies - Specification Part 9 Specific requirements for ends caps (first revision)
IS 7328: 1992	High density polyethylene materials for moulding and extrusion
IS 9845: 1986	Method of analysis for the determination of specific and/or overall migration of constituents of plastics materials and articles intended to come into contact with foodstuffs
IS 7328: 1992	High density polyethylene materials for moulding and extrusion
IS 10141: 1982	Positive list of constituents of polyethylene in contact with foodstuffs, pharmaceuticals and drinking water
IS 10146: 1982	Polyethylene for its safe use in contact with foodstuff, pharmaceuticals and drinking water
IS 8112: 1989	Specification for 43 grade ordinary Portland cement
IS 4990:1993	Specification for plywood for concrete shuttering work

Any other relevant codes required for the project will be applicable as per the directions of Engineer-in-Charge.

General

Prior to the procurement of Pipes, valves the Contractor shall obtain the Engineer-in-charge approval for the QAP, GAD & Data sheet. Shop inspection, Pressure testing of Pipes, Material testing at manufacturer's testing facility in presence of EIC/Representative of EIC followed by a certificate from the manufacturer's shop testing shall be provided for review by the Engineer-in-charge.

Excavation

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided. The excavation shall include excavation in earth and murrum and others shall be carried out to the correct levels required and specified and no clearance, plus or minus (ie. no overcuts), shall be permitted as per the authority.

Road crossing with the trench less technology / HDD (Horizontal directional drilling): Trench-less technology tunneling work include the laying by hydraulic jacking and smooth controlled

pushing method in all types of soils including hard rock true to the alignment and gradient under running traffic condition as per standards including carrying out the survey work at the site for determining underground cable trenches like telephone, fiber optic cables , water supply pipes , irrigation pipes and resistivity test for finding the soil strata using necessary equipments for completeness of works mobilizing of the machineries and specialized crews at construction site etc, complete in all respects including the excavation of the driven pit and exit pit with proper protection with shoring sheets and ISMB (providing and casting MS cutting edges for front shield and construction thrust bed at designated level as directed by the engineer, necessary dewatering and providing the concrete foundation at the base of the driven pit, crane for holding the pipe and any other machinery, tools , tackle required, construction of the temporary works as per the requirement and approval of the concerned authorities and engineering in charge, as per the scope of work defined.

3. APPURTENANCES

3.1 Scope of Work

This chapter describes the minimum requirements for the provision of valves & valve chambers.

Prior to the procurement of valves, the Contractor shall obtain the Engineer in charge's approval for the QAP, GAD, Data sheet & drawings. General applicable Standards to be applied to the Works under this Section shall be Indian Standards and British Standards or other approved International Standard.

3.2 General

DI Resilient seated sluice valves shall be used as scour valves at following locations as mentioned in the Schecule - B Table-4 of reuse water supply scope. Shop inspection, Pressure testing of valves, Material testing at manufacturer's testing facility in presence of EIC/Representative of EIC followed by a certificate from the manufacturer's shop testing shall be provided for review by the Engineer in charge. Before delivery to Site all working surfaces shall be thoroughly cleaned and if metal protected with grease. The initial charges of oil, grease and similar materials necessary for the correct setting to work and operation of valves and penstocks shall be provided by the Contractor. Packing must be sufficient to ensure complete protection of the fitting during transit

and storage and all valves are to have their openings sealed until installation.

3.3 Installation

All valves, operators and appurtenances shall be installed in accordance with the manufacturer's recommendations and as per the specifications laid for pipe laying, and to the locations indicated on the drawings. The installation shall be true to alignment and rigidly supported. As soon as installation and operating conditions permit, all valves and appurtenances shall be given a field test to be witnessed by the Engineer in charge to demonstrate that they meet all requirements and operating conditions.

Valves shall be rated for PN 16 as minimum working pressure unless elsewhere defined as per the requirement or in tender document.

3.4 Flanges

Valves shall be flanged and the flange face at right angles to the valve centerline. Backside of valve flanges shall be machined or spot faced for proper seating of the head and nut. Flanges shall be machined on faces and edges to IS 6392 or BS 4504 for PN 16 nominal pressure rating unless otherwise required. Flange drilling shall conform to IS 1538.

3.5 Fastener:

Add IS codes and specifications for fasteners.

3.6 Operation

3.6.1 Scour valve

Scour valves shall be provided with extension spindle by contractor with supports for operation from operating level / ground level. All valves shall be protected against corrosion. Provision for indicator tags shall be made for identification / location of valves. Marking shall be either cast on the bonnet or the body and shall show the following:

- Manufacturer's name or mark
- Year of valve casting
- Size of valve

- Designation of working pressure
- Number of turns to open, with the direction of closing clearly indicated on the hand wheel or body as appropriate.

Nuts and bolts shall be of the best quality bright steel, machined on the shank and under the head and nut. Nuts and bolts shall be ISI Marked conform to IS 1363 and IS 1367, unless otherwise specified. Nuts and bolts shall be hot dip galvanized or shall be chromium plated.

3.6.1.1 Construction Scour Valve

The valve shall be constructed as per the arrangement drawing provided in the drawing. GFC drawing shall be provided by the contractor before installation/construction for approval of EIC.

Sluice Valves

3.6.1.2 Constructional Features

The valves shall be resilient seated, bubble-tight, straight and pocket less body passage, inside stem screw and electrostatic epoxy powder (EP-P) coated INSIDE AND OUTSIDE. The face to face dimensions shall conform to provisions of IS 14846/EN 558-1, Basic series F4/BS 5163. All tests shall be carried out as per these standards.

Valves shall be of non-rising spindle type except for the bypass valves. The spindles shall be of such lengths that when the valves are closed the bottom ends of the spindles engage fully in the spindle nuts. The spindle collars of thrust plates shall be concentric and machined, suitable for the specified test pressure. The thickness and bearing of the nut shoulders shall be adequate to resist operating thrusts. Spindles shall be greased and supplied with a cap top. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the 'stub shaft' type, which comprise two separate shafts inserted into the valve disc hub. Valves of 400 mm and above shall be provided with thrust bearing arrangement/Gear Arrangement for ease of operation.

Valve of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N.

Valves spindles and hand wheels shall be positioned to give good access for operational personnel. Hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

Valves shall have two positions marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the seating after moving a further distance equal to the depth of the seating.

The valves shall be so designed that the gates may be removed without removing the bodies from the connecting pipe work. The gate guides shall be cast integrally with the valve bodies and be of adequate strength and of sufficient length to guide the gates throughout their full length of travel. In the fully open positions, the gates shall be fully withdrawn well clear of the stream and the spindles shall not protrude into the bores of the valves.

All Sluice valves shall be open end tested. The Contractor shall provide test certificates for materials, strength and leakage in accordance with BS 5163 / IS 750/International reputed Standards.

3.6.1.3 Materials of Construction

Item	Material of Construction
Body, Dome	Spheroidal Graphite Iron IS 1865 Gr 400/12 or Gr500/7 Ductile Iron DIN 1693-GGG40 / GGG50
Wedge	Spheroidal Graphite Iron IS 1865 Gr 400/12 or Gr500/7 Ductile Iron DIN 1693-GGG40 / GGG50 Rubber Vulcanized with EPDM/
Spindle / Stem	SS : IS 6603 04 Cr17 Ni 12 M0 2 / AISI 316/SS 420
Bonnet Gasket	EPDM
Internal Fasteners	Stainless steel SS316
Nuts, bolts & washers for pipe flanges	High tensile steel Hot dip galvanized
Coating	Internal and external with powder or liquid food grade Fusion Bonded Epoxy(FBE) coating with minimum dry film thickness of 250 microns Or Thermoplastic-Powder Coating Internal/External min 250 microns

3.6.2 Air Valves

Air valves are used to protect the pipe line by filling air during draining, venting air during filling and Continues venting of entrapped air during operation. Air valves should match with the following specifications

3.6.2.1 Specifications:

- Air valve should be Single Chamber
- Body should be made of Ductile Iron ASTM A 536/ EN 1563/ GGG40
- Float should have made with Polypropylene
- Rolling Seal should be made with EPDM
- Gaskets and seals made of EPDM
- Valve should be Epoxy coating both inside and outside
- Flange Drilled as per DIN/ISO/BS/EN 1092

3.6.2.2 Material of Construction

Body (80 – 200 mm)	:	Ductile Iron ASTM A 536/ EN 1563/ GGG 40
Air & Vacuum Float	:	Polypropylene
Rolling Seal	:	EPDM
Automatic Float cover	:	Acetal
O-Ring	:	EPDM
Automatic Float	:	Polypropylene
Discharge Outlet	:	Polypropylene
Bolts and Nuts	:	Galvanized Steel
Body (50 mm)	:	Polypropylene

3.6.3 BUTTERFLY VALVES

3.6.3.1 Constructional Features

The valves shall be with integral body seat and bubble tight shut-off type, suitable for ON-OFF operation. Compatible for motorized operation during selection. Spindle arrangement for the wafer should be horizontal to the ground level.

Butterfly valves should be of double eccentric, design and Vulcanized type generally as per EN 593, API 609, BS 5155 and IS 13095 or any equivalent international standards approved by the end user. Underground Valves on transmission mains which are used

for only isolation purposes shall be provided with stainless steel extension spindle / telescopic arrangement so that valves can be operated from ground level.

Butterfly valves shall be suitable for mounting in any position. The valve shall be free from induced vibrations.

Butterfly valves shall be suitable for bi-directional pressure testing with dead-tight shut off even after long period of operation. The valves shall be of double flanged wafer Short type.

The valve body seat shall be of Vulcanized Rubber design. When the valve is fully closed, the seal shall seat firmly. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

The shaft shall be stainless steel with Bronze or equivalent seal with self-lubricating bearings. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.

All valve spindles and hand wheels shall be positioned to give good access for operational personnel. Valve of diameter 400 mm and above shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be of worm and worm wheel design type, totally enclosed, grease filled and weather proof. The operation with gearing shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. The valve disc shall have a 90-degree turn.

The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.

It should be possible to open the valve with upstream pipe fully filled and downstream pipe empty. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the discs by tapered stainless steel cotter pins.

Valves shall be provided with a continuous mechanical position indicator to show the position of the disc, mounted on the driven shaft end.

Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully open or closed position (i.e. set points).

Valves shall be capable of closing against the maximum flow that can occur in practice. The breakaway torque under maximum differential head conditions shall be within the manufacturer's limits.

All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

3.6.3.2 Features of Construction

The requirement shall be as follow: -

Table 'A'

S. No	Particulars	Required specifications
(A) General requirements		
1	Conforming to double eccen-tric	BS 5155 Generally or IS: 13095/EN 593/API 609
2	Fluid handled	Clear Water
3	Rating	(PN 1.0, 1.6, 2.0 and 2.5) As per design pressure / surge analysis at the point of installation
4	Temperature of fluid	4 to 45 degrees Celsius
(B) Service		
5	Tight shut off	Yes
(C) Modes of operation		
6	Direction of rotation of hand wheel	Clock-wise for closing
7	Orientation of hand wheel w.r.t pipeline	Perpendicular/Horizontal
(D) Type of construction		
8	Flanged or Wafer	Double flanged/Wafer series
9	Face to face dimension	As per BS 5155 or IS: 13095 or AWWA C 504 or EN 593/API 609
10	Whether lifting lugs and mounting feet are required	Yes
11	Valve installation	Horizontal

3.6.3.3 Material of Construction

S. No	Item	Material of construction

(1)	Body and Flanges	Spheroid Graphite Iron IS 1865 Gr 400/12 Ductile Iron DIN 1693/GGG 40/GGG 50
(2)	Disc	Spheroid Graphite Iron IS 1865 Gr 400/12 Ductile Iron DIN 1693/GGG 40/GGG 50
(3)	Shaft	Stainless steel IS :6603 -1972 Grade 316 or AISI 410 or BS 970 Grade 431 S29 Or AISI 420
(4)	Disc Seal Ring	EPDM/Ductile Iron GGG 40/50
(5)	Disc Seal Retaining Ring	Ductile Iron DIN 1693 GGG-40
(6)	Body Seat	Stainless steel AISI 316/ Nickel weld overlay micro finished/ integral micro finished seat with valve body/Vulcanized EPDM Minimum +60 Shore
(7)	Shaft Bearing	Bronze with EPDM `O' ring seal
(8)	Internal Fasteners	Stainless steel SS 316
(9)	Nuts, bolts & washers for pipe flanges	Stainless steel SS 316/Galvanized Steel
(10)	Coating	Internal and external with powder or liquid food grade Fusion Bonded Epoxy coating with minimum dry film thickness of 250 microns.

3.6.4 Electric Actuator

For Sluice/Butterfly valves installed on the Trunk network

Actuators shall be suitable for the medium, climatic, environmental and pressure conditions of the system in which they are to be fitted.

Actuators shall be provided with:

a. AC Electric Motor.
b. Reduction gear unit.
c. Torque switch mechanism.
d. Limit switch mechanism complete with set of limit switches and additional two spare sets for suitable position.
e. Hand wheel, for manual operation.
f. Valve position indicator.
g. Hand-auto lever with suitable locking arrangement.
h. 10 W single phase space heater in the switch compartment.
i. Blinking light throughout the valve operation.
j. Junction box for terminating power and control cables.
k. With additional accessories for integrating with PLC system.

The actuator shall be suitable for operation on 415V, 3 phase, 50 Hz power supply. The

motor winding insulation shall conform to class B as per relevant BS and motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1 1/2 times the required operator torque at the required time cycle of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at actuator end and one at valve end with universal couplings at suitable places. The required number of switch/contacts meet for requirements for PLC system. The electrical actuator for butterfly valves acting as flow controllers shall comprise of the additional necessary electronic card/ accessories required for generating a 4-20 ma signal and for integrating it with the PLC system.

The electric motors shall be of the squirrel cage type as per IS 325 with insulation to IS 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 15 minutes. They shall also be suitable for operating on the specified electric supply and shall satisfactorily open and close the valve under variations of electric supply specified.

Motor shall be protected by suitable overload protection device.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating fed from a 110 Volt control transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be of 650/1100-volt grade PVC insulated stranded copper conductor of minimum 1.5 sq. mm for control circuits and of minimum 4 sq.mm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC insulated/ sheathed, armored cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose proof to IP 67 and shall be fitted with an anti-condensation heater, which shall be switched off when the motor is

running.

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed.

The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during the opening cycle or when the valve is fully open.

The mechanism shall facilitate adjustment of the torque at which the switches are required to operate.

Non-adjustable limit switches shall stop the motor and give indication when the disc has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired value position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to give an indication whether the valve is fully open, fully closed or in an intermediate position.

Settings and emergency operation shall be possible with the use of a hand wheel. The Hand wheel shall be of stainless steel and the drive mechanically independent of the motor drive and any gearing should limit the operating torque at the hand wheel to less than 15 kg and be such as to permit emergency manual operation in a reasonable time. During electric operation, the hand wheel shall not rotate.

Actuators shall be adjusted at the manufacturer's works to ensure that they provide the correct, fully, open position and fully closed position. Mechanical adjustable stops shall be provided to prevent over-travel of the valve in the open and closed positions.

3.7 Inspection and Tests

The following Inspection and Testing procedures shall be carried out for all the equipment as applicable:

(a) Visual Inspection.
(b) Material Certificates for all the specified material shall be furnished.
(c) Welding Qualifications.
(d) Dimension Checking.

(e) Stage Inspections (in process inspection).
(f) Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable.
(g) Operation check.
(h) Liquid penetrating tests or magnetic particle tests for all machined surfaces of pressure parts.
(i) Ultrasonic test for forging materials viz.,
(j) Plates of thickness 20mm and above for pressed / formed parts such as heads, etc.
(k) Plates, flanges and bars of thickness / diameter 40mm and above used for fabrication of pressure and load bearing members and rotating parts.
(l) Radiographic testing for all but welded parts, as per applicable codes.
(m) Hardness tests for all Hardened surfaces.

The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

Requirement of shop tests for Valves are listed below:

(a) During testing, there shall be no visible evidence of structural damage to any of the valve components.
(b) Each valve operated actuator shall be shop-operated at least three times from the fully closed to the fully opened position, and the reverse, under no-flow condition, to demonstrate that complete assembly is workable.

The tests mentioned below shall be hold points and to be witnessed by a duty authorized representative of the Employer:

The following tests shall be carried out for butterfly valves in line with IS 13095:

(a) Seat leakage test. Seat test shall be carried out in each direction and the valve shall be drop tight.
(b) Body hydrostatic test
(c) Disc strength test at body test pressure in each direction.
(d) Valve operation with and without actuator

The following tests shall be carried out for sluice valves in line with IS 14846:

(a) Seat leakage test
(b) Body hydrostatic test
(c) Valve operation

The material certificates, physical properties, heat treatments and shop test certificates of valve body, disc, wedge and shaft shall be duly approved and certified by the manufacturer and these shall be subject to review & approval by the Engineer. Notwithstanding the above requirement for inspection and quality control, the following inspection and quality control measures shall be carried out by manufacturer:

(a) Magnetic particle tests on body and disc/door.

(b) Dye penetration tests on metal seats.

(c) Ultrasonic tests on shafts.

(d) Overload Torque Test shall be carried out on the gear boxes of the valves. The test shall be carried out by applying 1.5 times the rated torque.

3.8 Painting

The Contractor shall be responsible for the cleaning, preparation for painting, and priming or otherwise protecting of all parts at the place of manufacture prior to packing.Parts may be cleaned but surface defects may not be filled in before testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test, all surfaces shall be thoroughly cleaned and dried out if necessary by washing with an approved de-watering fluid prior to surface treatment. Except where the Specification provides to the contrary all painting materials shall be applied in strict accordance with the paint manufacturer's instructions. Protective coatings and painting shall be in line with the Standards for the particular type of valve.

Annexure – I (E)
SEWERAGE NETWORK

1.0 Sewerage Collection Network

Standards and Specifications for the Design and Construction of Sewer Network are given in this section.

2.0 Scope of sewer collection system

The scope of work of includes, Providing, Laying, Testing and Commissioning of Sewer Pipes of HDPE – DWC, Inner HAC lined DI K7 & K9 pipes, Inner HAC lined RCC NP4 pipes and Construction of Manholes along the right of way and crossings of Roads. The road wise sewer network details including Pipe Material, Diameter, Length and Type and Number of Manholes are given in schedule B. In general, this work shall include Earthwork in excavation, providing bedding (Sand/PCC), Supplying, laying, jointing and testing of all pipeline and appurtenances.

This contract package includes supplying, laying, jointing, testing and commissioning of sewers of Pipes of HDPE - DWC and HAC lined RCC NP4 pipes and Construction of Manholes for the various sewer network diameters from 200 mm to 1600 mm in the right of way of above mentioned roads.

This contract package includes supplying, laying, jointing, testing and commissioning of sewers of Pipes of HDPE - DWC and Inner HAC lined DI K7 & K9 pipes with outer polyethylene sleeves, Inner HAC lined RCC NP4 pipes. Inner HAC line DI K9 pipes for Pumping mains. The total length of sewer pipeline is around 17.237 km.

The detailed scope of work includes:

i. Detailed design, Engineering and preparation of GFC including LS, CS, Layout, Plan and CS of Manholes. On approval of design, detailed engineering & drawing from EIC/Competent authority, Contractor shall start execution.

ii. Prior to the procurement of Pipes, the Contractor shall obtain the Engineer in charge's approval for the QAP & Data sheet. Supplying of pipes and specials at sites as per the data sheet.

iii. Prepare a detailed methodology for laying of pipeline and construction of manholes taking into consideration of other utilities along the road and taking into consideration of orientation and levels as given in data sheet and drawings.

iv. Carry out the survey and determine the alignment of sewer pipe line and location of manholes.

v. Laying and Jointing and Testing of HDPE- DWC pipes, HAC lined DI K7 & K9 and HAC lined RCC NP4 class pipes with diameter ranging from 200 mm to 1600 mm, as per the quantities given in Schedule-B.

vi. HDPE-DWC pipes up to 490mm for total length of 10.792 km

vii. Inner HAC lined DI K7 & K9 pipes for total length of 6.095 km and at crossing locations

viii. Inner HAC lined DI K9 pipes for Pumping mains for a length of 0.350 km.

ix. Design and Construction of Manholes considering buoyancy factors.

x. Testing of sewer lines including Manholes as per CPHEEO manual/ relevant IS Codes.

xi. Back filling of trenches up to FGL with consolidation to achieve maximum dry density in layers not exceeding 150mm.

xii. Any work required for safe and satisfactory completion, testing and commissioning of the above works.

xiii. Prepare & Submit "As Built Drawings".

xiv. Removal of defects in all work components during defect liability period.

2.0 Sewer Pipes

2.1 Scope

This Specification covers the requirements for manufacturing, testing, supplying, lowering, laying, jointing, testing at work sites and commissioning of following pipes:
HDPE-DWC pipes (as per IS 16098 Part-2) up to 500 mm diameter

HAC lined DI (K7/K9) as per IS 8329 up to 1200mm diameter and RCC pipes (SRC) (HAC In-lining) (as per IS 458) above 1200 mm diameter.

2.2 Applicable Codes & Standards

The manufacturing, testing, supplying, jointing and testing at work sites of pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern. However, other codes as approved by Authority's Engineer but not specifically mentioned below pertaining to the use of RCC, HDPE DWC Pipes shall form part of these specifications.

Table-1 Applicable Codes

IS Code	Description
IS: 458	Specification for Concrete Pipes (with and without Reinforcement).
IS: 3597	Method of Tests for Concrete Pipes.
IS:432 Part I & II	Specification for mild steel and medium (tensile steel bars and hard drawn steel) wires for concrete reinforcement.
IS: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 783	Code of Practice for Laying of Concrete Pipes.
IS: 516	Method for test for strength of concrete.
IS: 8329	Centrifugally cast (spun) Ductile Iron Pressure pipes for water, gas and sewage.
IS: 9523	Ductile iron fittings for pressure pipes for water, gas and sewage.
IS: 12288	Code of practice for use and laying of ductile iron pipes.
IS: 5382	Specification for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers.
IS:16098 Part 2,	Structured wall plastics pipes for non-pressure drainage and Sewerage specifications
IS:7634 Part 2	Code of practice for Laying and Jointing of High Density Polyethylene pipes (HDPE) piping system.
IS: 2530	Method of test for polyethylene moulding materials and polyethylene Compounds.
IS: 7328	High Density Polyethylene material for moulding and extrusion.
IS: 4905	Method for random sampling.

2.3 HDPE-DWC Pipes

Scope

This Material Specification details the minimum requirements for the pipe procurement of Double Walled Corrugated High-Density Polyethylene (HDPE) pipe and fittings to be used for collection & conveyance of waste water.

Vendor has to substantiate the reason when he is deviating from any of the clause mentioned below and has to get approval for the same. The calculations for wall stress, deflection, buckling, bending stress and bending strain for DWC PE pipe shall be carried out by the vendor. The calculations performed shall be submitted for approval.

Specifications provided in this document is only for pipe procurement up to DN 500. Requirements for Laying, and site inspections are not covered under this specification.

Applicable Standards and Codes

The following codes and standards, to the extent specified herein, form a part of this specification. The latest edition of these codes and standards shall govern the work.

Table-2 Applicable Codes for DWC HDPE Pipes

Code No.	Title/Specification
IS 4905-1968	Methods for random sampling
IS 5382:1985	Specification for rubber sealing rings for gas mains, water mains and sewers (first revision). Type-I & Type-VI
IS 12235	Methods of test for thermoplastics pipes & fittings.
(Part 1): 1986	Method of measurement of outside diameter.
(Part 5):1986	Reversion test
(Part 8):1986	Internal hydrostatic pressure test
IS 16098 Part- 2	Structured wall plastics pipes for non-pressure drainage and Sewerage specifications

Other Codes not specifically mentioned here but pertaining to the use of HDPE-DWC pipes form part of these Specifications.

Pipes and fittings will be designated on the basis of its material/structure wall construction/nominal ID (DN/ID)/nominal ring stiffness, such as PE/DWC/ID/SN as per IS 16098:2013 (Part-2).

Material

The material from which the pipe is produced shall consist substantially of polyethylene (PE), to which may be added only those additives that are needed to facilitate the manufacture of these pipes and fittings confirming to requirement of the standards as per Tables 1, 2, 3 and 4 of IS: 16098

A pipe of fittings with a smooth internal & profiled external surface forming a finished double walled profile shall come under this standard. When sealing rings are retained by means of retaining devices (rings or caps), the devices may be made from polymers, provided they conform to the same functional dimensions and test requirements as applied to sockets with either loose or fixed sealing rings.

The manufacturer 's own rework material conforming to the requirements given in 3.25 of IS: 16098 is permissible. No other rework material shall be used.

Dimensions

Mean inside Diameter

The mean inside diameter, at any point and tolerances shall be as given in Table 5 of IS: 16098 and shall be measured according to the method given in IS 12358 (Part 8).

Wall Thickness

The nominal wall thickness, e, shall be in accordance with Table 5 of IS: 16098. Tolerances in inside diameters shall be those given in IS: 16098.

Length of pipe

Effective length of pipes (Le) with sockets shall be not less than that specified by the manufacturer when measured as shown figure 2 of IS: 16098 2013. The lengths may be supplied as agreed to between the purchaser and the manufacturer.

Dimensions of pipes & spigots of pipes & fittings

The nominal size and minimum mean inside diameter for DN-ID series are specified in Table-5 (16098 Part2). The outside diameters of the DN-ID series pipes and spigots intended to have jointing dimensions as pipes and /or fittings according to this standard shall comply with the outside diameters and tolerances as specified by the manufacturer. However, the guidelines for pipes, spigots and fittings not intended to have jointing dimensions as pipes and /or fittings according to this standard, the tolerances of the outside diameter of pipes and spigots fittings shall be + 0.3mm/ (-) 0.6mm of the nominal size of outside diameter.

Inspection and Testing

The material will be inspected and tested at manufacturers premises by the EIC/representative of EIC prior to the delivery of pipes. The sampling procedure to be adopted and the criteria for conformity shall be as given in IS: 16098. The following tests shall be conducted:

Type Tests

Type tests are intended to prove the suitability, performance of a new technique or a new size of pipe and water tightness. Type testing shall be in accordance with tables 15 to 18 as applicable of IS: 16098 part-2. All tests are to be carried out either in an in-house laboratory or at an authorized third-party laboratory.

Physical Characteristics

Appearance

The structured outer layer of finished pipes and fittings shall be uniformly corrugated. The inner layer shall be smooth and plain. Both layers shall be free from any visual defects such as cracks, blisters, foreign inclusions and any other visual irregularities which may cause harm to its construction integrities. The inner surface may reflect slight shallow undulations. Color of Finished Pipes. The inner and outer layer of pipes and fittings shall be coloured throughout. The outside layer of pipes and fittings should preferably be black, orange brown or grey.

Mechanical Characteristics

The pipes shall be designated in the following nominal ring stiffness classes (SN) based on detailed calculations for wall stress, deflection, bending stress and bending strain.

- DN ≤ 500: SN 8 or SN 16
- The manufacturer ‘s guaranteed minimum stiffness between the SN values, of a component may be used for calculation purposes only. Such pipes shall be classified and marked as the next lower stiffness class.

Ring Flexibility

When tested in accordance with the test method using the indicated parameters, and visually inspected without magnification, requirements in (a) and (b) shall be satisfied during the test and requirements (c) to (d) shall be satisfied after the test.

a) There shall be no decrease of the measured force;

b) There shall be no cracking in any part of the wall structure;

c) There shall be no wall delamination except possible delamination between the outside and inside wall of double wall pipes occurring in reduced welding zone in the ends of test piece. Process aiding profile of material other than the pipe material is not subject to this requirement;

d) There shall be no other types of rupture in the test piece; and

e) Permanent buckling in any part of the structure of the pipe wall including depressions and craters, shall not occur in any direction.

Marking

General

Marking shall be labelled, printed or formed directly on the pipe or fitting, in such a way that after storage, weathering and handling the legibility shall be maintained. Marking shall not initiate cracks or other types of defects which adversely influence the performance of the pipes or the fitting. Minimum Required Marking

Pipes

Each pipe shall be marked at intervals of maximum 3 m, at least once per pipe, with the following information:

- Manufacturer ‘s name/Trade-mark:
- Diameter series, nominal size;
- Stiffness class;
- Material; and
- Lot number/batch number containing information regarding period of manufacture.

Fittings

Each fitting shall be marked with the following information:

- Manufacturer ‘s name/Trade-mark;

- Nominal Angle;
- Diameter series, nominal size;
- Stiffness class;
- Material; and
- Lot number/batch number containing information regarding period of manufacture

The Contractor should submit the following data / certificates regarding HDPE-DWC pipes along with the Qualification bid:

- Brand Name, Manufacturers capacity, previous supply details etc.
- Copy of valid ISO 9000 /14000 accreditation. (If any)
- Copy of valid BIS accreditation for manufacture of HDPE-DWC pipe as per IS 16098 2013.
- Manufacturer ‘s recommendation and Pressure testing procedure.

DUCTILE IRON PIPES

1.1 Scope

This specification covers the requirements for manufacturing, testing, supplying, jointing and testing at work site Ductile iron pipes (Pumping Main - DI-K9) and fittings used for Waste Water pumping. Schedule -B covers the specific requirement for the project.

1.2 Applicable Codes

The manufacturing testing, supplying, jointing and testing at work sites of Ductile Iron pipes and fittings shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless specified herein shall be referred. In all cases, the latest revision of the codes shall be referred to. If requirements of specifications conflict with the requirements of the codes and standards, this specification shall govern.

1.4 References

Code	Description
IS: 8329	Specification for Centrifugally Cast (spun) Ductile Iron pressure pipes for water, gas and sewage specification.

IS: 5382	Specification for Rubber sealing ring for gas mains, water mains and sewers
IS: 638	Sheet rubber jointing and rubber insertion jointing.
IS: 1387	General requirements for supply of metallurgical materials.
IS: 1500	Methods for Brinell hardness test for metallic materials.
IS: 9524	Ductile Iron fittings for pressure pipes for water, gas and sewage.
IS: 12820	Dimensional requirement of rubber gaskets for mechanical Joints and push on joints for use with cast Iron pipes and fittings for carrying water, gas and sewage.
ISO:4179	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining - General requirements.
ISO:2531	Ductile iron pipes, fitting and accessories for pressure pipe lines. Code of Practice
IS: 12288	Code of practice for use & laying of Ductile iron pipes.
IS: 13382	Cast iron specials for mechanical and push-on-flexible joints for pressure pipe lines for water, gas and sewage.

Supply of Material

The General requirements relating to the supply of material shall be as laid down in IS:1387. The material for DI fittings shall conform to IS:9523.

1.4 Manufacturing

The metal used for the manufacture of pipes shall be of good quality, commensurate with the mechanical requirements laid down in 19. It shall be manufactured by any method at the discretion of the manufacturer provided that the requirements defined in this standard are complied with.

The pipes shall be stripped with all precautions to avoid warping or shrinkage defects, detrimental to their good quality. The pipes shall be sound and free from surface or other defects. Pipes showing small imperfections inherited with the method of manufacture, and which do not affect their serviceability, shall not be rejected on that account alone. Minor defects arising out of manufacturing process may be rectified, for example, by welding in order to remove surface imperfections and localized defects which do not affect the entire wall thickness provided that the repairs are carried out in accordance with a written assurance system and the repaired pipes comply with all the requirements of classes K9 and K7 with the approval of the purchaser.

Pipes centrifugally cast shall be heat-treated in order to achieve the necessary mechanical properties and to relieve casting stresses caused due to the method of manufacture and repair work.

If necessary the pipes may be subjected to reheat treatment to ensure that Brinell hardness does not exceed the specified value and the other mechanical properties specified in the standard are achieved.

1.5 Rubber Gasket

Rubber gaskets used with push-on-joints or mechanical joints shall conform to IS 5382.

Material of rubber gaskets for push-on mechanical or flanged joints shall be compatible with the fluid to be conveyed at the working pressure and temperature.

Rubber gaskets for mechanical joint for conveyance of town gas may be suitably protected so that the elastomer does not come in direct contact with the gas.

Rubber gaskets for use with flanged joints shall conform to IS:638.

While conveying waste water the gaskets should not deteriorate the quality of sewage.

1.6 Sampling

Sampling criteria for various tests, unless specified in this standard, shall be as laid down in IS 11606.

The mechanical acceptance tests shall be carried out on samples of ductile iron pipes which shall be grouped in following batch sizes.

DN (mm)	Maximum Batch Size
80-250	200 pipes
300-600	100 pipes
700-1000	60 pipes
1100-1400	40 pipes
1600-2000	30 pipes

In order to check compliance with the requirements specified, a sample ring or bar shall be taken from the spigot end of pipe.

1.7 Mechanical Tests

Mechanical tests shall be carried out during manufacture. One test shall be conducted for every batch of production. The results obtained shall be taken to represent all the pipes of that batch.

1.7.1 Tensile Test

The thickness of the sample and the diameter

Castings Thickness mm	Test Bar. Method A Nominal Diameter mm	Test bar Method B		
		Nominal Area S_o mm^2	Nominal Diameter mm	Tolerance on Diameter mm
Centrifugally Cast Pipes				
- less than 6	2.5	5.0	2.52	0.01
-6 up to but not including 8	3.5	10.0	3.57	0.02
- 8 up to but not including 12	5.0	20.0	5.05	0.02
- 12 and over	6.0	30.0	6.24	0.03

A Sample shall be cut from the spigot end of the pipe. This sample may be cut perpendicular to or parallel with the pipe axis, but in case of dispute the parallel to axis sample shall be used.

Test Specimen: A test bar shall be machined from each sample to be representative of the metal at the mid-thickness of the sample, with a cylindrical part having the diameters given in Data sheet.

The test bars shall have a guage length at least five times the nominal test bar diameter. The ends of the test bars shall be such that they will fit the testing machine.

Two methods of measuring the tensile strength may be used at the manufacture's option:

Method A - Machine the test bar to its nominal diameter + 10 percent, measure the actual diameter before the test with an accuracy of 0.01 mm and use this measured diameter to calculate the cross-sectional area and the tensile strength; or:

Method B - Machine the test bar to its nominal area So within a specified tolerance on diameter (see19.1.2) and use the nominal area to calculate the tensile strength.

Equipment and Test Method: The sample shall be tested as per procedures laid down in IS 1608. The tensile testing machine shall have suitable holders or grips to suit the test bar ends so as to positively apply the test load axially.

1.7.2 Brinell Hardness Test

When tested in accordance with IS 1500, the Brinell hardness shall not exceed 240 HP on the external un-machined surface.

1.7.3 Retest

If test piece representing a batch fails in the test in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same batch. If both the test results satisfy the specified requirements, the batch shall be accepted. Should either of these additional test pieces fail in the test, the batch shall be deemed as not complying with this standard.

1.7.4 Hydrostatic Test

All pipes shall be tested hydrostatically at a pressure specified in Table. To perform the test, pressure shall be applied internally and shall be steadily maintained for a period of 10s. The pipes shall withstand the pressure test and shall not show any sign of leakage, sweating or other defects of any kind.

It is recommended that the Hydrostatic test pressure at works ‘p’ be expressed in MPa as a function of the coefficient K be calculated using the following formulae:

For DN 80 to 300 $p = 0.05 (K+1)^2$

For DN 350 to 600 $p = 0.05 (K)^2$

For DN 700 to 1000 $p=0.05 (K-1)^2$

For DN 1100 to 2000 $p = 0.05 (K-2)^2$

When pipes are required to be tested for higher pressure, the test pressures are subject to agreement between the purchaser and the manufacturer at the time of enquiry and order.

Test shall be carried out before the application of surface coating and lining.

Nominal Diameter (DN) Mm	Minimum Hydrostatic Test pressure at Works, MPa				
	Centrifugally cast pipes with flexible joints		**Pipes with Screwed or welded on flanges**		
	Class K7	**Class K9**	**PN10 Flange**	**PN16 Flange**	**PN25 Flange**
80 to 300	3.2	5.0	1.6	2.5	3.2
350 to 600	2.5	1.0	1.6	2.5	3.2
700 to 1000	1.8	3.2	1.6	2.5	3.2
1100 to 2000	1.2	2.5	1.6	2.5	2.5

1.8 Sizes

The standard nominal diameters DN, of pipes and flanges followed in this standard are as follows: 150, 200, 250, 300, 350, 400, 450, 500, 600, 700, 4000, 800, 900, 1000 mm.

1.9 Dimensions

Length: The standard working length of socket and spigot pipes shall be 4m, 5m, 5.5m and 6m and for flanged pipes shall be 4m, 5m and 5.5 m other lengths are available by agreement between the manufacturer and the purchaser.

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per the relevant tables of IS.8329/IS:9523 for different class of pipes and fittings. The tolerances for pipes and fittings regarding dimensions and deviations from straight line in case of pipes shall be as per relevant IS codes. The standard weight of uncoated pipes and fittings and the permissible tolerances shall be per relevant IS codes.

1.10 Tolerances

1.10.1 Diameter

External Diameter: The values of the external diameter (DE) of the spigot end of socket and spigot pipes and when measured circumferentially using a diameter tape shall confirm to the requirements specified. The positive tolerance is +1 mm and applies to all thickness classes of pipes.

The negative tolerance of the external diameter depends on the design of each type of joint and maximum negative tolerance is specified in this standard.

EXTERNAL DIAMETER DE (mm)

DN	Nominal	Tolerance
100	118	+1, -2.8
125	144	+1, -2.8
150	170	-1, -2.9
200	222	+1, -3
250	274	+1, -3.1
300	326	+1, -3.3

1.10.2 Tolerance on Ovality

Pipes shall be as far as possible circular internally and externally. In case of oval spigot ends for push on joints (DE), the minor axis is permitted to be less than the minimum allowable diameter by the value given below provided the mean diameter DE measured by circumferential tape, comes within the minimum allowable dimensions of DE after applying the tolerance.

Table-1: Allowable Ovality for Push-on-Joint Pipes.

Nominal Diameter DN mm	Allowable Difference Between Minor Axes and DE, Min mm
80-300	1.0
350-600	1.75
700	2.0
4000-800	2.4
900-1000	3.5
1100-1200	4.0
1400 to 1600	4.5

Tolerance on Thickness: The tolerance on the wall thickness (e) and the flange thickness (b) of the pipes shall be as follows:

Dimensions	Tolerance, mm
Wall Thickness (e)	- (1.3 + 0.001 DN)
Flange thickness (b)	+ (2 + 0.05b)

The tolerance given is subject to minimum thickness against Classes K7 and K19 given. No limit for the plus tolerance is specified.

Tolerance on Length: The tolerance on length of pipes shall be as follows:

Type of Casting	Tolerance, mm
Socket and spigot and plain ended pipes	+ 100
Flanged pipes	+ 10

1.12 Coating

1.12.1 Pipes shall be normally delivered internally and externally coated.

1.12.2 Internal Linings: By agreement between manufacturer and the purchaser, the following lining may be applied depending on the internal conditions of use:

- ✓ Portland cement (with or without additives) mortar, as included in Annex A.
- ✓ Blast furnace slag cement mortar as included in Annex A.
- ✓ High alumina (calcium aluminate) cement mortar as included in Annex A.
- ✓ Cement mortar with seal-coat: as included in Annex A.
- ✓ Bituminous paint as included in Annex B.

1.13 Quality Assurance System

The manufacturer shall control the quality of the product during their manufacturing process by a system of process control in order to comply with the technical requirements contained in this standard. Wherever possible, statistical sampling techniques should be used to control the process so that the product is produced within the specified limits.

1.14 Marking

Each pipe shall be marked with the logo of ADC along with month and year of Work Order. Each pipe shall have as cast or stamped or legibly and indelibly painted on it with the following appropriate marks.

h. Indication of the source of manufacture;
i. The nominal diameter;
j. Class reference;
k. The last two digits of the year of manufacturer;
l. The non-standard length of the pipe if specially ordered;
m. Where applicable, an indication of length over which the pipe is suitable for cutting on site; and
n. A short white line at the spigot end of each pipe with push-on joint in sizes DN 700 and above, to indicate the major axis of the spigot.

Marking may be done:

iii. on the socket faces of pipe centrifugally cast in metal mould, and
iv. on the outside of the socket or on the barrel of pipe centrifugally cast in sand mould.

BIS certification Marking:

The pipes may also be marked with the Standard Mark:

The use of Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made there under. The details of conditions under which license for the use of Standard Mark may be granted to the manufacturers or producer may be obtained from the Bureau of Indian Standards.

1.15 Jointing

Jointing of DI pipes and fittings shall be done as per the requirements of specifications and as per the relevant IS code. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. In case, rubber sealing rings/gaskets are used for Jointing these shall conform relevant IS codes.

1.16 Spigot and Socket Pipes

The Spigot and socket pipes and DI fittings shall have push on joints as specified in IS code/ as recommended by manufacturer. The gaskets/sealant used for push on joints/flanged joints shall be suitable for Waste water conveyance. In jointing Ductile iron spigot and socket pipes and fittings with tyton flexible joints the contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per relevant IS code is correctly positioned in line, before the joint is

made. The rubber rings and any recommended lubricant shall be obtained only through the pipe supplier or as otherwise directed by engineer.

1.17 Flanged Pipes

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS:638 of thickness between 1.5 to 3 mm suitable for Waste water conveyance and as specified by manufacturer. The fibre board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness. Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified. They shall be coated with coal tar epoxy coating after tightening.

1.18 Cleaning of Pipes and Fittings

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by Owner/Engineer to prevent entry of mud or silt etc. If as a result of the removal of any obstructions Owner/Engineer considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by Owner / Engineer.

1.19 Specials for Ductile Iron Pipes

This section covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton joints to be used with Ductile Iron pipes with flanged and Tyton jointing system.

1.19.1 Types of specials

The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523.

- flanged socket
- flanged spigot
- double socket bends (90^0, 45^0, 22 $1/2^0$, 11 $1/4^0$)

- double socket branch flanged tee
- all socket tee
- double socket taper
- blind flange/dummy flange

1.19.2 Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

1.19.3 Lubricant for ductile iron pipes and specials

1.19.3.1 General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

1.19.3.2 Specification

The lubricant has to have the following characteristics:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non-toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf live not less than 2 years

Acceptance tests

They shall be conducted in line with the provisions of the IS 9523

EXCAVATION

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided. The excavation shall include excavation in earth and murrum and others shall be carried out to the correct levels required and specified and no clearance, plus or minus (ie. no overcuts), shall be permitted as per the authority.

Road crossing with the trench less technology / HDD (Horizontal directional drilling): Trench-less technology tunneling work include the laying by hydraulic jacking and smooth controlled pushing method in all types of soils including hard rock true to the alignment and gradient under running traffic condition as per standards including carrying out the survey work at the site for determining underground cable trenches like telephone, fiber optic cables , water supply pipes , irrigation pipes and resistivity test for finding the soil strata using necessary equipments for completeness of works mobilizing of the machineries and specialized crews at construction site etc, complete in all respects including the excavation of the driven pit and exit pit with proper protection with shoring sheets and ISMB (providing and casting MS cutting edges for front shield and construction thrust bed at designated level as directed by the engineer, necessary dewatering and providing the concrete foundation at the base of the driven pit, crane for holding the pipe and any other machinery, tools , tackle required, construction of the temporary works as per the requirement and approval of the concerned authorities and engineering in charge, as per the scope of work defined.

1.19.4 Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

1.20 Testing at Work Site

After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Engineer shall be subjected to pressure

test and leakage test as per relevant BIS codes. Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until atleast two days, have elapsed. Each section of' the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made plugs inserted after the tests have been completed.

The duration of test shall be 8 hours. No pipe installation shall be accepted until the leakage is less than the number cm3/hr as determined by the formula:

$$QL = \frac{ND\sqrt{P}}{3.3}$$

Where, QL = the allowable leakage in cm3/hr

N = number of joints in the length of the pipeline.

D = diameter in mm, and

P = the average test pressure during the leakage test in kg/cm2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to Owner/Engineer until the leakage is within the specified allowance. Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to Owner/Engineer. Water used for testing shall be removed from the pipe and not released in the excavated trenches. After the tests mentioned above are completed to the satisfaction of Owner/Engineer, the backfilling of trenches shall be done as per specifications in layers.

Field Hydrostatic Testing

The entire pipeline shall be subjected to a hydraulic test as follows, to the required test pressure as per Annexure E of IS: 8329 and as per the procedure laid down in IS: 12288. The completed pipeline may be tested either in one length or in sections; the length of section depending upon:

1) availability of suitable water,

2) number of joints to be inspected, and

3) difference in elevation between one part of the pipeline and another

Where the joints are left uncovered until after testing, sufficient material should be backfilled over the centre of each pipe to prevent movement under the test pressure. It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1.5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section undertest should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

The test pressure to be applied should be not less than any of the following:

- The maximum pressure, sustained operating
- The maximum static pressure plus 5N/mm2, and
- The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions. The length of this period of time depends on many factors such as slight movement of the pipeline under pressure whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized up to the full test pressure and the section under test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point. In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipeline because of expansion of water during the high day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much high pressure. However, sufficient care

should be taken to prevent floating bulging of the pipeline because of building up of such high pressure during the temperature rise.

If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section undertest should be sub-divided and each part tested separately.

After all sections have been joined together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the maximum sustained operating pressure or the maximum static pressure of the pipeline and, during the test, inspection made of all work which has not been subject to section tests. During the test, the pressure at the lowest point in the pipeline should not exceed the maximum hydraulic field test pressure. It is important to ensure that proper arrangements are made for the disposal of water from the pipeline after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, heavily chlorinated water, some treatment may be necessary before final disposal.

1.21 Measurement

All pipes shall be measured according to the work actually done and no allowance will be made for any waste in cutting to the exact length required. Pipes and fittings shall be described by their internal diameter and length measured in running meters. The measurement shall be taken along the centre line of pipe excluding fittings which shall be measured separately. The lengths of pipes shall not include the portion of spigots within the sockets of fittings and pipes.

The rate for providing, laying and jointing of DI pipes and fittings shall be deemed to include the cost of jointing material and testing at work site.

Notes

If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified, Contractor shall be held responsible for the same and shall replace the damaged pipeline and retest the same at his own cost of the full satisfaction of Engineer. Water for testing of pipeline shall be arranged by Contractor at his own cost.

Annexure A

CEMENT MORTOR LINING

Materials

Cement: For internal lining of Ductile Iron pipes either blast furnish slag cement / ordinary Portland cement may be used. The type of cement to be used is to be mutually decided between the purchaser and manufacturer. Nominal recommendations are:

Portland cement (as per IS 8112 or IS 455) mortar lining perform rather well and have an expected life of approximately 50 years in soft water with moderate amount of aggressive CO2 and when pH is within 6 to 9. Longer service life can be obtained by increasing the mortar lining thickness.

Where cement mortar lining may be exposed to sulphate attack, ordinary Portland cement should be replaced by sulphate resisting Portland cement (as per IS 12430 or IS 6909). The sulphate concentration limit for sulphate resisting Portland cement is approximately 3000 mg/litre, the same as blast furnace slag cement which naturally possess a good resistance to sulphate attack. For sea water transmission blast furnace slag cement which has C, A content below 3 percent can be used.

High alumina cement (as per IS 6452) mortar lining is suitable for continuous use of pH between 4 and 12 and no severe damage occur after occasional exposure to pH 3 to 4 and 12 to 13.

Sand: The sand used shall have a controlled granulometric distribution from fine to coarser elements; it shall be clean and shall be composed of inert, hard, strong and stable granular particles.

The fine fraction comprising particles passing through a sieve of aperture size 0.125mm shall not be more than 10 percent by mass.

The fraction comprising grains upto a maximum diameter equal to one third of the normal thickness of the mortar lining shall not be less than 50 percent by mass.

The corsest fraction (Comprising particles which do not pass through a sieve of the aperture size closest to half the normal thickness of the mortar lining) shall not exceed 5 percent by mass.

Water: The water used for the preparation of the mortar shall not contain substances deleterious to the mortar nor to the water it is eventually intended to transport in the pipe. The presence of solid mineral particles is, however, admissible provided that these requirements are still fulfilled.

Mortar: The mortar of the lining shall be composed of cement, sand and water.

Additives, which shall be specified, may be used, provided that they do not prejudice the quality of the coating and that of the transported water.

The mortar shall be thoroughly mixed and shall have a consistency which results in a dense and homogeneous lining.

The mortar shall contain by mass at least one part of cement to 3.5 parts of sand.

Application of the lining: The cement mortar lining at work is applied by a centrifugal spinning process or a centrifuged sprinkler or a combination of both methods.

Apart from the inner surface of the joint, the parts of the pipe coming into contact with the transported water shall be entirely covered with mortar.

Once centrifuging is finished, the lining shall be cured at temperatures greater than 4o C. Any loss of water from the mortar by evaporation shall be sufficiently slow so that hardening is not impeded.

Repair of Lining: Repairs to damaged or defective areas are allowable. The damaged mortar shall first be removed from these areas. Then the defective part shall be repaired by using, for example, a trowel with fresh mortar so that a continuous lining having a constant thickness is again obtained.

For the repair operation, the mortar shall have a suitable consistency, if necessary; additives may be included to obtain good adhesion against the side of the existing undamaged mortar.

Thickness of the lining: The normal thickness of the lining and the minimum permissible mean and local values are given in the Table A.

At the pipe ends, the lining may be reduced to values below the minimum thickness. The length of the chamfer shall be as small as possible but, in any case, shall be less than 50mm.

Determination of lining thickness: The thickness of the lining is checked on the freshly centrifuged mortar by the insertion of a steel pin, or on the hardened mortar by means of a non-destructive method of measurement. The thickness of the lining shall be measured at both ends of the pipe in at at least one section perpendicular to the pipe axis.

Surface Condition of the Hardened lining: The surface of the cement mortar lining shall be uniformly smooth. Only isolated grains of sand are allowed to appear on the surface of the lining.

The lining shall be such that it cannot be dislodged with pressure of hand and shall be free from corrugations or ridges that could reduce the thickness of the lining to less than the minimum value at one point, as specified in the Table B.

Table-A Thickness of the Lining

DN (mm)	Thickness (mm)		Maximum Crack Width / Radial Displacement
	Nominal Value	Tolerance	
80 to 300	3.0	-1.5	0/8
350 to 600	5.0	-2	1/0
700 to 1200	6.0	-2.5	1/2
400 to 2000	9.0	-3	1/5

Table-B Minimum Bore Clearance Cement

Mortar Lining of Ductile Iron Pipe

DN	Minimum Bore of Cement Mortar Lined Pipe (mm)
80	67.0
100	87.0
150	137.0
200	247.0
250	247.0
300	287.0

On contraction of the lining, the formation of cracks cannot be avoided. These cracks, together with other isolated cracks which may result from manufacturer or may develop during transportation, are acceptable up to a width given in the above.

Seal Coat:

General: When specified the cement lining shall be given a seal-coat of bituminous material or any other epoxy based material compatible with cement mortar lining. Other seal-coat materials may be used, but they shall be agreed on at the time of purchase and shall be specified on the purchase order.

The purpose of seal-coat is to minimize lime leaching of the cement mortar as well as to restrict the unwanted rise in pH value of the transmitted water.

When the pipes are to be used for conveying potable water the inside coating shall not contain any constituent soluble in such water or any ingredient which could impart any taste or whatsoever to the potable water after sterilization and suitable washing of the mains.

RCC (SRC) NP4 Pipes with HAC in lining Manufacturing

SCOPE

This Material Specification details the minimum requirements for the pipe procurement of Reinforced Cement Concrete (RCC) non-pressure pipes shall be as per IS 458. Specifications provided in this document is only for pipe procurement. Requirements for Laying, and site inspections are not covered under this specification.

ALIGNMENT AND GRADE

The sewer pipe shall be laid to alignment and gradient shown in the drawing. The alignment as proposed should be marked on ground with a line of white chalk and got approved from Engineer In-Charge. The contractor will the prepare an L-Section along this alignment showing the location of proposed pipeline.

APPLICABLE STANDARDS AND CODES

The manufacturing, testing, supplying of pipes shall comply with all currently applicable statutes, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of

the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern.

Table-3 Applicable Codes for RCC Pipes

IS Code	Description
IS: 458	Specification for Concrete Pipes (with and without Reinforcement).
IS: 3597	Method of Tests for Concrete Pipes.
IS: 432 Part I & II	Specification for mild steel and medium (tensile steel bars and hard drawn steel) wires for concrete reinforcement.
IS: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 783	Code of Practice for Laying of Concrete Pipes.
IS: 516	Method for test for strength of concrete.
IS: 5382	Specification for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers.
IS: 4905	Method for random sampling.

*Latest revisions of all codes shall be followed

DESIGN

Design of RCC pipes, details of reinforcement and the ends of the pipe shall be in accordance with the relevant clauses of IS: 458.

Manufacturing

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

ENGINEER-IN-CHARGE shall at all reasonable times have free access to the places where the pipes and rubber rings are manufactured for the purpose of examining and testing the pipes and rubber rings and of witnessing the test and manufacturing.

All tests shall be performed by Supplier / Contractor at his own cost and in presence of EIC/Representative of EIC, if desired. For this, sufficient notice before testing of the pipes shall be given to EIC/Representative of EIC.

If the test is found unsatisfactory, EIC/Representative of EIC may reject any or all pipes of that lot. The decision of ENGINEER-IN-CHARGE in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

Lining using High Alumina Cement Mortar

General:

The main purpose of using High Alumina Cement for lining is to protect the pipe against sulphate attacks when it is used in sewer lines. All reinforced concrete pipes shall be of spun concrete and lined with a 12mm thick High Alumina lining. (Test procedure for measuring thickness to be as per the relevant standard IS codes-latest revision.

The normal proportion of the mix shall be as follows:

1. High Alumina cement - one part - as per IS: 6452
2. Granite dust passing through IS sieve 150 microns - one part
3. Fine aggregate passing through IS sieve 1.18mm as per IS 383
4. Water cement ratio of the lining mix shall not be more than 0.35 and shall be sufficient to ensure maximum density.

Process of Manufacture: The pipes shall be made by spinning process. The centrifugal force generated by spinning action will force the concrete against the mould, removing excess resulting in a dense concrete. The mix for High alumina cement lining shall be mixed in small separation mixer. All the ingredients shall be weighed. As soon as the spinning of pipe is completed, the cement mortar shall be fed into the rotating mould uniformly and the pipe shall be spun until the cement mortar is set.

Precaution to be taken for high alumina lining:

1. It is not desirable to mix and do the lining in high constant temperature (temperatures more than 400 degrees.
2. Steam curing should not be used for curing pipes.
3. The high alumina lining shall be kept moist and cool for the first 24 hours. The curing of lining shall be started after 3 to 4 hours after operation.
4. The water cement ratio of the lining shall not be more than 0.35

Materials: For all materials, Factory's test result and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the ENGINEER-IN-CHARGE before carrying to sites.

Cement: Portland cement shall be used for the manufacture of RCC pipes and fittings and shall conform to relevant IS codes.

Aggregates: Aggregates used for the manufacture of RCC pipes shall conform to IS: 383. The maximum size of aggregate should be 10mm for pipes of internal diameter 150 to 250mm but should not exceed one third thickness of the pipe or 20mm, whichever is smaller, for pipes of internal diameter above 250mm.

Mixing and Curing Water: Water used for mixing of concrete and curing of pipes shall conform to IS: 456. Water shall be clean, colorless and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. CONTRACTOR shall submit water quality report before using it.

Reinforcement: Reinforcement used for the manufacture of the spigot and socket RCC pipes shall be mild steel Grade I or medium tensile steel bars conforming to IS: 432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). A reinforcement cage for pipes shall be as per relevant requirement of IS: 458.

Concrete: Concrete used for the manufacture of spigot and socket RCC pipes shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458 and IS: 456. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

Curing: Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

Workmanship and Finish

Pipes shall be straight and free from cracks except that craze cracks may be permitted. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3mm in pipes up to 600mm diameter (inclusive), and 6mm in pipes larger than 600mm diameter. The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash. The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or molding.

The pipes shall be free from local dents or bulges greater than 3.00 mm in depth and extending over a length in any direction greater than twice the thickness of barrel. The

deviation from straight in any pipes throughout its effective length, tested by means of a rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters, 3 mm for every meter run.

Dimensions and Tolerances

The internal diameter, wall thickness and length of barrel, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS: 458.

The following tolerances shall be permitted:

Table-4 Tolerances

Dimensions	Tolerances
Overall length	± 1 % of standard length
Internal diameter of pipes:	
Up to and including 300 mm	± 3 mm
Over 300 mm and up to and including 600 mm	± 5 mm
Over 600 mm	± 10 mm
Barrel wall thickness:	
Up to and including 30 mm	+ 2 mm
	- 1 mm
Over 30 mm up to and including 50 mm	+ 3 mm
	- 1.5 mm
Over 50 mm up to and including 65 mm	+ 4 mm
	- 2 mm
Over 65mm up to and including 80 mm	+ 5 mm
	- 2.5 mm
Over 80 mm up to and including 95 mm	+ 6 mm
	- 3 mm
Over 95 mm	+ 7 mm
	- 3.5 mm

Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.

During manufacture, tests on concrete shall be carried out as per IS: 458. The manufacturer shall supply, when required to do so by ENGINEER-IN-CHARGE the results of compressive tests of concrete cylinders or cubes made from the concrete used for the pipes. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with Clause 10.1 of IS: 458 and tested in accordance with the methods described in IS: 3597.After laying and jointing of pipe is completed the pipe line shall be tested at work site as per following specifications and as directed the EIC.

Sampling and inspection

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Specification shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot shall be in accordance Table 22 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every "rth" pipe be selected till the requisite number is obtained, "r" being the integral part of N/n where "N" is the lot size and "n" is the sample size.

All the pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

A lot shall be considered as conforming to the requirements of IS: 458 if the following conditions are satisfied.

The number of defective pipes (those not satisfying one or more of the requirements for dimensions, finish and deviation from straight) shall not be more than the permissible number given in Column 3 of Table 22 of IS: 458.All the pipes tested for various tests as per IS: 3597 shall satisfy corresponding requirements of the tests.

All result of tested data must be prepared by Contractor at site so that the ENGINEER-IN-CHARGE shall make decision of "fail or pass" at once. All cost for the test shall be borne by the Contractor.

Marking

The following information shall be clearly marked on pipe.

Name of manufacturer:

Class and size of pipe;

The words "SPUN PIPE" may be applicable, for Socket and Spigot pipes: and

Date of manufacture.

Marking shall be clearly marked on outside only for pipes up to and including 350mm internal diameter & both outside and inside for pipes above 350mm internal diameter. The information shall be clearly marked on the outside of pipes. Each pipe may also be marked with the Standard Mark.

Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes lay lengthways and crosswise in alternate layers. The height of the stock shall not exceed 1.5 m. Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals.

Steel Plate Shoring

Where the subsoil conditions are expected to be of a soft and unstable character in trench/pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Employers Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer Engineer's Requirements.

Bedding

For RCC (NP4 class) pipes bedding shall be of PCC with M10 Grade concrete. Bedding shall be designed considering the required external loading conditions, geotechnical requirements such as sub soil and bearing capacity of soil encountered in respective sewer line, type, class and material of pipe used for the laying purposes as per CPHEEO manual.

Manhole

Construction

The construction of RCC manholes shall be by Cast In-situ of Circular in shape or approved type Pre-Cast RCC, constructed using form vibrators of standard type, using SRC/PPC/PSC Cement. The type of manhole to be constructed shall be as approved by EIC, Contractor shall take prior approval for the Design and Process of manufacture of

the Pre-cast RCC manholes, the type of vibration for compaction of concrete for precast manholes shall be invariably of form or table vibrator type.

The work of Cast In-situ RCC manholes includes,

a). Providing and constructing of M-30 Grade of Cement Concrete foundation using approved quality aggregates of 40mm and downsize with an offset as given in the drawings.

b). Providing and laying Plain cement concrete of grade M-10 for beds of manholes etc., using 20 mm nominal size graded stone aggregate including laying, tamping, etc. for a depth, as per drawings, with water proof compound for top plaster in CM 1:3 curing and smooth finishing for exposed faces with necessary centering and form work etc., complete as per specification, drawing and as directed by the EIC.

c). Providing and laying cement concrete of grade M-30 proportion for vertical walls using 20 mm nominal size graded stone aggregate including laying, tamping, mixing of required quantity of water proof compound for everyone bag of cement for plastering in CM 1:3 curing and smooth finishing for exposed faces with necessary centering and form work etc., complete as per specification, drawing and as directed by the EIC.

d). Providing and constructing benching with Cement Concrete of grade M-15 to the dimensions as on drawings with 1: 12 slope in the concrete towards the central drain, plastered with CM 1:3 proportion, 20mm thick and finished with smooth coat of neat cement and fixing of inlet and outlet sewers in the walls with the internal periphery protected with an arch M-15 grade Cement Concrete with graded metal of 10 mm to 20 mm size.

e). Providing and laying cement concrete of grade M-30 proportion with 12mm to 20mm I.S.I gauge of approved gradation hard broken granite/aggregate including cost and conveyance of all materials with wood or steel shuttering form work including machine mixing, centering form work, scaffolding, tamping, vibrating , curing and smooth finish with CM 1:3, 12mm thick for inside surface for RCC Covering Flat Slab with all lead and lifts, etc. complete as per drawing, specification and as directed by the EIC.

f). Providing, Supplying and fabricating of TMT (Fe-415) reinforcement steel of all sizes, including straightening, cutting, bending, hooking, lapping and/or welding wherever required, placing in position, tying with binding wire of approved quality and gauge including the cost of binding wire and anchoring to adjoining members wherever

necessary including all laps and wastages etc., with all lead and lifts, complete as per design, specification and directed by EIC.

g). Manholes shall be provided with CI rung ladder with epoxy painting having diameter 16mm at a spacing of 300mm and providing and fixing of circular steel fiber reinforced concrete (SFRC) manhole frame and covers of not less than 560 mm diameter conforming to IS 12592 and the payment for providing of SFRC manhole frame and covers shall be paid separately as per quoted rate for the item in bill of quantities.

h). The RCC Manhole cost includes all materials, steel, curing, pouring tar over MH frame and cover, cost of tar, engraving manhole number and flow direction on the inner surfaces etc., with all lead and lifts, finishing etc. complete. The cement used for the construction of RCC manhole and internal & external plastering works of manholes shall be of sulphate resisting cement /PPC/PSC only.

The work of construction of Pre-cast RCC manhole includes,

a). Providing & laying mechanically mixed cement concrete of M-15 grade with stone aggregate (with 20 mm nominal size graded stone aggregate) in benching, Neat cement punning over PCC benching, as given in the drawings.

b). Construction of approved type vibrated Pre-Cast RCC Manhole Chambers constructed using Sulphate resistant Cement /PPC/PSC& form vibrator of standard type for Circular Manhole Chambers of various internal dia. (as indicated in BOQ) at bottom and 0.56 dia. at top made up of pre-cast monolithic base, modular riser and top cone in M-30 grade concrete placed & aligned to provide vertical sides, with ring rubber gasket at each joint, water tight & adjustment rings over top cone, complete and all connections shall have, a water tight seal between the pipe and the manhole complete as per standard design & drawing.

c). Providing, Supplying and fabricating of TMT (Fe-415) reinforcement steel of all sizes, including straightening, cutting, bending, hooking, lapping and/or welding wherever required, placing in position, tying with binding wire of approved quality and gauge including the cost of binding wire and anchoring to adjoining members wherever necessary including all laps and wastages etc., with all lead and lifts, complete as per design, specification and directed by Engineer.

d). Manholes shall be provided with CI rung ladder with epoxy painting having diameter 16mm at a spacing of 300mm and providing and fixing of heavy duty circular steel

fiber reinforced concrete (SFRC)/Plastic fiber reinforced concrete (PFRC)/Polypropylene fiber reinforced concrete(PPFRC) manhole frame and covers of not less than 560 mm diameter conforming to IS 12592

f). The RCC Manhole cost includes providing danger lighting & use of sight rails & boning roads shoring & strutting wherever required, including sand bedding, watering, curing, cost of all materials, labor, supply & fabrication of steel, pouring tar over MH frame and cover, cost of tar, engraving manhole number and flow direction on the inner surfaces etc., with all lead and lifts, finishing etc. complete. The cement used for the construction of RCC manhole and internal & external plastering works of manholes shall be of sulphate resisting cement only, confirming to IS:12330/PPC/PSC.

Testing

All RCC Manholes and pipe lines shall be tested as in specifications CPHEEO Manual on Sewerage and Sewage Treatment (latest edition), Relevant IS code (latest edition) for Testing and commissioning.

Measurement & Payment

The depth of manhole shall be measured from the top of cover to the invert level of the deepest outgoing sewer from the manhole. The quoted rate for the Manholes for various depths as per the specifications and drawings shall include the cost of sulphate resisting cement/PSC/PPC, bedding concrete, benching concrete, plastering, footsteps, fixing SFRC manhole frame with cover, dewatering to keep the manhole dry until final testing etc. complete.

The Rates for any fractional variation (increase or decrease) in the depth of the manhole on decimeter basis, shall be paid as per actual, by adding the difference in rates between the immediately preceding and succeeding depths of such fractional depth of manhole on linear basis.

Drop manhole:

In a manhole, wherever the difference between the invert level of downstream sewer and the invert level of the upstream sewer is greater than 60 cm, a drop manhole shall be provided at that position. The locations and construction of the drop manholes shall be provided as on drawings.

Depending upon the sewer material, the drop arrangement pipe shall be suitably supported with MS fasteners at 300 mm c/c. for diameters pipe line as per Bill of Quantities, construction drawings and as directed by EIC, specials conforming to IS:1729 shall

be used for providing the drop in the manhole & a suitable expander/reducer T-Joint at the top with incoming sewer and 45 degree bend at the bottom with similar incoming sewer pipe specials to the direction of flow in the receiving sewer. The benching concrete in the manhole should surround the joint of the terminating bend and a neat channel shall be made in the benching concrete to direct the flow to the receiving sewer. A continuation of the incoming sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with half blank flange as on drawing. The drop manhole arrangements shall be tested along with sewer lines.

Table-5 Relevant Standards and Specifications:

S. No.	Code or Standard	Description
1	Manual for Water Supply & Treatment	CPHEEO Manual for Water Supply & Treatment – 1999-MoUD, GoI
2	Manual for Sewerage and Sewerage Treatment Plants.	CPHEEO Manual for Sewerage – 2013-MoUD, GoI
3	SP 7 (Part-9 Section-1) 1983	National Building Code of India
4	SP 35:1987	Hand book on water supply & drainage
5	IS 1172 :1993	Code of Basic requirements for water supply, drainage and sanitation
6	IS. 3370 Part I to IV	Code of practice for concrete structure for the storage of liquids
7	IS 456-2000	Code of Practice for plain and reinforced concrete
8	IS 1893-2002 part I to V	Criteria for earthquake –resistant design of structures
9	IS 13920-1993	Detailing of reinforced concrete Structures subjected to seismic forces
10	IS 1992-1969 / IS 6403-1971	Code for exploration to find the safe bearing capacity
11	IS 2309-1969	Code for Lighting arrestors
12	IS 875 part I to III,1987	Code of practice for design loads for building and structures
13	IS 7357	Code of practice for structural design of tanks
14	IS 1786-1985	High strength deformed steel bars and wires for concrete reinforcement
15	IS: 638	Specification for rubber and insertion jointing.
16	IS. 226-1975	Specification for Structural steel
17	IS: 9523	Ductile iron fittings for pressure pipes for water, gas and sewerage
18	IS: 1500	Code for Hardness test for DI pipes

19	IS 3764-1966	Safety code of Excavation Works and related Drilling Operations
20	IS 11906:1986	Recommendations for cement mortar lining for cast iron, Mild steel and Ductile Iron pipes and fittings for transportation of water
21	IS 8062	Code of practice for cathodic protection for steel structures
22	IS 12288:1987	Code of practice for laying of ductile iron
23	IS 14846:2000	Sluice valves for water Works purposes (50 to 1200 mm size)
24	IS 2906:1990	Sluice valves for water Works purposes (350 to 1200 mm size)
25	IS 2685:1971	Code of practice for selection, installation and Maintenance of sluice valves
26	IS 3950:1979	Surface boxes for sluice valves
27	IS 5312	Swing check type reflux(non-return) valves for water Works purposes
28	IS 10446:1983	Glossary of terms relating to water supply and sanitation
29	IS 2951-1965	Recommendation for estimation of flow of liquids in closed conduits.
30	Advisory note on improving Urban Water Supply & Sanitation Services	Guidelines for preparation of DPRs for water supply system by MoUD, 2013
31	Is :4733-1972	Indian Standard Code: Methods of Sampling Test Sewage Effluent
32	IS: 6908-1975	Indian Standard Code: Sewage and Drainage
33	IS :7022 (PT 11)-i 979	Indian Standard Code: Glossary of Terms Relating to Water Sewage and Industrial Effluents PT II
34	IS:1538-(PT-XXIV)-1 982	Indian Standard Code: Pressure Pipes for Water. Gas and Sewage
35	IS 5600: 2002	Indian Standard Code: Pumps-sewage and Drainage-Specification
36	IS 5611 :1987	Indian Standard Code: Code of practice for waste stabilization ponds (facultative type) (first revision)
37	IS: 5600-1970	Indian Standard Code: Specification for Sewage and Drainage Building Elements
38	IS: 4764-1973	Indian Standard Code: Tolerance Limits for Sewage Effluents Discharged into Inland Surface Water
39	IS 6279 :1971	Indian Standard Code: Equipment for gnt removal devices
40	IS 6280:1971	Sewage screens

41	IS 7232:1974	Indian Standard Code: Method for lmhoff cone test
42	IS 7784: Part 1 & 2: Sec 1 to 5	Indian Standard Code: Code of practice for design of cross drainage work Part 1 General features
43	IS 4111(Part 1):1986	Code of practice for ancillary Structures in sewerage system: Part I Manholes
44	IS 4111(Part 4):1968	Code of practice for ancillary Structures in sewerage system: Part 4 Pumping stations and pumping mains (rising mains)
45	IS 12251:1987	Code of practice for drainage of building
46	IS 12288:1987	Code of practice for use and laying of ductile iron
47	SP 35(S&T): 1987	Handbook on water supply and drainage with special emphasis on plumbing.
48	IS 458	Pre-cast Concrete Pipes (with and without reinforcement).
49	IS 651	Specification for Salt Glazed Stoneware Pipes and Fittings.
50	IS 783	Code of Practice for Laying Concrete Pipes
51	IS 1729	Cast Iron /Ductile Iron Drainage Pipes and Pipe Fittings Socket and Spigot Series for Over-ground Non-Pressure Pipe Line.
52	IS 4885	Specifications for Sewer Bricks
53	IS 12592 (Part I & II)	Pre-cast Concrete Manhole Covers and Frames – Specifications
54	IS-8112: 2013	Specification for 43 grade ordinary Portland cement
55	IS-383: 1970	Specification for Coarse and Fine Aggregates from Natural Sources For Concrete
56	IS:3597 (1998)	Concrete Pipes: Methods of Test
57	IS: 783	Code of Practice for laying of Concrete Pipes
58	IS:376	Safety code for Excavation work
59	IS: 1077	Common Burnt Clay Building Bricks
60	IS:3102	Classification of Burnt Clay Bricks
61	IS: 395	Method of Sampling and Testing Clay Building Bricks
62	IS: 2212	Code of practice for brick work

TESTING AND COMMISSIONING

Testing at site

All sewers and appurtenances shall be tested before commissioning and trial run as per the specifications in this section. After laying and jointing of sewer pipes and before backfilling the trenches, the complete length of the sewer is to be checked for water

tightness and the sole responsibility of arranging the necessary equipment and apparatus lies with the Contractor at his own cost. Any damage during testing shall be Contractor ‘s responsibility and shall be rectified by him free of cost. Water for testing shall be arranged by the Contractor ‘s at his own cost.

Water test for Sewers

After laying and jointing of sewer pipes and before backfilling the trenches, the complete length of the sewer is to be checked for water tightness. Owner may exempt water test for lateral sewers, where house service connections are to be connected immediately.

The procedure for testing is as detailed below,

a) Each section of sewer shall be tested for water tightness from manhole to manhole to prevent change in alignment and disturbance after the pipes have been laid, it is desirable to backfill the pipes up to the top keeping at least 90cm length of the pipe open at the joints in case of longer length pipes.

b) In case of concrete and stoneware pipes with cement mortar joints, pipes shall be tested three days after cement mortar joints have been made. It is necessary that the pipelines are filled with water for about a week before commencing the application of pressure to allow for the absorption by pipe wall.

c) The sewers are tested by plugging the upper end with a provision for an air outlet pipe with stop cock. The water is filled through a funnel connected at the lower end provided with a plug. After the air has been expelled through the air outlet, the stop cock is closed and the water level in the funnel is raised to 2.50m above the invert at the upper end. Water level in the funnel is noted after 30 minutes and quantity of water required to restore the original water level in the funnel is determined. The pipeline under pressure is then inspected while the funnel is still in position. There shall not be any leaks in the pipe or the joints (small sweating on the pipe surface is permitted). Any sewer or part there of that does not meet the test shall be emptied and repaired or relaid as required and tested again.

d) The leakage or quantity of water to be supplied to maintain the test pressure during the period of 10 minutes shall not exceed 0.2 lit/mm dia. of pipe per kilometer length per day.

e) Ex filtration test for detection of leakage shall be carried out at a time when the ground water table is low.

f) For concrete, R.C.C. pipes of more than 600mm dia. the quantity of water inflow can be increased by 10% for each additional 100mm of pipe dia.

g) After completion of the test all temporary seals shall be removed, the test water shall be drained out / pumped out and the line cleaned properly.

Test for straightness & obstruction

As soon as a stretch of sewer is laid and tested, before commissioning the cleanliness of the pipeline is to be checked by the following tests as applicable and as decided by the Engineer In-Charge.

Torch & Mirror Test

In this method of testing, a torch will be held one end of the pipeline inside a manhole and its image through the pipeline will be reflected and seen on a mirror held at the opposite end of the pipeline, inside the next manhole. Any obstruction / debris / major misalignment will not give a clear image in which case the pipeline will again be cleaned /rectified and the tests re-done.

Ring Test

In this method of testing two steel/ wooden rings of suitable thickness and design shall be fixed facing each other at a distance of 2 feet or more. The block of rings shall be inserted from one end of the pipeline, inside manhole and pulled by a rope fixed to the block from the other end of the pipeline, inside the next manhole. The rings shall be of dia. 75 mm less than the inside diameter of pipe under testing. The rope used for pulling the ring block may be inserted in the pipeline by suitable means. Any construction / debris / major misalignment will prevent the ring to pass through the pipeline in which case the pipeline will again be cleaned / rectified and the test redone, and no extra payment will be made.

Alternately upon the approval of the Engineer, the sewer may be tested by inserting at the high end of the sewer, a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball should roll down the invert of the pipe and emerge at the lower end. Any construction / debris / major misalignment that prevent the ball to pass through the pipeline in which case, the pipeline shall be again cleaned / rectified and the tests redone, and no extra payment will be made.

Water test for Manholes

The entire height of Brick and RCC manhole shall be tested for water-tightness by closing both the incoming and outgoing ends of the sewers and filling the manhole with water. A drop-in water level not more than 50mm per 24 hours shall be permitted. In case of high subsoil water, it should be ensured that there is no leakage of ground water into the manhole by observing the manhole for 24 hours after emptying it.

Test records

Complete test records shall be maintained for all tests carried out for sewers both during construction and after being in service. The tests carried out as in specifications, approved QAP shall be documented in the formats as approved by the Contractor and shall be carried out in the presence of the Engineer or his representative and shall be certified by the Engineer In-Charge or his representative. All completed Test records/documents shall be submitted to the Engineer In-Charge before submission of bills.

Commissioning

After satisfactory completion of works and Testing of the sewer lines and appurtenances as per specifications in above clauses, the system shall be commissioned for trial run and operation.

Final finishing

The Contractor will ensure that the entire structure along with all its installations is in finished and in new and fully operative condition when handed over. He shall have repaired and removed all signs of damage that might have been done during the course of construction of manholes and laying of sewers. He shall also see that the entire exterior has been finished properly and the entire site is cleared of all extra construction material, debris, and excavated soil. This shall have to be done to the satisfaction of the Engineer In-Charge.

As Built Drawings

The Contractor shall submit to the Engineer In-Charge within two months of actual completion of the work, “As Built” Drawings as specified below and operation and maintenance instructions for the whole of the Works. These Drawings shall be accurate and correct in all respects, including the existing sewer network for which the Contractor has done the condition assessment survey, shall be submitted to, and approved by

the Engineer In-Charge. Completion Drawings as below on two prints and one polyester film shall be supplied by the Operator, along with a soft copy in CD. These drawings shall be developed in Auto CAD. Drawing shall be of standard size as below,

i) . Strip Plans and L-sections of Sewerage Network system showing pipe work in package area on scale as per standard practices to the satisfaction of the Engineer, showing sewer alignments, levels, appurtenances, sizes and material of pipe etc. complete.

ii). Structural Drawings showing reinforcement details of all the components covered under this contract as per standard practices.

Annexure - I (F)

Pipe Conduits and RCC ducts for power Cables

General:

This specification envisages manufacturing, testing at works, transport to site, insurance, storage, erection and commissioning of High-Density polyethylene primarily intended for buried for laying of underground Power cables up to 400 mm2 as per NEMA TC-7 or any equivalent Indian standard with latest amendment. The expected service life of HDPE pipe and accessories shall not be less than 50 years.

1.1 Detail Requirements of HDPE Pipe.

Three-layer construction:

The HDPE pipe shall have three concentric layers viz. outer layer, middle layer and inner layer with ribs. The outer layer shall be made of HDPE material in red colour, middle layer shall be made of HDPE in translucent (natural) and the inner ribbed layer of solid permanent lubricant (PLB) i.e. Silicore. These concentric layers shall be continuous, co-extruded and integral part with HDPE outer/middle layer and shall distinctively visible in cross-section under normal lighting conditions and outer layer generally conform to IS-9938.

The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the pipe. The colour of HDPE pipe shall be as per CRDA requirement and shall be uniform throughout the length of the pipe.

The HDPE pipe shall Inner Ribbed of standard make and shall have the outer diameter as fallows.

S No	Type of Cable	Outer Diameter of Pipe in mm
1	33 kV	225, 200
2	LV cable	160
3	Service Cable	110

1.2 Standards:

The PLB (Permeant Lubricant) HDPE pipe shall conform to the following standard and the technical specifications described below.

S. No	Properties	Test Method	Requirements
1	**Density of Raw Material**	ISO 1183	≥ 930 Kg/m³
2	**Melt Flow Rate**	ISO 1133	The melt flow rate of the duct should be 0.2 to 1.1 Grams/10 Minutes @5kg.
3	**Tensile Strength at Yield**	ISO 6259 - 1 & 3	Min 18 N/mm²
4	**Environmental Stress Crack Resistance**	ASTM D 1693	There should be no crack or split when tested with 10% IGEPAL - CO – 630 solution at 50 ± 1º C for 96 hours.
5	**Ovality**	IS 4984-1995	Maximum 2% of outer diameter.
6	**Reversion**	IS 4984-1995	3.00% Max
7	**Elongation**	ISO 6259 - 1 & 3	Min 350%
8	**Colour Pigment Dispersion (Outer Layer)**	ISO 4427 / ISO 18553	≤ Rating A3
9	**Ash Content of Outer Layer of the Duct**	ASTM D5630	≤ 0.3%
10	**Impact Strength**	IS 12235 (Part 9)	There should be no crack / split when 10 Kg load dropped from 1.50 Meter height after conditioning at 0º C for 1 hour.
11	**Toe- in**	ASTM F 2160	Outside diameter at cut end of the conduit shall not be more than 1.5% smaller than outside diameter that measured at 300mm away from the cut end of the conduit.
12	**Friction redution**	ASTM F 2160	Lubrication materials shall be compatible with the conduit & any cable jacketing.

1.3 Material:

The raw material used for the HDPE pipe shall meet the following requirements

i. The anti-oxidant establishers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.

ii. Usage of any additives used separately or together should not impair the long-term physical and chemical properties of the HDPE pipe.

iii. Suitable Ultra-Violet stabilizers may be used for manufacture of the HDPE pipe to protect against UV degradation when stored in open for a minimum period of 8 months.

iv. In case of HDPE pipe of three concentric layer construction, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer.

Tests on Material of HDPE pipe:

The base HDPE resin material shall be subjected to following tests and shall satisfy

i. Melt flow Index: ISO 1133

ii. Density: ISO 1183

1.4 Dimension of pipe:

Duct shall have Nominal Diameter of either 110mm,160mm 200mm and 225mm and shall have a dimensional ratio of 13.5 (SDR)

1.4.1 Dimensions of inner Ribbed HDPE Duct:

S. No	Description	225 DIA	200 DIA	160 DIA	110 DIA
1	Outer Diameter of Pipe (mm)	225 + 1.5	200 + 1.50	160 + 1.00	110.0 +1.00
2	Wall Thickness (mm) (**Excluding rib height**)	16.70 to 18.50	14.80 to 16.50	11.90 to 13.2	8.20 to 9.20
3	Ovality	Max 4.5	Max 4	Max 3.2	Max 2.2

Pipe Length shall be 6 or 12 meters, length of supply preferred to be 12 mtrs

1.4.2 HDPE Ducts should be sourced from the manufacturer with ISO 9001 accredited manufacturing facility.

1.5 Accessories:

The following accessories are required for jointing the pipe and shall be supplied along with the pipe. The manufactures shall provide complete design details, procedure for method of installation and type of the material used for the accessories.

Plastic coupler: The coupler shall be used to join two HDPE pipes. The coupling shall be able to provide a durable water tight joint between two pipes without deteriorating the strength of the pipes. The strength of coupler shall match the primary strength of the HDPE pipe. It should either snap fit or Split type. The jointing shall meet the air pressure test of 2 kg/cm^2 for a minimum period of 2 hours without any leakage.

1.6 Workmanship:

The pipe shall be free of blisters, shrink holes, break and other defects. The HDPE pipe ends shall be cut as square as possible to longitudinal aspects. The external HDPE pipe surfaces shall be smooth and inner ribbed layer. The color of outer surface should be Red uniform throughout.

1.6 Marking:

Each straight length of pipe shall be clearly marked hot embossed on white base or ink jet in black on straight length of the pipe at every meter of pipe with the following information:

a) Employer's name,
b) Manufacturer's name/Trade-mark,
c) Designation of pipe,
d) Lot number/Batch number,

1.8 Tests on finished HDPE pipe:

1.8.1 Visual Inspection: The external surfaces of the pipes shall be smooth and inner surface of the pipe shall be ribbed, clean and free from grooving and other defects. The pipe shall be cleanly cut and shall be square with axis of the pipes. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible, if the wall thickness remains within the permissible limits.

1.8.2 **Dimensions**: The wall thickness and diameter of the pipe, shall be measured by a dial Vernier or ball ended micrometer. The diameter shall be measured with micrometer and shall conform to the figures given in the clause 1.4.1.

1.8.3 **Reversion Test**: This test shall be carried out as per IS: 4984. The dimension of inner layer or outer layer shall not change by more than 3% in the longitudinal direction when a sample pipe placed (sample length 200mm approx..) horizontally in an air-oven at 110+/-2° C for 60 minutes and cooled to the room temperature.

1.8.4 **Tensile Strength at yield and Elongation at break Test**: The tensile strength and elongation of the HDPE pipe shall be carried out as per ISO: 6259 1& 3.The tensile strength for finished material shall be minimum 18 N/mm^2 and elongation at break shall be 350%.

1.8.5 **Environmental Stress Crack Test:** The test shall be conducted as per ASTM D 1693 with the specimen prepared from HDPE pipe after making compression moulding sheet. The specimen shall be immersed in 10% IGPAL (CO 630) Solution at 50± 1° C for 96 hrs. There shall be no crack or split.

1.8.6 **Impact Strength Test**: The test shall be carried out as per IS:12235 (Part 9). A sample HDPE pipe 150mm in length shall be conditioned at 0°C for one hour and placed on a heavy rigid block whose faces are at angle of 120°. A striker with a total weight of 10kg shall be allowed to fall freely in a suitable vertical guides through a height of 1.5m. The HDPE pipe shall not crack or split.

1.8.7 **Crush Resistance**: The test shall be in a sample of 200± 2 mm length of HDPE pipe which shall be subjected to crush load as specified below with compression speed 12.5 mm per minute. The deflection with crush load on period shall not exceed 5%.

i) **225 mm:** 1700 N Minimum
ii) **200 mm:** 1500 N Minimum
iii) **160 mm:** 1200 N Minimum
iv) **110 mm:** 800 N Minimum

1.8.8 Ovality test: The ovality is the difference between maximum outside diameter and the minimum outside diameter of the HDPE pipe at same cross section of the duct at 300mm away from the cut end. The same shall be measured as per IS-4984 as described above.

Raw Material: HDPE Virgin material shall be used. No other reworked or recycled material shall be used

1.9 Packing and condition of delivery:

1.9.1 The pipe may be supplied in loose sticks.

All materials furnished and all work performed shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall furnish all manpower and materials for tests, including testing facilities, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein including the expenses of Inspector/Employer's representative shall be treated as included in the quoted unit price of materials.

Acceptance or waiver of tests will not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified type. Acceptance, Routine or Manufacturing tests to assure the Employer of specification compliance.

The Employer also reserves the right to require any retesting of previously approved tests at the Employer's expenses. However, if the retest(s) reveal non-compliance to the specification, the Contractor shall bear the expenses for the retesting and remedial action at no cost to the employer.

1.10 Factory Acceptance Test:

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Visual inspection shall be carried out on 100% basis for all the equipment/items offered. Factory acceptance testing shall be carried out on HDPE and accessories.

Material shall not be dispatched to the Employer until required factory tests are completed satisfactory all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to dispatch shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorized representatives.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. The factory acceptance test for items shall be proposed by the Contractor in accord-

ance with technical specifications and Contractor's (including Subcontractor's/supplier's) standard FAT testing program. For Test equipment, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/report.

1.10.1 Sampling for FAT:

From each batch HDPE pipe presented by the Contractor for Factory acceptance testing, the Employer shall select random sample (s). For HDPE pipes, following sampling plans shall be followed.

B. Sampling plan for Visual inspection and dimensional test

Scale of sampling for Visual inspection and dimensional test shall be as per below table:

No of Pipes in the Lot	Sample No A	Sample Size	Cumulative Sample Size	Acceptance No	Rejection No
(1)	(2)	(3)	(4)	(5)	(6)
Up to 150	First	13	13	0	2
	Second	13	26	1	2
151 to 280	First	20	20	0	3
	Second	20	40	3	4
281 to 500	First	32	32	1	4
	Second	32	64	4	5
501 to 1200	First	50	50	2	5
	Second	50	100	6	7
1201 to 3500	First	80	80	3	7
	Second	80	160	8	9
3501 to above	First	125	125	5	9
	Second	125	250	12	13

The number of pipes given for the first sample in col 3 of above Table shall be examined for dimensional and visual requirements given in clause 1.8.1 & 1.8.2. A pipe failing to satisfy any of these requirements shall be considered as defective. The lot shall be deemed to have satisfied these requirements, if the number of detectives found in the first sample are less than or equal to the corresponding acceptance number given in col 5 of above Table. The lot shall be deemed not to have met these requirements if the

number of detectives found in the first sample is greater than or equal to the corresponding rejection numbers given in column 6 of above Table.

If, however, the number of detectives found in the first sample lies between the corresponding acceptance and rejection numbers given in col 5 and 6 of above Table, the second sample of the size given in col 3 of above Table shall be taken and examined for these requirements. The lot shall be considered to have satisfied these, requirements, if the number of detectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col 5 of above Table; otherwise not.

B. Sampling Plan for performance test

The lot having satisfied dimensional and visual requirements shall be tested for other requirements with the sample size selected as per below Table from the lot. The lot shall be considered to have met the requirements of these tests, if none of samples tested fails.

No. of pips in the lot	Sample size
Up to 150	3
151 to 1200	5
1201 and 3500	8
3501 and above	12

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/approvals until such a report is made and remedial actions taken, as applicable.

1.10.2 SITE ACCEPTANCE TESTS

- Randoms checks somewhere in the middle of the pipe, by cutting the duct, will be made at site to ensure that ducts supplied are of correct dimension and thickness and there is no compromise on thickness in intermediate length, for saving in materials cost.
- 100% Duct pipe being supplied would be measured length to cross check the length of the duct pipe.

- To keep a check on the use of filler material, ash contents would be determined on randomly selected samples as per ASTM D 1603 method and the value of ash content, thus determined, shall not exceed 0.3% (outer coloured layer).
- UV Stabilise Content: UV Stabiliser content of finished duct shall not be less than 0.15%
- Third party inspection on above, in addition to inspection at factory, would be carried out by independent agencies. on randomly picked up samples from field for testing of relevant parameters, thereby ensuring right quality of ducts. Failure of samples to pass any of the prescribed tests/parameters would result in immediate invoking of PBG/Blacklisting of the Vendor.

DATA REQUIREMENTS SHEETS for
HDPE CONDUIT

S.N.	Parameter	Units	Guaranteed Value
HDPE Pipe parameters			
1	Manufacturer		
2	Pipe diameter (outside) nominal tolerance	 mm mm	
3	Wall thickness nominal tolerance	 mm mm	
4	Standard Length nominal tolerance	 mm mm	
5			
6	Three concentric layers type Con-struction.		
7			
8	Construction material of outer layer		
	Construction material of middle layer		
9	Construction material of inner layer		
10	Pipe color		
a	Outer Layer		
b	Middle Layer		
c	Inner layer		
12	Base HDPE Resin: a. Density at 27°C b. Melt flow rate at 190°C & 5 kg load.	 Kg/m^3 g/10 minutes	
13	Service life span	year	

UG Cable. DRS

Date …… Signature …….

Place …….. Name ……

Seal Designation ……..

DATA REQUIREMENTS SHEETS for
HDPE CONDUIT

S.N.	Parameter	Units	Guaranteed Value
15	Suitable for laying in trenches by- a. Directly burying	Y/N	
16	Tensile strength	N/mm^2	
17	Elongation at break	%	
18	Bend radius		
---- End of Table ----			

UG Cable. DRS

Date ……

Place ……..

Signature …….

Name ……

Seal Designation ……

Annexure- I (G)

Pipe Ducts for ICT

Specification for Multi-Channel

For Fiber Optic Cable and Communication Cable Installations

1.0 General:

Multiple Bundled PLB (Permanent solidly Lubricated Silicore) HDPE ducts provides pathways & the ability to install fiber optic cables and communication cables for the Fiber optic network, all within the same multi-channel construction. The multiple channels enables to install OF cables for present needs and a provision for futuristic use as when demand grows. Thus, Bundled Multi Channel pathway gives maximum cost effective builds and good return on investment for existing and future networks.

This specification envisages manufacturing, testing at works, transport to site, insurance, storage, erection and commissioning of Bundled HDPE (High-Density polyethylene) multi-channel primarily intended for buried for laying of underground Fiber Optic Cable up to 16mm outer diameter.

This contract package includes providing, laying, jointing, testing and commissioning of DWC HDPE ducts (IS: 14930 Part-2) of 160 mm diameter as per the details furnished in the drawing. Double-wall corrugated pipe is a kind of pipe material with ring-structure external wall and smooth internal wall at a length of 6 m each piece.

1.1 Bundled Multi Channel Requirement

Construction:

Bundled HDPE multi channel consists of multiple pathways in different colours for identification and in specific sizes all bound together with an over sheath for ease of placement. All of the multi channels shall have internal spiral ribs with a solid permanent solidly lubricated material i.e. Silicore to reduce friction during cable placement installations.

The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the duct. The colour of HDPE duct shall be as per requirement and shall be uniform throughout the length of the duct.

The PLB multi channel shall have Inner spiral Ribbed and shall have the dimensions of outer diameter as per project requirement.

1.2 Standards:

1.2.1 PLB HDPE DUCTS:

The PLB (Permanent Lubricant) HDPE duct shall conform to the following standard and the technical specifications described below:

S. No	Properties	Test Method	Requirements
1	**Workmanship**	ASTM F 2160	The Co-extruded layers of duct/conduit shall be homogeneous throughout & essentially uniform in colour, opacity, density & other properties. The outside surfaces shall be free from visible cracks, holes, blisters, voids, foreign inclusions, or other deleterious. The inner surface shall be Spiral ribbed.
2	**Density of Raw Material**	ISO 1183	0.940 - 0.958 g/cc
3	**Melt Flow Rate**	ISO 1133	The melt flow rate of the duct should be 0.2 to 1.1 grams/10 Minutes @5kg.
4	**Tensile Strength At Yield**	ASTM F 2160/ ASTMD 638 Type IV	Min 20 N/mm²
5	**Elongation**	ASTM F 2160/ ASTMD 638 Type IV	Min 500%
6	**Environmental Stress Crack Resistance**	ASTM D 1693	No cracking when tested with 10% Igepal Solution at 50 ± 1º C for 96 Hours. (Type Test shall be for minimum 500 Hours.)
7	**Oxidation Induction test**	ISO 11357-6	Oxidation Induction time should not be less than 30 minutes.
8	**Reversion**	ISO 2505	Reversion of duct shall not be more than 3%
9	**Hydraulic Characteristics (Acceptance Test)**	IS 4984	No swelling leakage or bursting observed after 48 Hours at a Induced stress of 4.9Mpa @ 80ºC (Type for 165 hrs at a Induced stress of 4.6Mpa @ 80ºC)
10	**Crush Resistance test**	Standard	Deflection shall be < 15% when 1000N load applied on 200mm length of the sample. Sample should not crack or split after the test.
11	**Impact Strength**	ASTM D 2444	There should be no crack / split when 9.1 Kgs load (Tup B) dropped from 1.5 Meters. Height after conditioning at 0ºC for 1 hour.

12	**Inner Surface of the Duct**		The Inner Surface shall be spirally ribbed and shall be of a configuration for faster installation of Cable.

1.2.2 BUNDLED MULTI CHANNEL SHEATHING:

S. No	Properties	Test Method	Requirements
1	**Density of Raw Material**	ISO 1183	0.940 - 0.958 g/cc
2	**Melt Flow Rate**	ISO 1133	The melt flow rate of the duct should be 0.2 to 1.1 Grams/10 Minutes @5kg.
3	**Workmanship**	Standard	This is bundle of seven PLB HDPE ducts where external Sheath shall be in Orange Color and shall be free from visual defects like blisters, shrink holes, flaking, scratches, groove lines & surface roughness.
4	**Colour of PLB HDPE ducts in Bundle**		The Color of the Ducts shall be Green, Blue, Yellow, Brown, Violet, Grey, Red
5	**Outer Sheath Thickness**	Standard	1.2 mm ± 0.2 mm
6	**Outer Sheathing: Anti Termite**		Outer sheath of Bundled PLB Multi Channel shall be complied with Anti termite property as per Standard testing procedure/protocol of IICT, Hyderabad. Certificate of Anti Termite shall be submitted for from IICT, Hyderabad or any reputed government testing laboratory. (Type Test)
7	**Minimum Bending Diameter IN FIELD installation**	Standard	3000 mm
8	**Additional Requirement (Optional)**	Standard	A Locatable tracing feature/ mechanism shall be provided

1.3 Material:

The raw material used for the Bundled PLB Multi Channel shall meet the following requirements

i. The anti-oxidant establishers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.
ii. Usage of any additives used separately or together should not impair the long-term physical and chemical properties of the HDPE duct.
iii. Suitable Ultra-Violent stabilizers may be used for manufacture of the HDPE duct to protect against UV degradation when stored in open for a minimum period of 8 months.
iv. Suitable anti-termite master batch shall be used in outer sheath of Bundled PLB Multi Channel to protect damages of the duct from anti-termite when using for underground application.
v. In case of PLB Multi Channel duct with inner spiral ribs construction, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer.
vi. HDPE Virgin material shall be used. No other reworked or recycled material shall be used

Tests on Material of HDPE duct:

The base HDPE resin material shall be subjected to following tests and shall satisfy

i. Melt flow Index: ISO 1133
ii. Density: ISO 1183

1.3 Dimension of duct:

Bundled PLB Multi Channel should consist seven 40mm PLB HDPE ducts with inner spiral ribs in colour sequence of Green, Blue, Yellow, Brown, Violet, Grey, Red colors clockwise when viewed from outer end of the coil.

1.4. Dimensions of PLB HDPE Duct:

S. No	Description	40 PLB HDPE duct
1	Outer Diameter of duct (mm)	40 + 0.4 mm
2	Wall Thickness (mm) (**Excluding rib height**)	2.9mm ± 0.3mm
3	Ovality before bundling	Max 1.4

The Bundled PLB HDPE duct should be supplied in length of 100 meters of coil. HDPE Ducts should be sourced from the manufacturer with ISO 9001, 14001 and 18001 accredited manufacturing facilities.

1.5 Accessories:

The following accessories are required for jointing the PLB Multi Channel and shall be supplied along with the duct. The manufactures shall provide procedure for method of installation and type of the material used for the accessories.

a) **Plastic coupler**: Plastic Coupler (Push-fit type type): It is used to couple two ducts. The design of this shall be simple, easy to install and shall ensure that the two ducts are butted smoothly without any step formation in the inner surface. The jointing shall meet the air pressure test of 15 kg/cm² for a minimum period of 2 hours without any leakage.
Note: Both sides of the coupler shall be marked with the manufacturers name by engraving and that the ends of the opening (for entry of duct) shall be covered with paper sticker, to prevent the entry of foreign matter while not in use.

b) **End Plug:** This is for scaling the ends of the empty ducts, prior to installation of the OF cable and shall be fitted immediately after laying of the duct, to prevent the entry of any dirt, water, moisture, insects/rodents etc.

1.6 Workmanship:

The outer sheath of Bundled PLB Multi Channel shall be free of blisters, shrink holes, break and other defects... The external surface of PLB Multi Channel shall be smooth and free from visual defects like blisters, shrink holes, flaking, scratches, groove lines & surface roughness and inner ribbed layer. The color of outer sheath surface should be uniform throughout.

1.7 Marking:

Each coil length of Bundled PLB Multi Channel shall be clearly marked with ink jet in black and contrast to outer surface colour on length of the duct at every meter of duct with the following minimum information:

a) Employer's name,
b) Manufacturer's name/Trade-mark,
c) Description of duct,
d) Coil Number/Batch number,
e) Sequential meter making at every one meter

1.8 TESTS ON PLB MULTI CHANNEL:
(Each of the test shall be carried out individually on the HDPE Duct)

1.8.1 **Visual Inspection**: The external surfaces of the Bundled PLB Multi Channel shall be smooth and inner surface of the PLB Multi Channel shall be spirally ribbed, clean and free from grooving and other defects.

1.8.2 **Dimensions**: The wall thickness and diameter of the PLB Multi Channel, shall be measured by a dial Vernier or ball ended micrometer and shall conform to the clause 1.4.1.

1.8.3 **Reversion Test**: This test shall be carried out as per ISO 2505. The dimension of inner layer or outer layer shall not change by more than 3% in the longitudinal direction when a sample duct placed (sample length 200mm approx..) horizontally in an air-oven at 110+/-2^{o} C for 60 minutes and cooled to the room temperature.

1.8.4 **Tensile Strength at yield and Elongation at break Test**: The tensile strength and elongation of the HDPE duct shall be carried out as per ASTM D 638 Type IV. The tensile strength for finished material shall be minimum 20 N/mm^2 and elongation at break shall be 500%.

1.8.5 **Environmental Stress Crack Test:** The test shall be conducted as per ASTM D 1693 with the specimen prepared from HDPE duct sample. The specimen shall be immersed in 10% IGPAL (CO 630) Solution at 50± 1^{o} C for 96 hrs. There shall be no crack or split.

1.8.6 **Impact Strength Test**: The test shall be carried out as per ASTM D 2444. A sample HDPE duct 150mm in length shall be conditioned at 0°C for one hour and placed on a heavy rigid flat block. A striker as per Tup B and loaded to a total weight of 9.1kg shall be allowed to fall freely in a suitable vertical guides through a height of 1.5m. The HDPE duct shall not crack or split.

1.8.7 **Crush Resistance**: The test shall be in a sample of 200± 2 mm length of HDPE duct which shall be subjected to 1000N crush load with compression speed 12.5 mm per minute. The deflection shell be < 15% on PLB HDPE duct.

1.8.8 **Ovality test**: The ovality is the difference between maximum outside diameter and the minimum outside diameter of the PLB HDPE duct at same cross section of the duct at 300mm away from the cut end.

1.8.9 **Hydraulic Characteristics**: The duct shall be tested for internal pressure creep rupture test as per the test method outlined in IS: 4984. For this purpose, a sample length of 10 times the outside diameter of the duct shall be taken. At the end of the

test, the sample shall not show signs of localized swelling or leakage and shall not burst during the test duration. The test showing failure within a distance equivalent to the length of end cap from the end shall be disregarded and the test repeated. This test temperatures and the duration of the test shall be as follows:

Test	Test Temp. °C	Test Duration (Hrs.) (Min. holding time)	Induced Stress (Mpa)
Type Test	80	165	4.6
Acceptance Test	80	48	4.9

1.8.10 Oxidation Induction Test: The induction time oxygen when tested as per method in Annexure-I, shall not be less than 30 minutes. Testing should be carried out on computerized machine and graphs should be submitted along with the test results.

1.9 TEST ON BUNDLED PLB HDPE DUCTS

1.9.1 Visual Inspection: The external surfaces of the Bundled PLB HDPE ducts/ PLB HDPE duct shall be smooth and clean and free from grooving and other defects...

1.9.2 Dimensions: The outer sheath thickness of the Bundled PLB HDPE duct, shall be measured by a dial Vernier or ball ended micrometer and shall conform to the clause 1.2.2.

1.9.3 Tracing mechanism: PE insulated copper wire with nominal diameter 0.63mm and overall nominal 1.2mm diameter with PE insulation should be used during bundling of PLB HDPE ducts...

1.9.4 Outer Sheathing: Outer sheath of Bundled PLB HDPE duct should complied to Anti termite property as per Standard testing procedure of IICT, Hyderabad. Certificate of Anti Termite shall be submitted for from IICT, Hyderabad or any reputed government testing laboratory

2.0 Packing and condition of delivery:

2.1 The duct should be supplied in coils of 100 meters.

All materials furnished and all work performed shall be inspected and tested. Deliver-ables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.

Except where otherwise specified, the Contractor shall furnish all manpower and materials for tests, including testing facilities, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the Contractor and shall be deemed to be included in the contract price.

The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein including the expenses of Inspector/Employer's representative shall be treated as included in the quoted unit price of materials.

Acceptance or waiver of tests will not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

All tests shall be witnessed by the Employer and/or its authorised representative (hereinafter referred to as the Employer) unless the Employer authorises testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.

Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified type. Acceptance, Routine or Manufacturing tests to assure the Employer of specification compliance.

The Employer also reserves the right to require any retesting of previously approved tests at the Employer's expenses. However, if the retest(s) reveal non-compliance to the specification, the Contractor shall bear the expenses for the retesting and remedial action at no cost to the employer.

3.0 Factory Acceptance Test:

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Visual inspection shall be carried out on 100% basis for all the equipment/items offered. Factory acceptance testing shall be carried out on HDPE and accessories.

Material shall not be dispatched to the Employer until required factory tests are completed satisfactory all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to dispatch shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorized representatives.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. The factory acceptance test for items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's/supplier's) standard FAT testing program. For Test equipment, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/report.

3.0.1 Sampling for FAT:

From each batch Bundled PLB Multi Channel presented by the Contractor for Factory acceptance testing, the Employer shall select random sample (s). For HDPE ducts, following sampling plans shall be followed.

A. Sampling plan for Visual inspection and dimensional test

Scale of sampling for Visual inspection and dimensional test shall be as per below table:

No of Ducts in the Lot	Sample No A	Sample Size	Cumulative Sample Size	Acceptance No	Rejection No
(1)	(2)	(3)	(4)	(5)	(6)
Up to 150	First	13	13	0	2
	Second	13	26	1	2
151 to 280	First	20	20	0	3
	Second	20	40	3	4
281 to 500	First	32	32	1	4
	Second	32	64	4	5
501 to 1200	First	50	50	2	5
	Second	50	100	6	7
1201 to 3500	First	80	80	3	7

	Second	80	160	8	9
3501 to above	First	125	125	5	9
	Second	125	250	12	13

The number of ducts given for the first sample in col 3 of above Table shall be examined for dimensional and visual requirements given in clause 1.8.1 & 1.8.2. A duct failing to satisfy any of these requirements shall be considered as defective. The lot shall be deemed to have satisfied these requirements, if the number of detectives found in the first sample are less than or equal to the corresponding acceptance number given in col 5 of above Table. The lot shall be deemed not to have met these requirements if the number of detectives found in the first sample is greater than or equal to the corresponding rejection numbers given in column 6 of above Table.

If, however, the number of detectives found in the first sample lies between the corresponding acceptance and rejection numbers given in col 5 and 6 of above Table, the second sample of the size given in col 3 of above Table shall be taken and examined for these requirements. The lot shall be considered to have satisfied these, requirements, if the number of detectives found in the cumulative sample is less than or equal to the corresponding acceptance number given in col 5 of above Table; otherwise not.

B. Sampling Plan for performance test

The lot having satisfied dimensional and visual requirements shall be tested for other requirements with the sample size selected as per below Table from the lot. The lot shall be considered to have met the requirements of these tests, if none of samples tested fails.

No. of coils in the lot	Sample size
Up to 150	3
151 to 1200	5
1201 and 3500	8
3501 and above	12

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/approvals until such a report is made and remedial actions taken, as applicable.

3.0.2 SITE ACCEPTANCE TESTS

- Randoms checks somewhere in the middle of the PLB Multi Channel, by cutting the single duct, will be made at site to ensure that ducts supplied are of correct dimension and thickness and there is no compromise on thickness in intermediate length, for saving in materials cost.
- 100% Duct being supplied would be measured length to cross check the length of the duct.
- Third party inspection on above, in addition to inspection at factory, would be carried out by independent agencies. on randomly picked up samples from field for testing of relevant parameters, thereby ensuring right quality of ducts. Failure of samples to pass any of the prescribed tests/parameters would result in immediate invoking of PBG/Blacklisting of the Vendor.

DATA REQUIREMENTS SHEETS FOR
BUNDLED PLB HDPE DUCT

S.N.	Parameter	Units	Guaranteed Value
Bundled PLB Multi Channel parameters			
1	Manufacturer		
2	No of PLB Multi Channel in Bundled HDPE duct	Nos.	
2	Outer Sheath thickness of Bundled PLB Multi Channel		
3	PLB Multi Channel diameter nominal tolerance	 mm mm	
4	Wall thickness (Excluding inner ribs nominal tolerance	 mm mm	
5	Standard Length of Bundled Multi Chan-nel nominal tolerance	 mm mm	
6	Construction material of outer sheath of Bundled Multi Channel		
7	Construction material of PLB Multi Channel		
8	Construction material of inner layer of PLB Multi Channel		
9	Outer Sheath color of Bundled Multi Channel		
10	Colours of all seven PLB Multi Channels		
11	Base Duct Resin: c. Density at 27°C d. Melt flow rate at 190°C & 5 kg load.	 Kg/m^3 g/10 minutes	

Date …… Signature …….

Place …….. Name ……

Seal Designation ……..

DATA REQUIREMENTS SHEETS FOR
SILICORE MULTI CHANNEL

S.N.	Parameter	Units	Guaranteed Value
12	Suitable for laying in trenches by- b. Directly burying	Y/N	
13	Tensile strength	N/mm^2	
14	Elongation at break	%	
15	Minimum Bend diameter for field installation		
---- End of Table ----			

UG Cable. DRS

Date ……

Place ……..

Signature …….

Name ……

Seal Designation ……

Annexure - 1
OXIDATION INDUCTION TEST

1.0 A short length of completed duct (approximately 30 cm) shall be sealed at the ends and placed in an oven at temperature of 68 ± 1° C for 8 hours. The sample shall then be allowed to cool at room temperature for at least 16 hours. The sample shall be clean and dry. The sample shall then be tested by means of a Differential Scanning Calorimeter (DSC) or by Differential Thermal Analyser (DTA).

2.0 Instrument Test Procedure:

2.1 Cell Cleaning: The cell shall be held at approximately 400° C for 10 minutes in Nitrogen. The cell shall be cleaned after standing over night and between testing of different formulations.

2.2 Temperature Calibration: This has to be done according to the instrument manual. The temperature scale should be adjusted until the determined melting point of pure Indium metal is 156.6° C at a heat rate of 5° C per minute or any other heat rate as indicated in the manual of the equipment is permitted.

2.3 Aluminium Pan Preparation: Standard aluminium DSC pans as per ASTM D 4565 are required to hold specimens during testing. A fresh pan shall be used for each test.

2.4 Sample Preparation: Take the sample weighing about 5 mg from the duct conditioned as indicated above. Position the sample in the center of the pan.

2.5 Nitrogen Purge: Place the sample pan and reference pan in instrument cell. Flush for 5 minutes with cylinder of nitrogen (99.6% extra dry grade) at 60 ± 10 cc per minute.

2.6 Oxidation Test: Rapidly increase the temperature of the sample (20° C/min or greater) from 100° C or lower initial temperature to 199 ± 1° C. After thermal equilibrium is obtained (steady recorder signal) switch to 80 ± 20 cc per minute oxygen flow and simultaneously start time-base recording. The oxygen used for the test should be equivalent to or better than 99.6% extra dry grade.

2.7 Induction Period: The oxygen induction point shall be recorded as time zero, and the chart speed shall be sufficient to provide a clearly discernible slope at the start of the exothermic reaction. The test in the pure dry oxygen atmosphere shall continue until the exothermic peak is produced. The intersection of the tangent of the exothermic sloped line with the extended base line will be drawn. The time zero to this intersection point is read from the base line and recorded as the oxidative induction time.

TECHNICAL SPECIFICATIONS FOR LAYING OF ICT DUCTS

Relevant NHAI guidelines and other guidelines referred in this document shall be followed.

CLASSIFICATION OF SOIL:

The excavation work generally involves various soil conditions on such routes like soft soil, hard muram soil, hard rocks requiring chiseling/blasting as per relevant specification.

EXCAVATION

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided. The excavation shall include excavation in earth and murrum and others shall be carried out to the correct levels required and specified and no clearance, plus or minus (ie. no overcuts), shall be permitted as per the authority.

Road crossing with the trench less technology / HDD (Horizontal directional drilling): Trench-less technology tunneling work include the laying by hydraulic jacking and smooth controlled pushing method in all types of soils including hard rock true to the alignment and gradient under running traffic condition as per standards including carrying out the survey work at the site for determining underground cable trenches like telephone, fiber optic cables , water supply pipes , irrigation pipes and resistivity test for finding the soil strata using necessary equipments for completeness of works mobilizing of the machineries and specialized crews at construction site etc, complete in all respects including the excavation of the driven pit and exit pit with proper protection with shoring sheets and ISMB (providing and casting MS cutting edges for front shield and construction thrust bed at designated level as directed by the engineer, necessary dewatering and providing the concrete foundation at the base of the driven pit, crane for holding the pipe and any other machinery, tools , tackle required, construction of the temporary works as per the requirement and approval of the concerned authorities and engineering in charge, as per the scope of work defined.

ALIGNMENT OF THE TRENCH:

Contractor shall carry out detailed survey of route and submit the final survey report for approval before implementation. The final survey report shall include the following:

- A drawing of the proposed ICT duct route indicating all details including relevant details of soil strata, bridges, culverts, & other utilities & other important landmarks, etc.
- The distance of the ICT duct route from the center of the median of road shall be indicated on the route maps as well as documented in tables.
- Sections where RCC manholes are required.
- Location and number of manholes as proposed.
- Location of all turns, bends and major landmarks.
- The final LS, CS and Plans have to be approved by the Engineer-in-Charge.

The Contractor shall prepare and submit for approval by the Employer, specific construction drawings for all types of soil strata/crossings taking into consideration the guidelines given in this specification. The construction/implementation shall be carried out as per the approved drawings. The Construction drawings shall interalia include the longitudinal sectional diagram of the trench for different soil strata and detail arrangement of crossings, number of pipes, size of pipe, locations and position of manholes, other details as per the technical specifications. Route maps shall be drawn to the scale as required by the authority.

The trench will normally follow the alignment in the ROW permitted by Authority. The Engineer-in-charge will decide the alignment of the trench, which shall be proposed by the contractor in consultation with the Engineer-in-Charge. While marking the alignment, only the center line will be marked and given, and the contractor shall set out all other work to ensure that the excavated trench is as straight as possible.

The contractor shall provide efficient staff for the purpose of this marking and the contractor shall solely be responsible for accuracy of such setting out.

The contractor shall clear, prepare and grade the right of way to facilitate the making of the alignment of the trench. Contractor shall remove all bushes, undergrowth, slumps, rocks and other obstacles to facilitate marking the central line.

TRENCHING DEPTH & WIDTH:

The standard depth as specified is subject to the following conditions: -

It is likely that, due to uneven ground condition if 1.65 m is adopted as the uniform depth throughout, the bottom of the trench will also follow the same unevenness as the surrounding

terrain. This should not be the case and the bottom of the trench has to be at uniform level. In this process, it is possible that in some locations the depth of excavation may be more. However, it is to be ensured that at no location, the depth is less than 1.65 meter.

DEWATERING:

The contractor shall be responsible for all necessary arrangements to remove or pump out water from trench. The contractor should survey the soil condition encountering the section for which he is trenching and make his own assessment about de-watering arrangements that may be necessary. No extra payment shall be admissible for this and the tendered rate may take care of this aspect.

The contractor shall provide sufficient width of the trench and all such places where it is likely to cave in due to soil conditions and for this no extra payment will be made.

A minimum free clearance as per standards defined in Schedule-D should be maintained above or below any existing/Proposed underground metallic or non-metallic lines or utility lines crossing the trench. No extra payment will be made towards this.

TRENCH EXCAVATION AND BACKFILLING:

The contractor shall carry out excavation and backfilling of trenches in all kinds of soil strata for proposed duct bank as per the indicative drawings.

EXCAVATION:

The cable trenches shall be dug as per route plan and detailed trench drawings (indicating the various dimensions and other details of the trench) approved by the Engineer-in-Charge for each type of soil strata. The Contractor shall take due care and precaution during excavation to avoid possible damage of other underground plans/facilities in the proposed underground ICT Duct route and shall indemnify the Employer for all damages and shall be solely responsible for all the damages and losses. The Employer shall not be liable for any damages/losses.

Depth of cover shall be at least 800 mm up to chequered tile from top level.

During the construction of trench, the Contractor shall be responsible for shoring and strutting the walls of the trench on either side by using suitable means such as wooden planks to avoid subsidence of soil. The Contractor shall also be responsible for supporting the exposed plant/facilities of other utilities such as water, gas and oil pipes, electric, telephone or fiber optic cables, etc. to avoid any possible damage. The contractor shall also be responsible for any dewatering of trench during digging and installation of pipes.

BACK FILLING AND DRESSING THE TRENCH:

Provided that the pipe has been properly laid and jointed in the trench, and the back-filling operation shall follow as closely as practicable. The back-filling operation shall be performed in such a manner as to provide firm support under and above the pipe and to avoid bend or deformation of the pipe, when the pipe gets loaded with the back filled with sand. Where in any location the back filling is unevenly centered over the trench due to carelessness or any other cause it shall be redressed at the contractor's expenses. No debris shall be allowed in backfill at any time.

The backfill shall be maintained by the contractor against wash out settlement below original levels and rotting until final completion of the works and until reinstated to the original surface conditions as acceptable to the Engineer-In-charge.

Wherever, the duct is laid at a depth less than 1.65 meters the contractor shall obtain the site instructions from Engineer-In-charge in writing.

ROAD CROSSINGS:

Road crossings: RCC encasing pipes of NP4 to be laid for the crossing of the HDPE-DWC ICT conduits with reference to the drawing.

Annexure - I (H)

DESIGN LIFE

Design Life				
S. No.	**Items**	**Design Period in years**	**Code Reference**	**Note**
A	**Road layers**			
1	Bituminous layers	10	IRC 37: 2012	
2	Base, Sub-base and Em-bankments	20	IRC 37: 2012	
3	Concrete Roads	20	IRC 67: 2014	
B	**Drainage Structures**			
1	Cross Drainage Works - HP drains	100	IRC 84: 2014	Clause no.7.2(iii) of page no 60
2	Cross Drainage Works - Box drains	100	IRC 84: 2014	Clause no.7.2(iii) of page no 60
3	RCC Side Drains	30	CPHEEO Manual	
C	**Misc. Items**			
1	High mast - GS	25	CPWD Manual	
2	Light poles - GS	25	CPWD Manual	
3	Underground cabling	20	CPWD Manual	
D	**Pumping and Pipes**			
1	Electric motors - single phase	15	CPHEEO Manual	
2	Electric motors - Three phase	15	CPHEEO Manual	
3	Electric Pump	15	CPHEEO Manual	
4	Diesel Pump	10	CPWD Manual	
5	Diesel Generator	12	CPWD Manual	
6	Sewage Pump	15	CPHEEO Manual	
F	**Civil Structures**			

Design Life				
S. No.	**Items**	**Design Period in years**	**Code Reference**	**Note**
2	Pumping station - Pump house- Civil Structure	30	CPHEEO Manual	
3	Sewage Treatment Plant			
a)	Civil Structures	30	CPHEEO Manual	
b)	Electrical & Mechanical Components	15	CPHEEO Manual	
4	Water treatment units	15	CPHEEO Manual	
5	Pipes and distribution sys-tems	30	CPHEEO Manual	
6	Reservoirs - Overhead and ground level	30	CPHEEO Manual	

Annexure – I (I)
Clash Analysis

Resolving the clashes during designs will avoid the cost overruns and time overruns during execution. While submitting construction drawings for each utility the following has to be maintained

- All clashes between utilities should be resolved during designs and accordingly final LS has to be prepared for each individual utility.
- Spacing between each utility should be maintained as given in table 1.
- Gravity systems should be given first priority and all other utilities which are colliding with them shall bend.
- Priority matrix for resolving the clashes between utilities are given in table 2.
- All joints should be away from crossings as far as possible.

ANNEXURE I (I)II

Minimum Depth from Ground Level, horizontal and vertical spacing requirements between utilities

Utility	Minimum Vertical depth from ground level (m)	Horizontal Spacing (m)									Vertical Spacing (m)								
		Water supply	Waste water	Reuse	Storm Drain	Power 220KV	Power 33KV	Power 415V	Gas	ICT	Water supply	Waste Water	Reuse Water	Storm Drain	Power 220KV	Power 33KV	Power 415V	Gas	ICT
Water supply	0.6	0.3									0.2								
Waste Water	1	3	0.5								0.2	0.2							
Reuse Water	1	0.6	0.5	0.5							0.2	0.2	0.2						
Storm Drain	-	0.6	0.5	0.5	0.5						0.2	0.2	0.2	0.2					
Power 220KV	1.2	0.6	0.5	0.5	0.5	0.2					0.2	0.2	0.2	0.2	0.2				
Power 33KV	1.05	0.3	0.3	0.3	0.3	0.2	0.25				0.2	0.2	0.2	0.2	0.2	0.2			
Power 415V	0.75	0.3	0.3	0.3	0.3	0.2	0.15	0.1			0.2	0.2	0.2	0.2	0.2	0.15	0.1		
Gas	1	0.6	0.5	0.5	0.5	1	0.3	0.3	0.15		0.4	0.4	0.4	0.4	0.5	0.3	0.3	0.6	
ICT (Optical Fibre)	0.75	0.6	0.5	0.5	0.5	0.5	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2

ANNEXURE I (I)III

S. No	Utility	Water supply	Sewerage	Reuse	Storm	Power 220KV	Power 33KV	Power 415V	Gas	ICT
1	Water supply	minor size pipe has to bend								
2	Sewerage	Water supply line has to bend	Merge / Pumping main line has to bend							
3	Reuse	reuse pipe has to bend	Reuse pipe has to bend	minor size pipe has to bend						
4	Storm Drain	Water supply line has to bend	Sewerage line has to bend	Reuse pipe has to bend	Minor Drain merges with Major Drain					
5	Power 220KV	Water supply line has to bend	Power lines has to bend	Reuse pipe has to bend	Power lines has to bend	Merge				
6	Power 33KV	For water supply trunk-33KV lines has to bend For Water supply distribution- water supply lines has to bend	Power lines has to bend	Power lines has to bend	Power lines has to bend	33KV Lines has to bend	Merge/Any one can bend			
7	Power 415V	Power lines has to bend	Power lines has to bend	Reuse pipe has to bend	Power lines has to bend	415V Lines has to bend	415V Lines has to bend	Merge/Any one can bend		
8	Gas	Gas line has to bend	Gas line has to bend	Reuse pipe has to bend	Gas line has to bend	Power lines has to bend	Gas line has to bend	Gas line has to bend	Merge/ minor size pipe has to bend	
9	ICT (Optical Fibre)	ICT lines has to bend	ICT lines has to bend	Reuse pipe has to bend	ICT lines has to bend	Power lines has to bend	ICT lines has to bend	ICT lines has to bend	ICT lines has to bend	Merge/ Any one can bend

Annexure – I (J)

List of Drawings

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Schedule - E Maintenance Requirements

1.0 Maintenance Requirements

1.1 The Contractor shall maintain the Project Works for a period of [10 years] as per **Schedule-B and Schedule-D** commencing from the date of the completion. However, contractor to note that the maintenance for Water supply system including head works (Intake well, Raw water pumping main, Water treatment plant, transmission and distribution supply lines, Cushion tanks and Semi underground reservoirs, Integration with entire water supply and other Ancillary works to WDC's) shall commence only after the commissioning of this network integrating with total supply network the payment for the maintained of these networks shall commence from the year on which the maintenance starts in accordance with the price quoted in the price break up. For the performance of its Maintenance obligation, shall be paid on Quarterly basis not exceeding the O&M amount set forth in the Price Bid.

Schedule F – Applicable Permits

Contents

Applicable Permits

1.1 The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits and any other permits defined in the Schedule-D:

(a) Permission of the State Government for extraction of boulders from quarry;

(b) Permission of Pollution Control Board for installation of crushers;

(c) License for use of explosives;

(d) Permission of the State Government for Drawing water from river/reservoir;

(e) License from inspector of factories or other competent authority for setting up batching plant;

(f) Clearance of Pollution Control Board for setting up batching plant;

(g) Clearance of Pollution Control Board for setting up asphalt plant;

(h) Permission of State Government for borrow earth; and

(i) Any other permits, clearances or approvals required under Applicable Laws.

(j) Contractor has to coordinate with different govt. officials of all type of clearances/permissions as per the requirement of the project.

1.2 Applicable permits, as required, relating to environmental protection and conservation shall have been procured by the Authority in accordance with the provisions of this Agreement.

Schedule G – Form of Bank Guarantee

(See Clause 7.1.1, 7.5.3 and 19.2)

Contents

Annex-I
(See Clause 7.1.1)
Performance Security

……
Authority……
Vijayawada.

WHEREAS:

(A) _____ [name and address of contractor] ("hereinafter called as Contractor") and [name and address of the Authority], (**"the Authority "**) have entered into an Agreement (the **"Agreement"**) for " Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India.

(B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period and Defects Liability Period (as defined in the Agreement) in a sum of Rs. …. Crore (Rupees …. Crore) (the "Guarantee Amount").

(C) We, ……...through our branch at ……. (the "Bank") have agreed to furnish this Bank guarantee (hereinafter called the "Guarantee") by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor's obligations during and under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the Authority, under the hand of an officer not below the rank of […….of Authority], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the Authority and the Contractor, or any Dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority , and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Agreement or for the fulfillment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.

7. Notwithstanding anything contained herein before, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.

8. The Performance Security shall cease to be in force and effect 90 (ninety) days after the end of the Defects Liability Period as set forth in Clauses 7.1

9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and Sealed this……. Day of ……. 20…….. at…….

SIGNED, SEALED AND DELIVERED

For and on behalf of the bank

By:(Signature)

Name Designation:

Code Number:

Address NOTES:

(i) The Bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex-II
(See Clause 7.5.3)
Form for Guarantee for Withdrawal of Retention

……..,
……...Authority,
Vijayawada

WHEREAS:

[Name and address of contractor] (hereinafter called "the Contractor") has executed an Agreement (hereinafter called the "Agreement") with the [name and address of the Authority], (hereinafter called "the Authority ") for the " Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India.

A. In accordance with the Clause 7.5.3 of the Agreement, whenever the amount of the retention money (hereinafter called "Retention Money") held by the Authority exceeds 1% (one per cent) of the Contract Price, the Contractor may, at its option, withdraw the Retention Money after furnishing to the Authority a Bank guarantee for an amount equal to the proposed withdrawal.

B. We, ……..through our branch at ……. (the "Bank") have agreed to furnish this Bank guarantee (hereinafter called the "Guarantee") for the amount of Rs. ……. (……. in words) (the "**Guarantee Amount"**).

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the Authority, under the hand of an officer not below the rank of […….of Authority], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the Authority and the Contractor, or any Dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority , and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Retention Money.

7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority

under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.

8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of then Defects Liability Period specified in Clauses 17.1 of the Agreement.

9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the end **** month in the year ***** or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and Sealed this……. Day of ……. 20……. at…….

SIGNED,SEALED AND DELIVERED

For and on behalf of the bank

By:(Signature)

Name Designation:

Code Number:

Address NOTES:

(i) The Bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annex-III

(See Clause 19.2)

Form for Guarantee for Advance Payment

……..,
…….. Authority,
Vijayawada

WHEREAS:

- [name and address of contractor] (hereinafter called "the Contractor") has executed an Agreement (hereinafter called the "Agreement") with the [name and address of the Authority], (hereinafter called "the Authority ") for the Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India.

i. Engineering Procurement and Construction (the "EPC") basis, subject to and in accordance with the provisions of the Agreement.

ii. in accordance with the Clause 19.2 of the Agreement the Authority shall make to the Contractor an interest bearing Advance Payment (hereinafter called "Advance Payment") equal to 10% (ten per cent) of the contract price for mobilization expenses and acquisition of equipment; and that the Advance Payment shall be made in three installments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled Bank for an amount equal to the 110% amount of each installment to remain effective till the complete and full repayment of the installment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement; and the amount of (first/second/third) installment of the Advance Payment is Rs. **** cr. (Rupees ***** crore) (the "Guarantee Amount").

iii. We, ……...through our branch at ……. (the "Bank") have agreed to furnish this Bank guarantee (hereinafter called the "Guarantee") for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid installment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority , upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the Authority, under the hand of an officer not below the rank of [……of Authority], that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the installment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the Authority and the Contractor, or any Dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority , and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have

the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Advance Payment.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities here-under.
8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of the one year from the date of payment of the installment of the Advance Payment, as set forth in Clause 19.2 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and Sealed this……. Day of ……. 20…….. at…….

SIGNED, SEALED AND DELIVERED

For and on behalf of the bank

By:(Signature)

Name Designation:

Code Number:

Address NOTES:

(i) The Bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Schedule H (Contract Price Weightages)

(See Clause 10.1.4 and 19.3)

Contents

1.0 The Contract Price for this Agreement is Rs…….

2.0 Proportions of the Contract Price for different stages of Construction of the Road and Utilities/Services shall be as specified below;

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
1	Investigation & Survey, Design, Approval of detailed engineering drawings, Preparation of BoQs.			0.5%
2	Road Works including Main Carriageway, BRT, Cycle Track, Footpath, Cross Drainage Structures, Junctions etc., but excluding Storm Water Drainage		(a) Earthworks upto Subgrade in Main Carriageway (MCW), BRT	11.31%
			(b) Sub Base and Granular Base Courses for MCW, BRT	
			(c) Bituminous works for MCW & BRT	
			(d) Cycle Track	
			(e) Side walk	
			(f) Junctions	
			(g) Culverts	
			(h) Bridges	
			(i) Foundation	
			(ii) Substructure	
			(iii) Superstructure including miscellaneous works	
			(i) Traffic signs, markings and appurtenances, Street Lighting, Plantation and all road furniture's & Facilities	
3	Storm Water Drainage		(a) Longitudinal Trunk Drains	8.29%
			(b) Median Drains of size 0.6m x 0.6m	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
			(c) Collecting chambers of 0.6m x 0.6m	
			(d) Man Holes	
			(e) Miscellaneous	
4	Potable Water with Head works		Intake well cum raw water pumping station along with Electro-mechanical items	65.87%
			Raw water raising main with surge protection system	
			Water Treatment Plant (190 MLD)	
			Semi Underground reservoir at WTP with pump house	
			Electro-mechanical items &surge protection system at WTP	
			Clear water pumping mains (MS & DI-K9) and additional pipelines for WTP & WDC connectivity.	
			Ring main isolation system(TCMS)	
			7 no. of Cushion tanks (ELSRs)	
			8 No. of SUGRs & pump houses along with Electro-mechanical items	
			RMS, BMS for WDCs, SUGRs & Cushion tanks & Electrical supply to Isolation valve electrical actuators in the entire network	
			WDC Ancillary Works	
			SCADA and Control system	
			Laying of the Trunk mains with DI K9 pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
			Laying of the Trunk mains with MS pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	
			Laying of the Distribution mains with DI K7 pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and also provision for bedding or encasing if required complete as per the approved drawing	
			All types of valves including valve actuators and valve chambers and Thrust blocks.	
			Laying of the 40mm dia. lubricated HDPE pipes along with specials complete as per the approved drawing along the Main Trunk	
			Miscellaneous	
5	Recycled water		a) Laying of the Trunk lines (DI K7, HDPE) with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	0.98%
			b) Laying of the Distribution lines (DI K7, HDPE) with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	
			c) Laying of the MDPE pipes for tapping from distribution with specials / saddles, complete as per the approved drawing	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
			d) Laying of the laterals (Drip pipes) in 3 rows, in each green zone, complete as per the approved drawing	
			e) All types of valves including valve actuators and valve chambers and Thrust blocks.	
			f) Miscellaneous	
6	Sewerage		a) Laying of the pipelines (DWC HDPE) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	3.89%
			b) Laying of the pipelines (Inner HAC lined DI K7 & K9) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	
			c) Laying of the pipelines (RCC NP4) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	
			d) Laying of the pipelines (Inner HAC lined DI K9) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	
			e) Manholes including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing	
			f) Miscellaneous	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
7	Power		a) RCC Power duct of size 4.28m x 4.40m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	4.89%
			b) RCC Power duct of size 4.28m x 4.0m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	
			c) RCC Power duct of size 4.28m x 3.15m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	
			d) RCC Power duct of size 3.40m x 3.15m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	
			e) RCC Power duct of size 2.50m x 2.80m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	
			f) RCC Power duct of size 2.00m x 2.50m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	
			g) RCC Power duct of size 1.50m x 2.50m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
			h) Laying of 225mm dia. HDPE Silicore Power ducts of given configuration including excavation, dewatering if required, filling, disposal of the surplus earth, placing of spacers, warning tapes, tiles including all complete as per drawing	
			i) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing	
			j) RCC Man holes including excavation, dewatering if required, filling, disposal of the surplus earth, cover including all accessories complete as per drawing	
			k) Miscellaneous	
8	ICT (Pipe Conduits)		a) Laying of 7-way 40mm multi ducts & 160mm HDPE pipes including excavation, dewatering if required, filling, disposal of the surplus earth, placing of spacers, warning tapes, tiles including all complete as per drawing	3.86%
			b) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing	
			c) Manholes including excavation, dewatering if required, filling, disposal of the surplus earth, cover including all accessories complete as per drawing	
			d) Miscellaneous	

Table 1				
S No	**Item**	**Weightage in percentage to the Contract Price**	**Stage for Payment**	**Percentage weightage**
9	Gas		a) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth, closing the pipe ends with brick work and provision for bedding complete as per the approved drawing	0.41%
10	Submission of Completion drawings (as built drawings), Preparation of O&M Manuals, Training the staff in batches, Trial run & Commissioning of the Utilities			-

3.0 Procedure of Estimating the Value of Work Done

3.1 Road Works (MCW & BRT), Cycle Track, Footpath, Cross Drainage Structures, Junctions etc., but excluding Storm Water Drainage.

Procedure for estimating the value of Road work done shall be as follows in Table 2

Table 2: Road Works		
Stage for Payment	**% of weightage**	**Payment procedure**
(a) Earthworks upto Subgrade in Main Carriageway (MCW), BRT	11.31%	Unit of measurement is linear length. Payment of each stage shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
(b) Sub Base and granular base courses for MCW, BRT		
(c) Bituminous works for MCW & BRT		
(d) Cycle Track: Including Earthworks, Subgrade, Sub Base, Base & Premix Carpet		
(e) Side walk: Including Earthworks, GSB, Concrete bed & Tiles		

Table 2: Road Works		
Stage for Payment	**% of weightage**	**Payment procedure**
(f) Junctions: Including Earthworks, Subgrade, Sub Base, Base & Bituminous Works		Cost of Two Completed Junctions shall be determined on pro rata with respect to the total number of Junctions. Payment shall be made on the completion of Two Junctions.
(g) Culverts: Pipe Culverts & Box Culverts		Cost of Two Completed Culvert shall be determined on pro rata with respect to the total number of Culverts. Payment shall be made on the completion of Two Culverts.
(h) Bridges		
(i) Foundation: On completion of the foundation work including foundations for wing and return walls		Cost of each Bridge shall be determined on pro rata basis with respect to the total linear length (m) of the Bridges. Payment shall be made on completion of each stage of a Bridge as per the weightage given in this table.
(ii) Substructure: On completion of abutments, piers up to the abutment/pier cap, wing walls, return walls, guide bunds, if any.		
(iii) Superstructure: On completion of the super structure in all respects including hand rails/crash barriers, tests on completion etc., complete in all respects.		
(i) Traffic signs, markings and appurtenances, Street Lighting, Plantation, and all road furniture's & Facilities		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.

3.2 Storm Water Drainage

Procedure for estimating the value of Storm Water work done shall be as follows in Table 3;

Table 3: Storm Water Drainage		
Stage for Payment	**% of weightage**	**Payment procedure**
(a) Longitudinal Trunk Drains - including Excavation, dewatering if required, refilling with Sand, disposal of surplus material, PCC bedding, Weep holes etc. complete as per the approved drawing	8.29%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
(b) Median Drains of size 0.6m x 0.6m		

Table 3: Storm Water Drainage		
Stage for Payment	**% of weightage**	**Payment procedure**
(c) Collecting Chambers: Laying of PVC pipes, Kerb inlets, Collecting chambers of 0.6m x 0.6m under grated inlets		
(d) Man Holes including Covers		

~~**3.3 EMP**~~

~~Procedure for estimating the value of EMP work done shall be as follows in Table 4;~~

~~Table 4: EMP~~		
~~**Stage for Payment**~~	~~**% of weightage**~~	~~**Payment procedure**~~
~~Environmental Protection measures as per Environmental Mitigation Plan~~		~~Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Twenty percent of the total length.~~

3.4 Potable Water with Headworks

Procedure for estimating the value of Potable Water work done shall be as follows in Table 5;

Table 5: Potable Water with Headworks		
Stage for Payment	**% of weightage**	**Payment procedure**
Intake well cum raw water pumping station along with Electro-mechanical items	4.07%	
Raw water raising main with surge protection system	0.78%	
Water Treatment Plant (190 MLD)	19.14%	
Semi Underground reservoir at WTP with Pump house	5.41%	
Electromechanical items & Surge protection system at WTP	5.58%	
Clear water pumping mains (MS & DI-K9) and additional pipelines for WTP & WDC connectivity.	1.06%	
Ring main isolation system (TCMS)	0.43%	
7 no. of Cushion tanks (ELSRs)	2.34%	

Table 5: Potable Water with Headworks		
Stage for Payment	**% of weightage**	**Payment procedure**
8 No. of SUGRs & pump houses along with Electro-mechanical items	3.01%	
RMS, BMS for WDcs, SUGRs & Cushion tanks & Electrical supply to Isolation valve electrical actuators in the entire network.	2.26%	
WDC Ancillary works	5.62%	
SCADA and Control system	1.61%	
Laying of the Trunk mains with DI K9 pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	14.54%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
Laying of the Trunk mains with MS pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Five percent of the total length.
Laying of the Distribution mains with DI K7 pipes with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
All types of valves including valve actuators and valve chambers and Thrust blocks.		
Laying of the 40mm dia. lubricated HDPE pipes along with specials complete as per the approved drawing along the Main Trunk		
Miscellaneous		

3.5 Recycled Water

Procedure for estimating the value of Recycled Water work done shall be as follows in Table 6;

Table 6: Recycled Water		
Stage for Payment	**% of weightage**	**Payment procedure**
a) Laying of the Trunk lines (DI K7, HDPE) with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	0.98%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
b) Laying of the Distribution lines (DI K7, HDPE) with specials including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing		
c) Laying of the MDPE pipes for tapping from distribution with specials / saddles, complete as per the approved drawing		
d) Laying of the PVC laterals in 3 rows, in each green zone, complete as per the approved drawing		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Twenty percent of the total length.
e) All types of valves including valve actuators and valve chambers and Thrust blocks.		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
f) Miscellaneous		

3.6 Sewerage

Procedure for estimating the value of Sewerage work done shall be as follows in Table 7;

Table 7: Sewerage		
Stage for Payment	**% of weightage**	**Payment procedure**
a) Laying of the pipelines (DWC) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing	3.89%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Twenty percent of the total length.

Table 7: Sewerage		
Stage for Payment	**% of weightage**	**Payment procedure**
b) Laying of the pipelines (RCC NP4) including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding or encasing if required complete as per the approved drawing		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
(c) Manholes including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing		Cost of Five completed manholes shall be determined on pro rata with respect to the total number of Manholes. Payment shall be made on the completion of Five Manholes.

3.7 Power

Procedure for estimating the value of Power work done shall be as follows in Table 8;

Table 8: Power		
Stage for Payment	**% of weightage**	**Payment procedure**
a) RCC Power duct of size 4.28m x 3.15m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing	4.89%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Five percent of the total length.
b) RCC Power duct of size 4.28m x 4.0m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing		
c) RCC Power duct of size 4.28m x 4.40m including excavation, dewatering if required, filling, disposal of the surplus earth including all accessories complete as per drawing		
d) Laying of 225mm dia HDPE Silicore Power ducts of given configuration including excavation, dewatering if required, filling, disposal of the surplus earth, placing of spacers, warning tapes, tiles including all complete as per drawing		Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
e) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing		
f) RCC Man holes including excavation, dewatering if required, filling, disposal of the surplus earth, cover including all accessories complete as per drawing		Cost of Five completed manholes shall be determined on pro rata with

Table 8: Power		
Stage for Payment	**% of weightage**	**Payment procedure**
		respect to the total number of Manholes. Payment shall be made on the completion of Five Manholes.
g) Miscellaneous		

3.8 ICT

Procedure for estimating the value of ICT work done shall be as follows in Table 9;

Table 9: ICT		
Stage for Payment	**% of weightage**	**Payment procedure**
a) Laying of 7way 40mm multi ducts 160mm HDPE pipes including excavation, dewatering if required, filling, disposal of the surplus earth, placing of spacers, warning tapes, tiles including all complete as per drawing	3.86%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of not less than Ten percent of the total length.
b) Laying of 7way 40mm multi ducts & 160mm HDPE pipes including excavation, dewatering if required, filling, disposal of the surplus earth, placing of spacers, warning tapes, tiles including all complete as per drawing		
c) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth and provision for bedding complete as per the approved drawing		
d) Manholes including excavation, dewatering if required, filling, disposal of the surplus earth, cover including all accessories complete as per drawing		Cost of Five completed manholes shall be determined on pro rata with respect to the total number of Manholes. Payment shall be made on the completion of Five Manholes.
e) Miscellaneous		

3.9 Gas

Procedure for estimating the value of Gas work done shall be as follows in Table 10;

Table 10: Gas		
Stage for Payment	**% of weightage**	**Payment procedure**
a) Laying of the RCC NP4 pipes at the crossings including excavation, dewatering if required, filling, disposal of the surplus earth,	0.41%	Unit of measurement is linear length. Payment shall be made on pro rata basis on completion of a stage in a length of

closing the pipe ends with brick work and provision for bedding complete as per the approved drawing		not less than Ten percent of the total length.

4.0 Procedure for payment for Maintenance

4.1 The cost for maintenance shall be as stated in Clause 14.1.1.

4.2 Payment for Maintenance shall be made in quarterly instalments in accordance with the provisions of Clause 19.7.

Schedule I – Drawings

Contents

1.0 Drawings

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Authority's Engineer, free of cost, all Drawings listed in **Appendix I-I** of this Schedule-I.

2.0 Additional Drawings

If the Authority's Engineer determines that for discharging its duties and functions under this Agreement, it requires any Drawings other than those listed in **Appendix I**, it may by notice require the Contractor to prepare and furnish such Drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such Drawings to the Authority's Engineer, as if such Drawings formed part of **Appendix I** of this Schedule-I.

Appendix I

(Schedule - I)

LIST OF DRAWINGS

All the Drawings that the Contractor is required to furnish under Clause 10.2 for the Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India are given in table below;

Table 1: List of Drawings

S. No.	Description	
1	**Road Works**	
	i	Drawings of horizontal alignment, vertical profile and cross sections
	ii	Drawings for all Minor Bridges
	ii	Drawings of cross drainage Works
	iii	Drawings of major junctions & minor junctions
	iv	Drawings of road furniture items including traffic signage, markings, safety barriers, etc.
		Other civil structures
2	**Utility Drawings**	
	i	LS, CS and Layout plans of water supply network with valves, fittings, specials and accessories.
	ii	Detail Structural drawing of all structures like valve chambers, thrust blocks etc.
	ii	LS, CS and Layout plans of recycled water supply network with valves, fittings, specials and accessories.
	iii	LS, CS and Layout plans of sewerage network with all appurtenance.
	iv	Detail Structural drawing of all structures like valve chambers, thrust blocks manholes and other civil structures etc.
3	**Standard Drawings**	
	i	Valve chambers
	ii	Thrust blocks
	iii	Trench Excavation details

S. No.	Description	
		Other civil structures
4	**Domestic and Industrial sewer**	
	i	RCC Man hole and Drop hole
	ii	House connection chambers
	iii	Pipe bedding details
	iv	Typical section of sewer trench
	v	Residential /Industrial network Drawing
		Other civil structures
5	**Storm water drainage network**	
	i	Storm water drainage layout plan
	ii	LS, CS and Layout plans of storm water network with all appurtenance
	iii	Primary Drainage network
	iv	Collection chamber
	vii	RCC storm water channels
	viii	Outfall structures
	ix	Other civil structures
6	**Power and ICT network**	
	i	LS, CS and Layout plans of Pipe Conduit sections of power and ICT network with all appurtenance.
	ii	LS, CS and Layout plans for the power RCC ducts along with ventilation shafts, entry and exit etc.
	iii	All GAD and Structural Drawings for all civil structures.
	iv	Other civil structures
7	**Street Lighting**	
	i	Schematic diagram for complete lighting system
	ii	SLD for complete lighting system
8	**Potable Water Supply – Headworks**	
	i.	Structural drawings for Intake well cum pump house, approach bridge and approach road along with architectural view.
	ii.	Structural drawings for WTP, SUGR at WTP, Clear water pump house at WTP along with architectural view.
	iii	Layout drawings of Intake well cum pump house, WTP, WDC with SUGRs & WDC with Cushion tanks
	iv	Process flow diagram & hydraulic flow diagram of WTP

S. No.	Description	
	v	Structural drawings of WDCs with SUGRs cum pump houses & Cushion tanks along with architectural view.
	vi	System Architecture drawings and P&ID drawings for Water supply SCADA system.
	vii.	Structural drawings for Indoor substation and SCADA control room at all locations
	viii	SLDs for Electrical components
	ix	Structural drawings for Chief Engineer bungalow, Plant Superintendent, Staff quarters, office buildings, Command Control Centre (C3), Guest house etc.
	x	Structural drawings for other civil structures

Schedule J – Project Completion Schedule

(See Clauses 10.3.2)

1 Project Completion Schedule

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the **Scheduled Completion Date**. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Authority of such compliance along with necessary particulars thereof.

Sr No	Milestone	Schedule
1	**Milestone 1**	To be completed within 6 months from the date of concluding agreement.
2	**Milestone 2**	Upon successful completion of milestone 1 whichever occurs later and shall be completed in 6 Months (i.e. 8 months from the date of concluding agreement)
3	**Milestone 3**	Upon successful completion of milestone 2 whichever occurs later and shall be completed in 6 Months. (i.e. 10 months from the date of concluding agreement)
Total Duration		18 Months from the date of concluding agreement.

2 Project Milestone-I

2.1 Project Milestone-I shall occur on the date falling on the 1st day from the Appointed Date (the "Project Milestone-I").

2.2 Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the Project Roads and Utilities and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 55% (Fifty-five per cent) of the Contract Price.

3 Project Milestone-II

3.1 Project Milestone-II shall occur on the date falling on the 241th day from the Appointed Date (the "Project Milestone-II").

3.2 Prior to the occurrence of Project Milestone-II, the Contractor shall have continued with construction of the Project Roads and Utilities and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 70% (Seventy per cent) of the Contract Price.

4 Project Milestone-III

4.1 Project Milestone-III shall occur on the date falling on the 301th day from the Appointed Date (the "Project Milestone-III").

4.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Project Roads and Utilities and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 80% (Eighty per cent) of the Contract Price.

5 Scheduled Completion Date

5.1 The Scheduled Completion Date shall occur on the 360th day from the Appointed Date.

5.2 On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

6 Extension of time

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

Schedule K - Tests on Completion

(See Clause 12.1.2)

Contents

1.0 Schedule for Tests

1.1 The Contractor shall, no later than 30 (thirty) days prior to the likely completion of Construction, notify the Authority's Engineer and the Authority of its intent to subject the Project components (roads and utilities / services and water supply head works) to Tests, and no later than 10 (ten) days prior to the actual date of Tests, furnish to the Authority's Engineer and the Authority detailed inventory and particulars of all Works and equipment forming part of Works at his own cost in presence of Authority engineer or his representative.

1.2 The Contractor shall notify the Authority's Engineer of its readiness to subject the Project components (roads and utilities / services) to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Authority's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Authority who may designate its representative to witness the Tests. The Authority's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12 and this Schedule-K and Schedule-D.

2.0 Tests

2.1 **Visual and physical test:** The Authority's Engineer shall conduct a visual and physical check of Construction to determine that all Works and equipment forming part thereof conform to the provisions of this Agreement.

2.2 **Riding quality test:** Riding quality of each lane of the carriageway shall be checked with the help of a calibrated bump integrator and the maximum permissible roughness for purposes of this Test shall be 1800 (Eighteen Hundred) mm for each kilometer.

2.3 **Tests for bridges:** All major and minor bridges shall be subjected to the rebound hammer and ultrasonic pulse velocity Tests, to be conducted in accordance with the procedure described in Special Report No. 17: 1996 of the IRC Highway Research Board on Non-destructive Testing Techniques, at two spots in every span, to be chosen at random by the Authority's Engineer. Bridges with a span of 15 (fifteen) meters or more shall also be subjected to load testing.

2.4 **Water Tightness test:** All hydraulic structures, such as sewer lines network, industrial network, joints, manholes etc. or any other liquid containers shall have to be tested for water tightness. The water tightness test shall be conducted as specified in IS: 4127-Latest revision.

2.5 **Water Tightness test:** Tests to be conducted for all civil structures (WTP, SUGRs, ELSRs etc.,) as per the latest revision of IS: 3370 (Part - 1)

2.6 **Water Tightness test for Manhole:** The entire height of the manhole shall be tested for water tightness as per CPHEEO Manual, by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and the drop-in water level not more than 50 mm per 24 hours shall be permitted.

2.7 **Hydraulic Test:** Fill the pipeline with water after it has been laid; bleed off any trapped air. Subject the lowest element in the system to a test pressure that is 1.5 times the design pressure should be maintained for a period (As per code) and check for any leakage. When, in the opinion of the engineer, local conditions require that the trenches be backfilled immediately after the pipe has been laid, apply the pressure test after backfilling has been completed but not sooner than a time which will allow sufficient curing of any concrete that may have been used. Typical minimum concrete curing times are 36 hours for early strengths and 7 days for normal strengths.

2.8 **Other Tests:** The Authority's Engineer may require the Contractor to carry out or cause to be carried additional Tests, in accordance with Good Industry Practice, for determining the compliance of the Project components (roads and utilities / services) with Standards and Specifications.

2.9 **Environmental audit:** The Authority's Engineer shall carry out a check to determine conformity of the Project components (roads and utilities / services) with the environmental requirements set forth in Applicable Laws and Applicable Permits.

2.10 **Safety Audit:** The Authority's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the Project components (roads and utilities/services) with the safety requirements and Good Industry Practice.

2.11 Visual and physical test for Street lighting covering pole, luminaire, power supply, grounding, communication between luminaire to control panel and central control system.

2.12 Installation testing including lighting performance verification.

2.13 All of the electrical equipment covered by this report shall be tested in accordance with all relevant design and installation standards and codes of practices. Routine and Type test reports shall be required as minimum. The contractor shall notify the engineer, in writing, when each Section of work is complete and whole of the work is completed. Each Section of the work and whole of the work shall be tested in accordance with all relevant design and installation standards and codes of practices.

3.0 Testing

3.1. This Sub-Clause shall apply to all tests on Plant, Materials and workmanship specified in the Contract.

The Contractor shall provide all apparatus, assistance, documents and other information, electricity, equipment, fuel, consumables, instruments, labor, materials, and suitably qualified and experienced staff, as are necessary to carry out the specified tests efficiently. The Contractor shall agree, with the Authority's Representative, the time and place for the specified testing of any Plant, Materials and other parts of the Works.

The Authority's Representative may vary the location or details of specified tests, or instruct the Contractor to carry out additional tests. If these varied or additional tests show that the tested Plant, Materials or workmanship is not in accordance with the Contract, the cost of carrying out this Variation shall be borne by the Contractor, notwithstanding other provisions of the Contract.

The Authority's Representative shall give Notice to the Contractor not less than 24 hours prior to the tests, of the Authority's Representative's intention to attend the tests. If the Authority's Representative does not attend at the time and place agreed the Contractor may proceed with the tests, unless otherwise instructed by the Authority's Representative, and the tests shall then be deemed to have been made in the Authority's Representative's presence.

The Contractor shall promptly forward to the Authority's Representative duly certified reports of the tests. When the specified tests have been passed, the Authority's Representative shall endorse the Contractor's test certificate, or Issue a certificate to him, to that effect. If the Authority's Representative has not attended the tests, he shall be deemed to have accepted the readings as accurate.

The Contractor shall carry out the Tests on Completion of Design-Build in accordance with this Clause.

The Contractor shall give Notice to the Authority's Representative not less than 21 days prior to the date after which the Contractor will be ready to carry out each of the Tests on Completion of Design-Build. Unless otherwise agreed, Tests on Completion of Design-Build shall be carried out within 14 days after this date, on such day or days as the Authority's Representative shall instruct.

Unless otherwise stated, the Tests on Completion of Design-Build shall be carried out in the following sequence and are further detailed in the Authority's Requirements:

Pre-commissioning tests, which shall include the appropriate inspections and ("dry" or "cold") functional tests to demonstrate that each item of Plant can safely undertake the next stage, (b); commissioning tests, which shall include the specified operational tests

to demonstrate that the Works or Section can be operated safely and as specified, under all available operating conditions; and trial operation, which shall demonstrate that the Works or Section perform reliably and in accordance with the Contract.

The Authority shall be the sole beneficiary of any revenue or benefit resulting from the Tests on Completion of Design-Build.

During trial operation, when the Works are operating under stable conditions, the Contractor shall give Notice to the Authority's Representative that the Works are ready for any other Tests on Completion of Design-Build, including performance tests to demonstrate whether the Works conform with criteria specified in the Authority's Requirements and with the Schedule of Guarantees.

Trial operation shall not constitute a commencement of the Operation Service. ~~The O&M shall only start after issue of Completion Certificate.~~

In considering the results of the Tests on Completion of Design-Build, the Authority's Representative shall make allowances for the effect of any use of the Works by the Authority on the performance or other characteristics of the Works. As soon as the Works, or a Section, have passed each of the Tests on Completion of Design-Build described in above sub-paragraph, the Contractor shall submit a report certified by the Contractor of the results of these Tests to the Authority's Engineer.

If the Tests on Completion of Design-Build are being unduly delayed by the Contractor, the Authority's Engineer may by Notice require the Contractor to carry out such Tests within 21 days after receiving the Notice. The Contractor shall carry out such Tests on the day or days within that period as the Contractor may fix and of which he shall give Notice to the Authority's Engineer.

If the Contractor fails to carry out the Tests on Completion of Design-Build within the period of 21 days, the Authority's Personnel may proceed with the Tests at the risk and cost of the Contractor. The Tests on Completion shall then be deemed to have been carried out in the presence of the Contractor and the results of the Tests shall be accepted as accurate.

If the Tests on Completion of Design-Build are being unduly delayed by the Authority, an extension of time shall be provided by the Authority for such delay, if the completion is or will be delayed.

\

Retesting of the Works

If the Works, or a Section, fail to pass the Tests on Completion of Design-Build, and the Authority's Engineer or the Contractor may require the failed Tests, and Tests on

Completion of Design-Build on any related work, to be repeated under the same terms and conditions.

Failure to Pass Tests on Completion of Design-Build

If the Works, or a Section, fail to pass the Tests on Completion of Design-Build repeated under above Sub-Clause [Retesting of the Works] the Authoritys Engineer shall be entitled to: order further repetition of tests on Completion of Design-Build under Sub-Clause (Retesting of the Works]; or If the Contractor fails to carry out any obligation under the Contract, the Authority's Engineer shall by Notice require the Contractor to make good the failure and to remedy it within the time specified in the said Notice.

4.0 Completion Certificate

4.1 Upon successful completion of Tests, the Authority's Engineer shall issue the Completion Certificate in accordance with the provisions of Article 12.

Schedule L – Provisional Certificate and Completion Certificate

Contents

Provisional Certificate

(See Clause 12.2)

- I, …….. (Name of the Authority's Engineer), acting as Authority's Engineer, under and in accordance with the Agreement dated …….... (the "**Agreement**"), for **"Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India**.through……. (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been undertaken to determine compliance of the Project..... with the provisions of the Agreement.

1. Construction Works that are incomplete on account of Time Extension have been specified in the Punch List appended hereto, and the Contractor has agreed and accepted that it shall complete all such Works in the time and manner set forth in the Agreement. In addition, certain minor Works are incomplete and these are not likely to cause Material inconvenience to the users of the Project ..... or other their safety. The contractor has agreed and accepted that as a condition of this Provisional Certificate, it shall complete such minor Works within 30 (thirty) days hereof. These minor Works have also been specified in the aforesaid Punch List.

2. In view of the foregoing, I am satisfied that that Project ..... can be safely and reliably placed in service of the users thereof, and in terms of the Agreement, the Project ..... is hereby provisionally declared fit for entry into operation on this the ……day of …….20 …..

ACCEPTED, SIGNED, SEALED AND DELIVERED

For and on behalf of

CONTRACTOR by

SIGNED, SEALED AND DELIVERED

For and on behalf of

Authority's Engineer by:

(Signature) (Signature)

Completion Certificate

(See Clause 12.4)

- I, …….. (Name of the Authority's Engineer), acting as Authority's Engineer, under and in accordance with the Agreement dated …….. (the "**Agreement**"), for "**Survey, Investigation, Design, Construction, Testing, Commissioning of smart infrastructure works of Additional lanes of Roads, Storm water Drains, Culverts, minor/major Bridges ,Water Supply including Headworks (Intake well, Raw water pumping main, Water treatment Plant, Cushion tanks , semi underground reservoirs, Integration with entire water supply and other Ancillary works), Sewerage Network, Power & ICT conduits, RCC duct for Power cables, Reuse water network ,Gas lines crossings, Cycle track, Street furniture and Avenue Plantation & 10 years O&M for Water supply including Headworks for Road E3 on EPC basis under Package-XV in Amaravati, the new Capital City of Andhra Pradesh state, India**.

through ……. (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been successfully undertaken to determine compliance of the Project ..... with the provisions of the Agreement, and I am satisfied that the Project ..... can be safely and reliably placed in service of the Users thereof.

1. It is certified that, in terms of the aforesaid Agreement, all Works forming part of Project Works have been completed, and the Project Works is hereby declared fit for entry into operation on this the ……..day of ……..20 …..

Authority's Engineer by: SIGNED, SEALED AND DELIVERED

For and on behalf of

(Signature) (Name)

(Designation) (Address)

Schedule M – Payment Reduction for Non-Compliance (Not used)

(See Clauses 17.2 &17.4)

Contents

Payment reduction for non-compliance with the Maintenance Requirements

1.1 Monthly lump sum payments for Maintenance shall be reduced in the case of non- compliance with the Maintenance Requirements set forth in Schedule-D and Schedule-E.

1.2 Any deduction made on account of non-compliance with the Maintenance Requirements shall not be paid even after compliance subsequently. The deduction shall continue to be made every month until compliance is done.

1.3 The Employer's Engineer shall calculate the amount of payment reduction on the basis of weightage in percentage or cost assigned to non-conforming items as defined in the Schedule-D

Schedule N - Selection of Employer's Engineer / Authority Engineer

(See Clause 18.1.1)

Contents

1. Selection of EMPLOYER's Engineer

1.1 The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an EMPLOYER's Engineer.

1.2 In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the EMPLOYER shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

2. Terms of Reference

The Terms of Reference for the EMPLOYER's Engineer (the "**TOR**") shall substantially conform with Annex 1 to this Schedule N.

3. Appointment of Government entity as EMPLOYER's Engineer

Notwithstanding anything to the contrary contained in this Schedule, the EMPLOYER may in its discretion appoint a government-owned entity as the EMPLOYER's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the EMPLOYER shall not be eligible for appointment as EMPLOYER's Engineer.

Annex – I

(Schedule - N)

Terms of Reference for Employer's Engineer

1.0 Scope

1.1 These Terms of Reference (the "**TOR**") for the EMPLOYER's Engineer are being specified pursuant to the EPC Agreement dated..... (the "**Agreement**), which has been entered into between the ……. Name of EMPLOYER (the "EMPLOYER") and ..... (the "**Contractor**") for "……
…….state on Engineering, Procurement & Construction (EPC)" Basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

1.2 The TOR shall apply to design, construction and maintenance of the Project Roads and Services

2.0 Definitions and interpretation

2.1 The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.

2.2 References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.

2.3 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Agreement shall apply, *mutatis mutandis*, to this TOR.

3.0 General

3.1 The EMPLOYER's Engineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.

3.2 The EMPLOYER's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the EMPLOYER before determining:

(a) any Time extension;
(b) any additional cost to be paid by the EMPLOYER to the Contractor;
(c) the Termination Payment; or
(d) any other matter which is not specified in (a), (b) or (c) above and which creates an obligation or liability on either Party for a sum exceeding Rs.5,000,000 (Rs. fifty lakh).

3.3 The EMPLOYER's Engineer shall submit regular periodic reports, at least once every month, to the EMPLOYER in respect of its duties and functions under this Agreement. Such reports shall be submitted by the EMPLOYER's Engineer within 10 (ten) days of the beginning of every month.

3.4 The EMPLOYER's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel provided, however, that it shall not delegate the authority to refer any matter for the EMPLOYER's prior approval in accordance with the provisions of Clause 18.2.

3.5 The EMPLOYER's Engineer shall aid and advise the EMPLOYER on any proposal for Change of Scope under Article 13.

3.6 In the event of any disagreement between the Parties regarding the meaning, scope and nature of Good Industry Practice, as set forth in any provision of the Agreement, the EMPLOYER's Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

4 .0 Construction Period

4.1 During the Construction Period, the EMPLOYER's Engineer shall review the Reports, Designs and Drawings furnished by the Contractor along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from borrow areas and quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1.6. The EMPLOYER's Engineer shall complete such review and send its observations to the EMPLOYER and the Contractor within 15 (fifteen) days of receipt of such Reports, Designs and Drawings; provided, however that in case of a Structure, the

aforesaid period of 15 (fifteen) days may be extended up to 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.

4.2 The EMPLOYER's Engineer shall review any revised Reports, Designs and Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Reports, Designs and Drawings.

4.3 The EMPLOYER's Engineer shall review the (a) Quality Assurance Plan (b) Health, Safety and Environmental Management Plan submitted by the Contractor and shall convey its comments to the Contractor within a period of 21 (twenty-one) days stating the modifications, if any, required thereto. The Employer's Engineer shall ensure the Contractor's Project Management requirements, BIM and CAD requirements regularly on a monthly basis to the Employer.

4.4 The EMPLOYER's Engineer shall complete the review of the methodology proposed to be adopted by the Contractor for executing the Works, and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.

4.5 Deleted.

4.6 The EMPLOYER's Engineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the EMPLOYER and the Contractor within 7 (seven) days of receipt of such report.

4.7 The EMPLOYER's Engineer shall inspect the Construction Works and the Project Roads and shall submit a monthly Inspection Report bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. In particular, the EMPLOYER's Engineer shall include in its Inspection Report, the compliance of the recommendations made by the Safety Consultant.

4.8 The EMPLOYER's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the EMPLOYER's Engineer may require.

4.9 For determining that the Works conform to Specifications and Standards, the EMPLOYER's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 4.9, the tests specified in the relevant Codes or any modification/substitution

thereof and standards for shall be deemed to be tests conforming to Good Industry Practice for quality assurance.

4.10 The EMPLOYER's Engineer shall test check at least 20 (twenty) percent of the quantity or number of tests prescribed for each category or type of test for quality control by the Contractor.

4.11 The timing of tests referred to in Paragraph 4.9, and the criteria for acceptance/ rejection of their results shall be determined by the EMPLOYER's Engineer in accordance with the Quality Control Manuals and/or the relevant Codes and Standards. The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own quality assurance in accordance with Good Industry Practice.

4.12 In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the EMPLOYER's Engineer shall require the Contractor to carry out remedial measures.

4.13 The EMPLOYER's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Project Works, whether because of an accident, unforeseeable event or otherwise; provided that incase of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.

4.14 In the event that the Contractor fails to achieve any of the Project Milestones, the EMPLOYER's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the EMPLOYER's Engineer shall determine that completion of the Project Works is not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the EMPLOYER's Engineer shall review the same and send its comments to the EMPLOYER and the Contractor forthwith.

4.15 The EMPLOYER's Engineer shall obtain from the Contractor two copies of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.4.

4.16 EMPLOYER's Engineer may recommend to the EMPLOYER suspension of the whole or part of the Works if the work threatens the safety of the Users and pedestrians. After the Contractor has carried out remedial measure, the EMPLOYER's Engineer shall inspect such remedial measures forthwith and make a report to the EMPLOYER recommending whether or not the suspension hereunder may be revoked.

4.17 In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the EMPLOYER's Engineer to inspect such works, the EMPLOYER's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the EMPLOYER forthwith, recommending whether or not such suspension may be revoked by the EMPLOYER.

4.18 The EMPLOYER's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 4.18 and all matters incidental thereto, the EMPLOYER's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

5.0 Maintenance Period

5.1 The EMPLOYER's Engineer shall aid and advise the Contractor in the preparation of its monthly Maintenance Programme and for this purpose carry out a joint monthly inspection with the Contractor.

5.2 The EMPLOYER's Engineer shall undertake regular inspections, at least once every month, to evaluate compliance with the Maintenance Requirements and submit a Maintenance Inspection Report to the EMPLOYER and the Contractor.

5.3 The EMPLOYER's Engineer shall specify the tests, if any, that the Contractor shall carry out, or cause to be carried out, for the purpose of determining that the Project Works is in conformity with the Maintenance Requirements. It shall monitor and review the results of such tests and the remedial measures, if any, taken by the Contractor in this behalf.

5.4 In respect of any defect or deficiency referred to in Paragraph 3 of Schedule-E, the EMPLOYER's Engineer shall, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards and shall also specify the time limit for repair or rectification of any deviation or deterioration beyond the permissible limit.

5.5 The EMPLOYER's Engineer shall examine the request of the Contractor for closure of any lane(s)/utilities lines of the Project Roads and/or Services for undertaking maintenance/repair thereof, and shall grant permission with such modifications, as it may deem necessary, within 5 (five) days of receiving a request from the Contractor. Upon expiry of the permitted period of closure, the EMPLOYER's Engineer shall monitor the reopening of such lane(s), and in case of delay, determine the Damages payable by the Contractor to the EMPLOYER under Clause 14.5.

6.0 Determination of costs and time

6.1 The EMPLOYER's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.

6.2 The EMPLOYER's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.

6.3 The EMPLOYER's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

7.0 Payments

7.1 The EMPLOYER's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the EMPLOYER's Engineer in accordance with the provisions of Clause 10.2.4 (d).

7.2 EMPLOYER's Engineer shall -

(a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and

(b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the EMPLOYER and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause19.10.

7.3 The EMPLOYER's Engineer shall, within 15 (fifteen) days of receipt of the Monthly Maintenance Statement from the Contractor pursuant to Clause19.6, verify the Contractor's monthly statement and certify the amount to be paid to the Contractor in accordance with the provisions of the Agreement.

7.4 The EMPLOYER's Engineer shall certify final payment within 30 (thirty) days of the receipt of the final payment statement of Maintenance in accordance with the provisions of Clause 19.16.

8.0 Other duties and functions

The EMPLOYER's Engineer shall perform all other duties and functions as specified in the Agreement.

9. 0 Miscellaneous

9.1 A copy of all communications, comments, instructions, Drawings or Documents sent by the EMPLOYER's Engineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the EMPLOYER's Engineer thereon, shall be furnished by the EMPLOYER's Engineer to the EMPLOYER forthwith.

9.2 The EMPLOYER's Engineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.

9.3 Within 90 (ninety) days of the Project Completion Date, the EMPLOYER's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the EMPLOYER, reflecting the Project ..... as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Project Works and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand them over to the EMPLOYER against receipt thereof.

9.4 The EMPLOYER's Engineer, if called upon by the EMPLOYER or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.

9.5 The EMPLOYER's Engineer shall inform the EMPLOYER and the Contractor of any event of Contractor's Default within one week of its occurrence.

9.6 The Employer’s Engineer, if called upon by the Employer, shall attend the meetings on Project reviews, discussions to be held at Employer office with required reports and presentations.

Schedule O – Insurance

Contents

1. Insurance during Construction Period

1.1. The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the last Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:

(a) Insurance of Works, Plant and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and

(b) Insurance for the Contractor's equipment brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.

(c) The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of issue of the last Completion Certificate, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire, terrorism and War and Riots Protection Insurance

1.2 The insurance under paragraph 1.1 (a) and (b) above shall cover the Authority and the Contractor against all loss or damage from whatsoever cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

1.3. "All risks of loss including theft of or damage to physical property and of personal injury and death which arise during and in consequence of the performance of the Contract other than the Exceptional Risks are the responsibility of the Contractor. Any loss not insured or not recovered (including policy excesses etc.) from insurers shall be borne by the Contractor. All insurances shall be in the joint name of contractor and the Authority. The contract shall maintain a Contractors All Risk Policy (CAR) for the entire duration of the contract including O&M period for the entire facility" The Contractor shall also take additional covers (Add-On covers) insurance like Third Party Liability, Surrounding properties, Clearance and Removal of debris, Cross liability, Express Freight, Extended Maintenance Cover up to Final Takeover, etc. The sum insured for such Add-On covers shall be decided by the CONTRACTOR based on his assessment and risk involved in the contract. Risks to be covered by insurance shall not be limited merely to the items mentioned above. The CONTRACTOR shall arrange for insurance of any other risks he may deem prudent, but the expenses thereof shall be to the account of the contractor only full plant. If

necessary, Transit and storage (all risks) insurance coverage for additional transit involved for sending equipment/material to Sub-Contractor/Fabricator's shop for fabrication/ reprocessing and receiving back at site shall be taken.

2. Insurance for Contractor's Defects Liability

The Contractor shall effect and maintain Insurance Cover for the Works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and arises from a cause occurring prior to the issue of Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

3. Insurance against injury to persons and damage to property

3.1 The Contractor shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Paragraph l and 2 of this Schedule or to any person (except persons insured under Clause 20.9), which may arise out of the Contractor's performance of this Agreement and occurring before the issue of the Performance Certificate. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences. The Insurance Cover shall be not less than: Rs. 20 Lakhs.

3.2 The insurance shall be extended to cover liability for all loss and damage to the Authority's property arising out of the Contractor's performance of this Agreement excluding:

(a) the Authority's right to have the Construction Works executed on, over, under, in or through any land, and to occupy this land for the Works; and
(b) Damage which is and unavoidable result of the Contractor's obligations to execute the Works.

4. Workmen Compensation Policy

5. Insurance to be in joint names

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the Authority.

Schedule P- CAD Requirement

(See Clause 3.1.7 K)

Annex – I

(Schedule - O)

CAD Guideline

1 OVERVIEW

Purpose

The primary goal of standardizing the use CAD is to create an environment for seamless integration/collaboration between all disciplines & business lines of all consultants/contractors regarding the use of CAD for production of any Drawing. The document will achieve this through setting out the Guideline for Drawing data production. This will then enable Drawing data to be incorporated into the ADCL GIS.

1.2 Application

This CAD standard shall be applied to all disciplines in all offices and design houses working in this Project. The scope of this document is to provide guidelines and procedures for adopting AutoCAD layering standards in preparing design and as-built Drawings for automated transference to ADCL GIS. This Guideline will address the following:

i. Layer assignments

ii. Standard symbols

iii. Layers and layer names

iv. Attributes to each future

v. Templates

vi. Color usage associated with line widths for all Highways and Utility Drawings.

The Guideline are to be applied for all Drawings from Concept through to As Built handover stage.

2 Filing and Storage of Drawings

2.1 Filing and Storage of Drawings

In order that the Project information is readily accessible it is essential that all Drawing data is filed and stored in a consistent and logical manner.

2.2 Electronic Copies

All electronic Drawing and sketch files associated with a particular Project shall be filed within the Project folder.

2.3 Folder Structure

The standard folder structure for CAD data is as shown in Figure 1 below, it adopts the Code of Practice BS1192:2007 on Common Data Environment for collaborative working.

Figure 1:

2.4 Folder Name: Project Number and Title

This can be under the main office or discipline folder, or, if the number of files would render lists unwieldy, then further sub-folder are permissible. Folder names are not to include any symbols.

2.5 Sub Folder Name: CAD

Contains Drawings and digital information organized as shown in Figure 1.

In a multi-disciplinary office, the main sub-folders defined below may be sub-divided as necessary into the relevant disciplines:

2.5.1 Sub Folder Name: WIP (Work in Progress)

Contains the current working Project Drawings and sketches. This is where all files currently in the iterative process of design have not yet been approved to be shared.

This folder shall contain further sub-folders which can be amended to suit Project requirements.

2.5.2 Sub Folder Name: Shared

Contains verified, checked and approved CAD data for use by others for reference. This folder will hold the Project specific Drawings such as title frames, references, images, etc.

This folder shall contain further sub-folders which can be amended to suit Project requirements

2.5.3 Sub Folder Name: Published

Contains all final published sheet files, figures or sketches. This folder must contain the last issued Models/Xrefs. Data filed in this area shall never be deleted or overwritten, but will remain until archived.

2.5.4 Sub Folder Name: Archive

Contains all previous issues and superseded data. This folder is to allow retrieval of previously issued Drawings at certain stages of design decisions. This folder will provide an audit trail of Documentation and changes through the life of the Project.

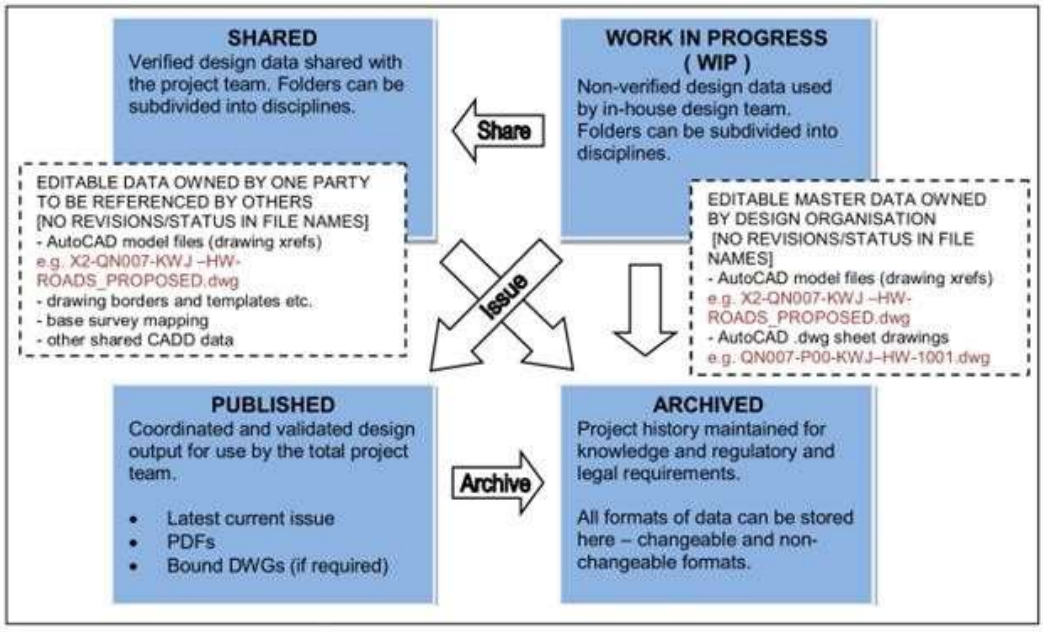
2.5.5 Sub Folder Name: Received

Contains read only copies of design data which have been received from Third Party sources or Stakeholders and will contain further sub-folders to identify the source and date of receipt.

The Received folder can be directly under the main Project folder structure, under CAD or wherever the Authority find it suitable. The vital concern is that a folder must be dedicated for incoming issues, where a full archive of all received information is stored with an audit trail that is related to the sending company and the date received and the current copy is easily identifiable throughout the Project.

2.6 Collaborative Working

Figure-2 Application of code of practice BS 1192:2007 on Common Data Environment (CDE)



i. Within WIP folder each discipline can create a folder structure to suit its needs.

ii. Common resource files such as title sheets, mapping, surveys, imagery and other shared CAD data must be available to all disciplines in the Shared area.

iii. Once data has been checked, verified and approved, it must be copied to the Shared area and other disciplines notified.

iv. When models are revised, or updated; other disciplines referencing the model will be affected, so effective communication between disciplines is essential.

v. When data files have been authorized and verified for issue, it is copied to the Published area, to maintain a local copy within the design organization's server.

vi. The previous version of the data in the Published area shall be moved to the Archive area as a historical record and to maintain an audit trail.

2.7 Hard Copies

The print containing the original stamped, checked and approved signatures becomes the hard-copy 'master plot' for the Drawing. See Section 3.3.13.

2.7.1 **Drawings**

The Project Implementation Plan (PIP) will define the area where the hard-copies for Projects are to be filed.

The electronic version of the master plot of the Drawing shall be known as the 'reference master'. The reference master, if required, shall be utilized for the electronic issue of the file.

Superseded master plots shall be retained and endorsed "superseded".

2.7.2 Check Prints

All completed and signed check prints shall be filed within the Drawing office by the drafting checker in an area in accordance with the Project Implementation Plan (PIP).

All check prints are to be retained at least for the term of the Project unless otherwise agreed with the AUTHORITY. No check prints are to be disposed of without the consent of the Project Manager.

3 DRAWING DEVELOPMENT

3.1 Drawing Numbering System

The Drawing numbers are to be entered into the Drawing register during creation of the Drawings so as to eliminate duplicate Drawing numbers being assigned. The Drawing number shall be unique for each Drawing and will normally be in the form:

Table 1

	Originator code		Project Name	-	Discipline / Drawing Type code		Document code	Drawing Number	-	Sheet No
Example	**ADCL**	**-**	**SIIMP**	**-**	**SWD**		**DWG**	**1001**	**-**	**001**
See Reference	3.1.1		3.1.2		3.1.3		3.1.4	3.1.5		

Fields will be separated by a hyphen **(-)**

3.1.1 Originator Code

A three-letter code to identify who prepared the Drawing. Refer to Appendix- C.

3.1.2 **Project Name**

Refer to Appendix C

3.1.3 **Drawing Type/ Discipline code**

Two letter codes to assist in identifying a discipline or type of Drawing (i.e. HW for Highways, ST for Structures, SK for Sketch, etc.). Refer to Appendix C.

3.1.4 **Document Code**

Two letter code to assist in identifying type of document. Refer to Appendix C.

3.1.5 **Drawing Number Code**

Four digits' sequential number for a specific Drawing type series. Refer to ***Appendix C.*** Subsequent issue of a Drawing shall have the revision coding incremented by the next sequential number or letter.

Note #3: Working Drawings shall not have the Drawing status and revision in the file name.

3.2 Model File (Xref) Naming

Model Files shall be named in accordance with the convention described below

Table 3

	Model type Identifier	Originator code		Project Name	-	Discipline code	-	Short Description
Example	D2	CRDA	-	**SIIMP**	-	**HW**	-	Proposed _Cen-tre_ line
See Reference	3.2.1	3.1.2		3.1.3		3.1.4		3.2.5

Example – CRDA – **SIIMP-WS - Proposed_Centre_Line**

3.2.1 **Model Identifier Code**

This code identifies the model file if it is in 2D or 3D Drawing as defined below:

Table 4

Description	Model Type Identifier
2D Model	D2
3D Model	D3

3.2.2 **Originator Code**

A three-letter code to identify the designer who prepared the Drawing. Refer to Appendix C.

3.2.3 **Project Name**

Refer to Appendix C

3.2.4 **Drawing Type/ Discipline code**

Two letter code to assist in identifying a discipline or type of Drawing (i.e. HW for Highways, ST for Structures, SK for Sketch, etc.). Refer to Appendix C.

3.2.5 **Short Description Field**

A short description of the model/X ref file. An underscore is to be used in place of any spaces in the description field.

Working models shall not have the Drawing status and revision in the file name.

3.3 Drawing Title Blocks and Signatures

A standard Drawing arrangement (Drawing border and title block) shall be adopted for all Drawings and shall be consistent across all Drawings within the Project. Title block entries shall be concise and informative to indicate fully the content of the Drawing.

3.3.1 **Drawing Title**

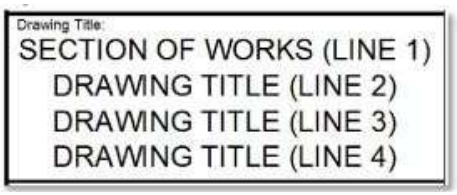
i) The top line shall identify the specific area or Section within the contract, i.e. "HIGHWAYS", or it may be left blank where no such area or Section exists.

ii) The second third and fourth lines shall identify the content or purpose of the Drawing, i.e. "TRAFFIC SIGNS AND ROAD MARKINGS"

iii) Where several Drawings depict similar detail and no other qualifications are available for distinguishing between them, the distinction shall be made by labelling each Drawing consecutively with sheet numbers, such as "SHEET 1 OF 10", "SHEET 2 OF 10", etc.

Figure 3

3.3.2 Drawing Status



The issue DRAWING STATUS box shown below (Figure 4) shall be completed to describe the current status of the Drawing. Refer to Table 5 for the list of Drawing status/stages:

Figure 4

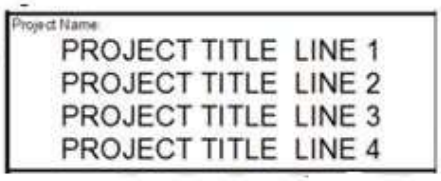
Table 5

Drawing Status
Concept Design
Preliminary Design
Detailed Design
Tender
Contract
As Built

3.3.3 Project Name Field

For Project Name refer to Baseline Assessment Report on detailed list of Projects.

Figure 5



3.3.4 Project Code Field

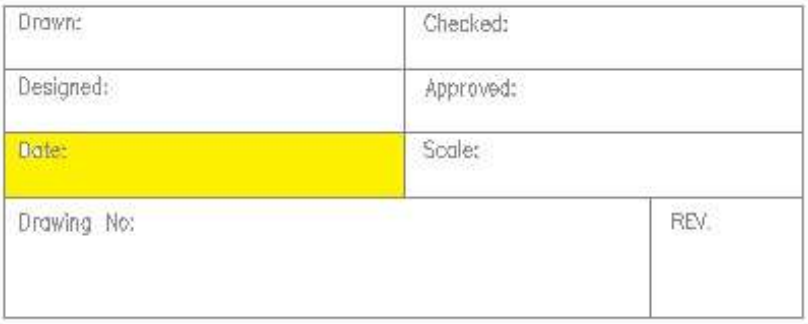
For AUTHORITY-specific Project codes refer to Baseline Assessment Report on detailed list of prioritized Projects.

Figure 6

3.3.5 Drawing Creation Date Field

The Drawing creation date shall be in the whole word format for **Month** and **Year** as highlighted below (Figure 7):

Figure 7



3.3.6 Revision History Table

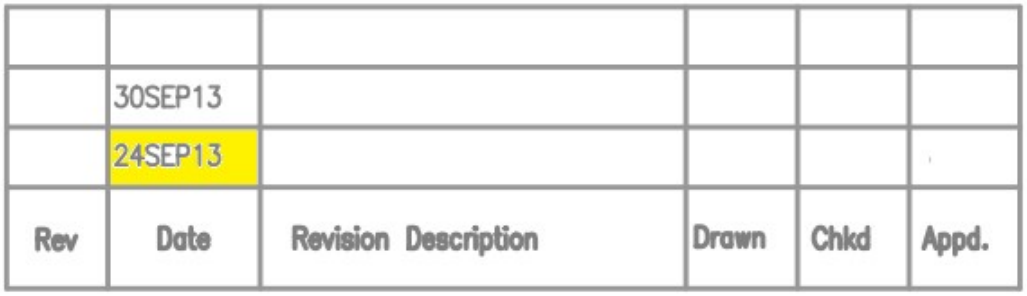
A concise description of each approved and issued revision shall be entered into the revision description column. The revision columns indicate the history and development of the Drawing; therefore, the description shall be as informative as is practical.

Drawings that are issued under specific Submissions or Milestones sets shall have clear, consistent revision description that states the purpose of the submission. e.g. **ISSUED FOR APPROVAL,** etc**.**

Figure 8

The date shown in the revision history table shall be in the format DDMMMYY as highlighted in Figure 9 below.

Figure 9



The months shall be abbreviated as shown in table 6 below:

Table 6

Abbreviation	Month	Abbreviation	Month
JAN	January	JUL	July
FEB	February	AUG	August
MAR	March	SEP	September
APR	April	OCT	October
MAY	May	NOV	November

JUN	June	DEC	December

The date of completion of the revision and the initials of the person effecting the revision shall be stated.

The earliest revision descriptions shall be deleted when there is no space to include the current revision within the revision column.

Drawn:	Checked:	
Designed:	Approved:	
Date:	SCALE (A1) : (A3) :	
Originator Drawing No:		
Project Drawing No:		REV.

3.3.7 **Drawing Number Field**

Drawing number field shall be completed as highlighted box below:

Figure 10

Refer to Section 3.1 for Drawing numbering convention.

3.3.8 **Revision Field Box**

Revision field box shall be completed as highlighted below: Refer to 3.10.3

Figure 11

3.3.9 **Name Fields**

The 'Drawn', 'Designed', 'Checked' and 'Approved' field boxes on the title block, as highlighted below, shall include the first name initial and the full last name of the person who performed or is responsible for the major portion of the work.

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.10 **Drawing Scale Field**

Figure 12

For completing the Drawing scale field box in the title frame, refer to Section 3.6. A scale bar for presenting the scale of the Drawing should be used in the Drawing layout.

Drawn:	Checked:
Designed:	Approved:
Date:	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

3.3.11 **Signatures**

Figure 13

The revision history table shall contain the current issue revision number, date of issue, Drafter/Author, Checker, Approver signatures or initials and description of current revision.

Table 7

TITLE BLOCK	CAD	HARD COPY	PDF COPY
DRAWN BY	See 3.3.12	See 3.3.13	See 3.3.14
CHECKED BY	See 3.3.12	See 3.3.13	See 3.3.14
APPROVER BY	See 3.3.12	See 3.3.13	See 3.3.14

3.3.12 **CAD Files**

When issued, Drawing files shall bear the typed CAD initials of the author, checker and approver on the revision history box.

Drawn:	K. RAVINDRA	Checked:	SATISH KAMRAJ
Designed:	RAM PRADEEP	Approved:	DR. KSSVV PRASAD
Date:	JANUARY 2017	SCALE	(A1) : (A3) :
Originator Drawing No:			
Project Drawing No:		REV.	

3.3.13 **Hard Copy**

Figure 14

The original hard copy set to be submitted shall be signed by hand and stamped. This set will become the control set for reference. The Drawing shall bear hand signature of the Drawing **Approver** beside his/her name in the

Approved field box on the title frame as shown in *Figure 15*. Each Drawing shall be stamped with the issuing company's official stamp.

Figure 15: Signed hard copy by Approver

Drawn: K. RAVINDRA	Checked: SATISH KAMRAJ
Designed: RAM PRADEEP	Approved: DR. KSSVV PRASAD
Date: JANUARY 2017	SCALE (A1) : (A3) :
Originator Drawing No:	
Project Drawing No:	REV.

Original hand-signed copy is required for all 'Final' Drawings submitted for: Concept design, Preliminary design, Detailed design, Tender set, Contract set, GFC Drawings (during Construction) and As Built.

Subsequent hard copies of the submitted original do not have to be hand signed. Scanned copies of the hand signed Drawing are permitted as long as the clarity of the Drawing is not compromised. Alternatively, copies may be printed directly from CAD. It is acceptable for these not to contain a copy of the hand signature, but to bear typed initials instead.

3.3.14 PDF Copy

When Issued, PDF copy can be generated electronically from the cad file bearing the typed initials of the author, checker and approver.

3.4 Units

All general Drawing work (e.g. Xrefs) are to be in model space and be produced in meters to three decimal places. Drawing borders to be in paper space and in millimeters.

e.g. **54.000**
78.720
0.325

Dimensions in meters and using whole numbers, can be expressed using the 'm' (meter) suffix as in the following

45.000m

The position of the decimal point shall be the same as a full stop and no space shall be left between the number and its units, to ensure clarity, as in the following example:

5.800m

All other non-linear measurements, e.g. areas and volumes, shall be followed by the unit symbol. The most common non-linear measurements are as follows

Square meter - **m^2**

Cubic meter - **m^3**

All detail Drawing work (e.g. standard details) is to be in model space and be produced in millimeters in whole numbers (i.e. no decimal places).

e.g. **10000**
787

Dimensions in millimeters using whole numbers, can be expressed using the 'mm' (millimeter) suffix as in the following

250mm

Chainages shall be in meters and written as shown

0+100 (Chainages in whole numbers can be written without the decimal accuracy)

15+255.345

Chainages are plan measurements taken along a setting out line, and provide a horizontal distance not taking into account slope lengths.

3.5 Drawing Sizes

Drawing sizes shall conform to the International Standards Organization (ISO). Sizes (in mm) are as follows: -

A0 – 1189 x 841
A1 – 841 x 594
A2 – 594 x 420
A3 – 420 x 297
A4 – 297 x 210

In general, all Drawings shall be produced at the preferred A1 original size. The use of A0 size Drawings shall be avoided wherever possible.

Each group or set of Drawings shall use only one Drawing size unless situations make this impractical.

3.6 Scales

Scales used on Drawings shall be selected as indicated in the table below. Only standard metric scales shall be used. In all cases, the selected scale shall be large enough to permit easy and clear interpretation of the information depicted.

Specific scale requirements of particular Drawings such as layouts will be as stated as per RFP.

Table 8

Permitted scales				
1:1	1:2		1:5	2:1
1:10	1:20	1:25	1:50	5:1
1:100	1:200	1:250	1:500	10:1
1:1000	1:2000	1:2500	1:5000	20:1
1:10,000	1:20,000	1:25,000	1:50,000	50:1

In exceptional cases where for functional reasons the recommended scale cannot be applied, intermediate scales may be chosen, provided that the required scale is of a whole number, such as 1:125, 1:150, etc.

The following scale notes shall be considered:

i. Number of scales on any one Drawing shall be kept to a minimum.

ii. CAD entities shall be drawn at full scale (1 Drawing unit = 1 Measurement unit). Final plotted scale shall be established during composition of the Drawing layout for plotting.

iii. Originators using AutoCAD shall employ the PAPER SPACE/MODEL SPACE facility to establish Drawing layout and scales. All Drawing entities shall reside in MODEL SPACE with the exception of view ports, general notes, revision clouding and its labels, title block and border.

iv. Where different scales exist, each scale shall be specified under the title of the area of the Drawing to which it applies and noted in the Title Block field as shown below.

Figure 16

v. Where a single scale is used on a Drawing, it shall be specified within the title block only. (See the object area and shall be large enough to below). The scales selected shall depend on the object area and shall be large enough to permit easy and clear interpretation of information and ensure clarity of prints on the original as well as reduced copies i.e. A3 versions of A1 Drawings.

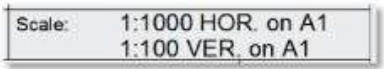
Figure 17

vi. Where different scales are used for horizontal and vertical dimensions, such as in profiles, each scale shall be clearly indicated on the Drawing as shown below:

Figure 18

vii. When the Drawing is not drawn to any scale, 'NTS' (Not to Scale) shall be placed in the title block as shown below:

Figure 19



Scale bars shall be shown on all Drawings containing plans.

3.7 Key Plan

Where layout plans are produced on a number of Drawings to cover the extent or Section of the Project, a Key Plan shall be included on each sheet, clearly indicating the Section of the Works under consideration. A dedicated box in the title frame is provided for the Key Plan as shown below.

Figure 20

3.8 Drawing Notes

Notes are to be numbered and positioned appropriately and shall include the following notes:

i. All Dimensions are in meters unless otherwise stated. (Only on Drawings drawn in meters)

ii. All levels are in meters (Only on Drawings where this note is applicable)

iii. All dimensions are in millimeters unless otherwise stated. (Only on Drawings drawn in millimeters)

3.9 General Notes

Where notes are, extensive and apply on several Drawings, a General Notes Drawing shall be provided which consolidates all notes. Deviation from these notes on a particular Drawing may be permitted, provided this amendment is shown in the Notes section of the Drawing.

Where a General Notes Drawing is used, the first note on each applicable Drawing shall contain the following statement: -

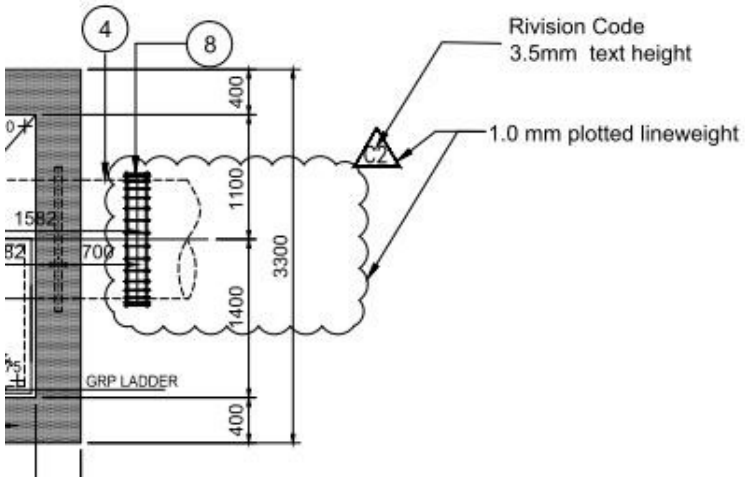
"1. FOR GENERAL NOTES, REFER TO DRAWING"

3.10 Drawing Revision

3.10.1 Revision Clouds and Triangles

Each area where changes/revisions made since the last issue / submission shall be ringed with a cloud and marked with an equilateral triangle containing the current revision letter. Revision clouds and its triangle label shall be placed on the paper space. Arc length of cloud shall be 15 as a general rule to maintain consistency.
Revision clouds shall be 1.0mm thick (gray or colour 252) and triangles shall be placed on layer REV.
Clouding and revision triangles denoting the previous revision shall be removed from the CAD file.

Figure 21



3.10.2 **Revision Description**

The date and description of the revision / issue shall be given in the revision history table on the title frame.

3.10.3 **Drawing Revision Code**

This code identifies the Drawing revision and shall be as defined in Table 11 below. Subsequent issue of a Drawing shall have the revision coding incremented by the next sequential number or letter.

Table 9

Revision / Issue Code
R01, R02, R03…. etc.

Note:

As Drawings move from one stage to another all historical revision history under that stage is to be removed from the revision history on the title block.

3.11 Drawing Register and Transmittal Record

The issue of Drawings shall be recorded on the Drawing register and a transmittal provided by Drawing originators containing like information. The Drawing register shall be a concise and continuous record of Drawing revisions and issue history.

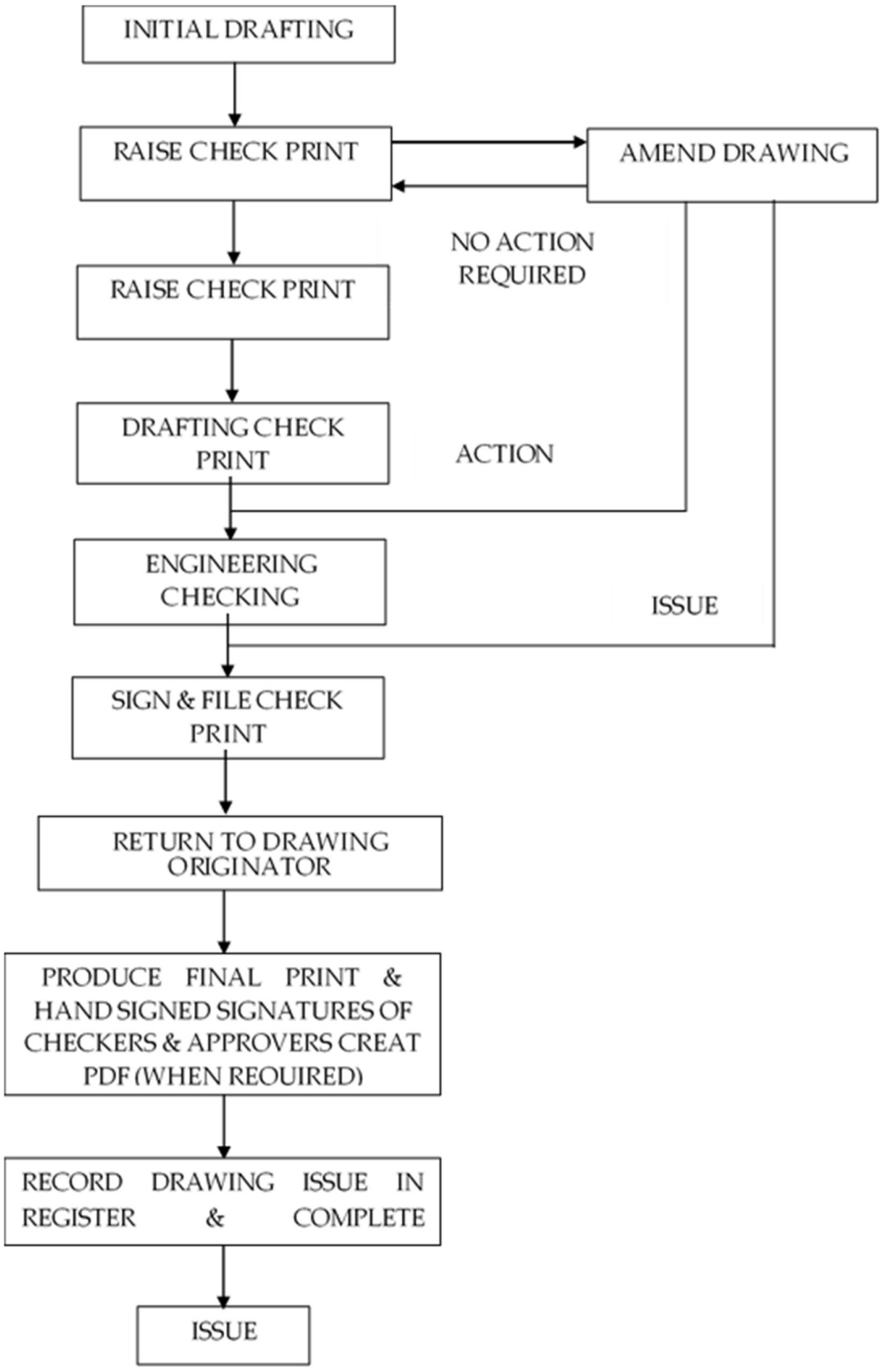
The current revision indicator shall be recorded for each issue.

3.12 Checking and Approval of Drawings

During Drawing production, a system of continuous checking shall be employed by the AUTHORITY to confirm that all CAD information fully complies with the conditions set out in this document.

It is imperative that all Drawings are subjected to a Quality Assurance and Quality Control (QA/QC) check and are duly signed and authorised prior to issue. Any Drawing leaving the Drawing office shall have been properly checked for presentation, clarity, accuracy, technical correctness and compliance with the relevant CAD Standard. Refer to the flow chart overleaf in *Figure 22* for an overview of the checking procedure.

Figure 22: **Flow diagram showing overview of CAD Drawing checking procedure**



3.12.1 **Self Check**

After preparation, the Drawing shall be checked by the Drawing originator and any required amendment to the Drawing is to be carried out prior to handing over the check print for checking.

3.12.2 **Drafting Check**

Generally, the Drafting Check must precede the Engineering Check.
The Drafting Check will normally be carried out by a person designated by the CAD Office representative/Manager.

The Drafting Check shall verify adherence to the Project Brief in conjunction with any applicable supplied criteria. The checker shall also make an assessment with respect to presentation, standard of workmanship and adherence to the CAD Standard Manual.

The Drafting Check shall, where deemed necessary, include an electronic check of the CAD File to ensure compliance with applicable standards and/or client requirements.

The check print shall be clearly marked by the checker with any required modifications.

Upon completion of the Drafting Check the checker shall then sign, date and highlight the required action to be taken.

Any amendment to the Drawing requirements may, if required, be carried out prior to the Engineering Check and a new print raised, duly stamped and signed.

3.12.3 **Engineering Check**

The Engineering check will normally be carried out by a competent and relevant experienced Senior Engineer within the AUTHORITY's organization.

The Engineering check shall verify adherence to the design calculations, design standards and associated Construction issues.

Upon completion of the Engineering Check, the checker shall then sign, date and highlight the required action to be taken.

3.12.4 **Further Drawing amendments**

Upon completion of the Drafting Check and Engineering Check the completed check print shall be returned to the originator of the Drawing for amendment of the Drawing. Where required, further check prints shall be raised and the checks repeated.

3.12.5 **Approval**

Upon completion of the checking process, a clean print of the Drawing shall be submitted to the relevant checkers for signature and to the designated authority for approval. This then becomes the controlled Drawing for reference. The checker's and approver's initials together with the relevant dates shall be entered in the appropriate areas of the CAD file.

4.1 Drawing set up

i. All AutoCAD Drawings should be produced & saved in AutoCAD version not lowers than 2009.

ii. Pre-defined Project Drawing templates will be used for setting the layers of identifiable Drawings (e.g. drainage, roads).

iii. Units in AutoCAD shall be set to meters for Infrastructure layouts and profiles and millimeters for detail Drawings such as standard details.

iv. The CAD files provided will be in the current version of AutoCAD file format used on the Project.

v. Fonts and line types are to be followed as provided in this manual.

vi. Files shall be purged before issue only.

vii. Drawing features/entities must be in model space. Title frames must be in paper space.

viii. The colour and line type of each entity is drawn on BY LAYER.

ix. All polygons shall be closed polylines.

x. Do not place entities on layer 0. This layer is for the creation of blocks only.

4.2 Line Work

4.2.1 Line Types

i. The following guidelines shall apply to the use of line types:

ii. LINETYPE to be set BYLAYER. (Deviation: Standard AutoCAD Blocks)

iii. All layers shall have their entities set to 'BYLAYER'

iv. All colours of AutoCAD objects to be BYLAYER. (Deviation: Standard AutoCAD Blocks)

v. The plotted appearance of line types shall be consistent across all Drawings.

vi. Modification of AutoCAD default source file is not permitted.

vii. Lines on a Drawing that cannot be represented by those in the default AutoCAD source file may be loaded from the approved Custom line types provided.

4.2.2 Line Weights

Table 10

Colour No.	Display Screen Color	Plotted Line Weight (mm)	Plotted Colour	
			ADCL_COL_A1.CT	ADCL_BW_A1.CT
1	RED	0.18	BLACK	BLACK
2	Yellow	0.25	BLACK	BLACK
3	Green	0.35	BLACK	BLACK
4	Cyan	0.50	BLACK	BLACK
5	Blue	0.70	BLACK	BLACK
6	Magenta	0.35	BLACK	BLACK
7	White	0.25	BLACK	BLACK
8	Dark Grey	0.20	Object Colour	Object
9	Light Grey	0.15	Object Colour	Colour
10	Object Colour	0.6	Object Colour	BLACK
11-79 & 81-249	Object Colour	0.35	Object Colour	BLACK
80	Object Colour	0.6	Object Colour	BLACK
250-255 (Greys)	Object Colour	0.15	Object Colour	Object Colour

4.3 Text

4.3.1 General

i. The AutoCAD Styles shall have a default height setting = 0.

ii. Sloping, italic, and elaborate fonts are not permitted.

iii. The objective shall be to make all lettering highly legible so that information can be communicated with the minimal possibility of error in reading. Lettering sizes shall be chosen such that it shall remain legible when Drawings are reduced to A3 size.

iv. Lettering shall be consistent, both in size and placement. Lettering sizes for specific applications, such as notes or titles, shall not vary within the same Drawing.

v. Lettering shall be uniform, clear, sharp and distinct. The mixing of lettering styles, sloping, italic, and elaborate fonts shall not be permitted.

vi. All text shall be regularly spaced, upright and uppercase and not be underlined. Deviation: Titles under plans, details etc. are to be underlined.

vii. All text shall be left justified. Deviation: Titles shall be centre justified and underlined.

viii. Specific notations shall be carefully placed so they relate to the portion of the Drawing or detail to which they apply.

ix. The placing of notes through Drawing lines is to be avoided.

x. Leader arrows relating to specific text or annotation shall be placed in model space with the detail it is referencing on the same layer as the text to which it relates.

4.3.2 Fonts

Permitted text fonts are as shown below:

Table 11

Auto CAD Style Name	Auto CAD Font File	CAD Usage
ISOCP	ISOCP.SHX	Technical/Engineering Drawings
ARIAL	ARIAL.TTF	Presentation Drawings

4.3.3 Text Assignments

The table below indicates approved texts with their appropriate colour/application assignments:

Table 12

Plotted Text Height (mm)	Width Factor	Plotted Line weight	Usage
1.8	1	0.18	General text, Dimensions, Notes – used on A3 & A4 only where Drawing is not plotted at a reduced scale.
2.5	1	0.25	General text annotations, Dimensions, Notes Special Notes
3.5	1	0.35	For more prominent notes or labels requiring special emphasis.
5.0	1	0.5	Normal Titles, Drawing Numbers, Section titles, Detail Titles
7.0	1	0.7	Major Titles

i. The preferred text height for general text and notes is 2.5mm.

ii. The text height adopted for a Project shall be consistent across all Drawings unless situations make this impractical.

4.4 Dimensioning

Automated dimensioning commands within CAD software programs shall be used for creation and editing of dimensions, as shown in table 16 below. The editing of dimension values via basic text editing commands is not permitted. Dimensions shall be associative and placed on their own unique layer.

Table 13

Dimension Text Height	Extension Line Offset	Extension Line Extension	Stack Off-set	Arrow Size	Centre Mark
2.5mm	Dimexo = 2	Dimexe = 2	Dimdli=6.25	Dimasz= 2.5	Dimcen = 1

4.5 Standard Symbols and Blocks

In order to promote consistency, standard symbols shall be utilized. All blocks are to be inserted into the Drawing on its appropriate Drawing layer. Where a symbol required is not available from the blocks provided with this manual, symbols compliant to International standards shall be used. These new blocks shall be submitted to AUTHORITY to update the list of standard symbols library for the programme.

All symbols shall be consistent within a Drawing or set of Drawings.

All blocks that need to be created as new blocks shall have all their elements saved on layer 0.

All symbols used within a Drawing must be defined using a legend.

4.6 Hatching

Wherever possible, all hatching created shall be associative and placed on its own unique layer. Exploding of hatches must be avoided.

4.7 Colours

In AutoCAD, entity colour shall be assigned “By Layer”. Deviation can be on standard blocks, i.e. are Road signs blocks where specific standard colours are assigned for each.

4.8 Layering

CAD Layering shall be in accordance with AUTHORITY AutoCAD Layering Standards as included in Appendix A of this document. Additional layers may be required

and the naming of such layers must be in the same format in accordance with AUTHORITY AutoCAD Layering Standards as shown in Section 4.8.1.

4.8.1 Layer Name Layout

Where new layers are to be created the AutoCAD layer naming convention is as follows:

1 2 3
RD_EX_CNRL

Where:
1 = Department Designator
2 = Status / Section Designator
3 = Feature / Entity Designator

Department Designator (Field 1)

This code identifies the AUTHORITY Department (i.e. B = Building Affairs, D = Drainage
Affairs and RD = Roads Affairs.)
Status / Section Designator (Field 2)

This code identifies the main classification of the type of element within a discipline. For example
‘’EX_SEW” describes as existing sewer.

Feature / Entity Designator (Field 3)

This code further identifies the entity description feature name. For example, ‘’ABD” describes as the abandoned sewerage network.

4.8.2 List of AUTHORITY Standard Layers

See Appendix A.

4.9 Models/Reference Files (Drefs)

i. Where CAD data is to be shared between Drawings the use of reference files is to be adopted.

ii. All reference files are to be inserted in model space with the UCS set to ‘world’. All files are to be inserted at 0,0,0.

iii. Unused reference files shall be detached upon completion of Drawings.

iv. The number of reference files on a Project shall be kept to a minimum.

v. The preferred method of attaching Drefs shall be Overlay option.

vi. Reference files shall be inserted on unique layer that does not conflict with the general content of the Drawing. (i.e. layer Z_DREF in AutoCAD).

vii. Reference files shall be "CLIPPED" within the Active Drawing sheet file to ensure that only the design data relevant to the Drawing is displayed.

viii. Reference files issued externally or shared between departments shall indicate revised areas with a revision cloud and triangle. A revision history shall be maintained within the reference file. In AutoCAD, the revision history log shall be placed in paper space, see Figure 29 below.

ix. For Model File Naming refer to Section 3.2

4.10 Plotting

The following standard colour source files shall be used:

Figure 23

Table 14

CAD REF: Z:\PROJECT\AITL\SIA\DRF\AARVEE-SIA-A1-TITLE-DEC 2014.dwg Last saved: 15 Dec 2014 11:45 AM

Colour	Black and White
Aarvee-CRDA--COL_A1.CTB	Aarvee-CRDA-BW_A1.CTB

This standard colour source file shall be flexible and can be adjusted to suit user's need during plotting. When Drawing, files are required, CTB file used for the plotting of the Drawing must also be submitted.

4.10.1 Date and File location update

These are field entities contained within the Drawing border and are used to print the date and time of print, file location, file name, etc.

4.11 Data Submission Standards

All Drawing files must conform to the AutoCAD layering standards set forth in this document.

4.11.1 **Submission**

Refer to Programme Management Information System (PMIS) and Document.

Management procedures on submission of Drawing.

4.11.2 **File Format**

Digital submittals shall be in PDF format & CAD format. DWG files must be in ZIP format when submitted in soft copy in CD. Also, refer to Document Management Procedures for submission of document.

Appendix A – AUTOCAD LAYERS DEFINITIONS

A.1 General Layers

CORE LAYERS NON-DISCIPLINE				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
Z_18TEXT	red	Continuous	0.18	TEXT AT RESPECTIVE HEIGHT
Z_25TEXT	white	Continuous	0.25	TEXT AT RESPECTIVE HEIGHT
Z_35TEXT	green	Continuous	0.35	TEXT AT RESPECTIVE HEIGHT
Z_50TEXT	cyan	Continuous	0.50	TEXT AT RESPECTIVE HEIGHT
Z_70TEXT	blue	Continuous	0.70	TEXT AT RESPECTIVE HEIGHT
Z_DIMS	red	Continuous	0.18	ALL DIMENSIONS
Z_DWG_GRID	251	Continuous	0.15	DESIGN ROAD FEATURE: GRID
Z_DWG_SHT	white	Continuous	0.25	DRAWING SHEET & TITLE BLOCK
Z_NORTH	green	Continuous	0.35	NORTH POINT
Z_REV	yellow	Continuous	0.25	REVISION CLOUD SAND TRIAN-GLE
Z_SECMK	green	Continuous	0.35	SECTION AND DETAIL MARKS
Z_XREF	white	Continuous	0.25	EXTERNAL REFERENCE (XREF)

GIS LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**

GIS_ACQ_BDRY	20	ACAD_ISO13W100	0.25	LAND AQUISITION BOUNDARY
GIS_CADAS-TRAL	red	Continuous	0.18	CADASTRAL PLOT

GIS LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
GIS_CNTRS	9	Continuous	0.15	CONTOURS
GIS_CNTRS_TEXT	red	Continuous	0.18	CONTOURS TEXT
GIS_CSTL	90	Continuous	0.35	COASTLINE
GIS_FLOWLINE	8	Continuous	0.20	FLOWLINES
GIS_PPLN	252	Continuous	0.15	POLICY PLAN
GIS_RD01	121	Continuous	0.35	MAJOR ROAD
GIS_RD02	151	Continuous	0.35	MINOR ROAD
GIS_RD03	181	Continuous	0.35	STREETS
GIS_ROW_BDRY	170	PHANTOM2	0.35	PROPOSED RIGHT OF WAY BOUNDARY
GIS_ZONE	13	Continuous	0.35	ZONE

A.2 Drainage layers

A.2.1 Surface Ground Water

PROPOSED SURFACE GROUND WATER (SGW)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
D_PR_SGW	80	SGW_PR	0.6	PROPOSED SURFACE GROUND WATER LINES
D_PR_SGW_ATT	white	Continuous	0.25	PROPOSED SGW ATTRIBUTES (ID, Diameter, Length, Material etc.)

PROPOSED SURFACE GROUND WATER (SGW)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
D_PR_SGW_DCH	90	Continuous	0.35	PROPOSED SGW DISCHARGE CHAMBER
D_PR_SGW_DT	yellow	Continuous	0.25	PROPOSED SGW DRAIN TRENCH
D_PR_SGW_FCH	90	Continuous	0.35	PROPOSED SGW FLUSHING CHAMBER
D_PR_SGW_FLOW	white	Continuous	0.25	ROPOSED SGW FLOW ARROW
D_PR_SGW_FMC	90	Continuous	0.35	PROPOSED SGW FLOWMETER CHAMBER
D_PR_SGW_GC	90	Continuous	0.35	PROPOSED SGW GULLY CON-NECTION
D_PR_SGW_GL	90	Continuous	0.35	PROPOSED SGW GULLY
D_PR_SGW_ICH	90	Continuous	0.35	PROPOSED SGW INSPECTION CHAMBER
D_PR_SGW_ITCH	90	Continuous	0.35	PROPOSED SGW INTAKE CHAMBER
D_PR_SGW_MH	90	Continuous	0.35	PROPOSED SGW MANHOLE

D_PR_SGW_MH_ATT	white	Continuous	0.25	PROPOSED SGW MANHOLE ATTRIBUTES (ID, Depth, Cov. Lvl, Inv. Lvl, etc)
D_PR_SGW_OFCH	90	Continuous	0.35	PROPOSED SGW OUTFALL CHAMBER
D_PR_SGW_PS	90	Continuous	0.35	PROPOSED SGW PUMP STATION
D_PR_SGW_RM	90	RM_PR	0.35	PROPOSED SGW RISING MAIN
D_PR_SGW_VALV	90	Continuous	0.35	PROPOSED SGW VALVE
D_PR_SGW_VC	90	Continuous	0.35	PROPOSED SGW VALVE CHAMBER
D_PR_SGW_WCH	90	Continuous	0.35	PROPOSED SGW WASHOUT CHAMBER

EXISTING SURFACE GROUND WATER (SGW)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
D_EX_SGW	96	SGW_EX	0.35	EXISTING SURFACE GROUND WATER LINES
D_EX_SGW_ATT	white	Continuous	0.25	EXISTING SGW ATTRIBUTES (ID, Diameter, Length, Material etc.)
D_EX_SGW_DCH	96	Continuous	0.35	EXISTING SGW DISCHARGE CHAMBER
D_EX_SGW_DT	yellow	Continuous	0.25	EXISTING SGW DRAIN TRENCH
D_EX_SGW_FCH	96	Continuous	0.35	EXISTING SGW FLUSHING CHAMBER
D_EX_SGW_FLOW	white	Continuous	0.25	ROPOSED SGW FLOW ARROW
D_EX_SGW_FMC	96	Continuous	0.35	EXISTING SGW FLOWMETER CHAMBER
D_EX_SGW_GC	96	HIDDEN2	0.35	EXISTING SGW GULLY CONNECTION
D_EX_SGW_GL	96	Continuous	0.35	EXISTING SGW GULLY

D_EX_SGW_ICH	96	Continuous	0.35	EXISTING SGW INSPECTION CHAMBER
D_EX_SGW_ITCH	96	Continuous	0.35	EXISTING SGW INTAKE CHAMBER
D_EX_SGW_MH	96	Continuous	0.35	EXISTING SGW MANHOLE
D_EX_SGW_MH_ATT	96	Continuous	0.35	EXISTING SGW MANHOLE ATTRIBUTES (ID, Depth, Cov. Lvl, Inv. Lvl, etc.)
D_EX_SGW_OFCH	96	DASHED2	0.25	EXISTING SGW OUTFALL CHAMBER
D_EX_SGW_PS	96	Continuous	0.35	EXISTINGSGW PUMP STATION
D_EX_SGW_RM	96	RM_EX	0.35	EXISTING SGW RISING MAIN
D_EX_SGW_VALV	96	Continuous	0.35	EXISTING SGW VALVE

EXISTING SURFACE GROUND WATER (SGW)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
D_EX_SGW_VC	96	Continuous	0.25	EXISTING SGW VALVE CHAMBER
D_EX_SGW_WCH	96	Continuous	0.25	EXISTING SGW WASHOUT CHAMBER

A.2.2 Domestic Sewage Water

PROPOSED DOMESTIC SEWAGE LINE				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line**	**Description**
SEW_DE_PSWR	242	SEW_PR	0.35	DESIGN SEWER FEATURE: PROPOSED SEWER LINES
SEW_DE_MH	242	Continuous	0.25	DESIGN SEWER FEATURE: MANHOLE
SEW_DE_SWPS	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE PUMPING STATION
SEW_DE_VSHFT	242	Continuous	0.25	DESIGN SEWER FEATURE: VENT SHAFT
SEW_DE_SCONN	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWER CONNECTION
SEW_DE_MHFC	242	Continuous	0.25	DESIGN SEWER FEATURE: MANHOLEFRAME & COVER
SEW_DE_STP	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE TREATMENT PLANT
SEW_DE_PM	242	Continuous	0.25	DESIGN SEWER FEATURE: SEWAGE PUMPING MAIN

A.2.3 Industrial Effluent Design Layers

PROPOSED INDUSTRIAL EFFLUENT				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
INEFF_DE_PINEF	white	Continuous	0.35	DESIGN INDUSTRIAL EFFLUENT FEATURE: PROPOSED INDUSTRIAL EFFLUENT
INEFF_DE_VSHFT	white	Continuous	0.25	DESIGN INDUSTRIAL EFFLUENT FEATURE: VENT SHAFT
INEFF_DE_IEPS	white	Continuous	0.25	DESIGN INDUSTRIAL EFFLUENT FEATURE: INDUSTRIAL EFFLUENT PUMPING STATION
INEFF_DE_SINLET	white	Continuous	0.25	DESIGN INDUSTRIAL EFFLUENT FEATURE: SECTONDARY TREATMENT PLANT INLET S
INEFF_DE_TERTIARY TREATMETN PLANT	white	Continuous	0.25	DESIGN INDUSTRIAL EFFLUENT FEATURE: TERTIARY TREATMENT PLANT

A.2.4 Potable Water

PROPOSED POTABLE WATER LINE				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
PW_DE_PWTM	Blue	Continuous	0.35	DESIGN POTABLE WATER FEATURE: POTABLE WATER TRANSMISSION MAIN
PW_DE_PWDIST	Blue	Continuous	0.25	DESIGNPOTABLE WATER FEATURE: POTABLE WATER DISTRIBUTION

PROPOSED POTABLE WATER LINE				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
PW_DE_PWPS	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER PUMPING STATION
PW_DE_VCH	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: VALVECHAMBER
PW_DE_FH	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: FIRE HYDRANT
PW_DE_POTRES	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER RESERVOIR
PW_DE_PWM	Blue	Continuous	0.25	DESIGN POTABLEWATER FEATURE: POTABLE WATER METER
PW_DE_PWFIT	Blue	Continuous	0.25	DESIGN POTABLE WATER FEATURE: POTABLE WATER FITTINGS

A.2.5 Recycled Water

PROPOSED RECYCLED WATER				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RW_DE_RWPM	Green	Continuous	0.35	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER PUMPING MAIN
RW_DE_RWDIST	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER DISTRIBUTION
RW_DE_RWPS	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER PUMPING STATION
RW_DE_RWRES	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER RESERVOIR
RW_DE_RWVCH	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER VALVE CHAMBER
RW_DE_RWFIT	Green	Continuous	0.025	DESIGN RECYCLED WATER FEATURE: RECYCLED WATER FITTINGS

A.3 ROAD LAYERS

A.3.1 Road Design Layers

PROPOSED ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_AFNCE	22	FENCELINE1	0.35	DESIGN ROAD FEATURE: ANI-MAL FENCE
RD_DE_BICYL	green	Continuous	0.35	BICYCLE LANE

PROPOSED ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_BRDG	yellow	Continuous	0.25	DESIGN ROAD FEATURE: BRIDGE FLYOVER
RD_DE_CHNL	red	HIDDEN2	0.18	DESIGN ROAD FEATURE: CHANNEL
RD_DE_CILND	green	Continuous	0.35	DESIGN ROAD FEATURE: ENTRAL/ROUNDABOUT IS-LAND
RD_DE_CLMN	red	Continuous	0.18	DESIGN ROAD FEATURE: COLUMN
RD_DE_CLVT	white	Continuous	0.25	DESIGN ROAD FEATURE: CULVERT
RD_DE_CNRL	red	CENTER2	0.18	DESIGN ROAD FEATURE: CENTERLINE
RD_DE_CSLPE	magenta	Continuous	0.35	DESIGN ROAD FEATURE: CONCRETE SLOPE PROTEC-TION
RD_DE_ECWAY	cyan	Continuous	0.5	DESIGN ROAD FEATURE: EDGE OF CARRIAGEWAY
RD_DE_FNCE	green	FENCELINE 2	0.35	DESIGN ROAD FEATURE: FENCE
RD_DE_FTPH	11	Continuous	0.35	DESIGN ROAD FEATURE: FOOTPATH
RD_DE_GRAIL	white	Continuous	0.25	DESIGN ROAD FEATURE: GUARD RAIL
RD_DE_ILND	green	HIDDEN2	0.35	DESIGN ROAD FEATURE: IS-LAND
RD_DE_JILND	green	Continuous	0.35	DESIGN ROAD FEATURE: JUNCTION ISLAND
RD_DE_KBDD	green	HIDDEN2	0.35	DESIGN ROAD FEATURE: DROPPED KERB
RD_DE_KBED	white	Continuous	0.25	DESIGN ROAD FEATURE: EDGE KERB
RD_DE_KBFL	yellow	DASHED2	0.25	DESIGN ROAD FEATURE: FLUSH KERB
RD_DE_KBRD	cyan	Continuous	0.5	DESIGN ROAD FEATURE: RAISED KERB

PROPOSED ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_LOW	blue	DASHDOT2	0.7	LIMIT OF WORKS
RD_DE_EMBK	yellow	Continuous	0.25	DESIGN ROAD FEATURE: EMBANKMENT
RD_DE_MEDIAN	green	Continuous	0.35	DESIGN ROAD FEATURE: MEDIAN
RD_DE_OTHR	red	Continuous	0.18	DESIGN ROAD DATA: OTHER INFORMATION
RD_DE_PBAY	green	Continuous	0.35	DESIGN ROAD FEATURE: PARKING BAY
RD_DE_PDCR	8	Continuous	0.2	DESIGN ROAD FEATURE: PEDESTRIAN CROSSING
RD_DE_PRAMP	green	Continuous	0.35	DESIGN ROAD FEATURE: PEDESTRIAN RAMP
RD_DE_PRKG	white	Continuous	0.25	DESIGN ROAD FEATURE: PARKING
RD_DE_PTS	yellow	Continuous	0.25	DESIGN ROAD DATA: IPS, CURVE POINTS ETC
RD_DE_PVMT	8	Continuous	0.2	DESIGN ROAD FEATURE: PAVEMENT (BITUMINOUS, CONCRETE ETC.)
RD_DE_RAILWAY	white	TRACKS	0.25	DESIGN ROAD FEATURE: RAILWAY
RD_DE_RAMP	yellow	Continuous	0.25	DESIGN ROAD FEATURE: RAMP
RD_DE_RLVL	white	Continuous	0.25	DESIGN ROAD FEATURE: ROAD LEVEL
RD_DE_RNDA	white	Continuous	0.25	DESIGN ROAD FEATURE: ROUND ABOUT
RD_DE_RSTL	white	Continuous	0.25	DESIGN ROAD FEATURE: ROAD SPEED TABLE
RD_DE_SHLDR	green	Continuous	0.35	DESIGN ROAD FEATURE: SHOULDER

PROPOSED ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_SPTR	20	Continuous	0.35	DESIGN ROAD FEATURE: ROAD

PROPOSED ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_UPSS	yellow	Continuous	0.25	DESIGN ROAD FEATURE: UNDERPASS TUNNEL
RD_DE_URARE A	40	DASHED2	0.35	DESIGN ROAD FEATURE: UTILITY RESERVE AREA
RD_DE_VBAR	magenta	Continuous	0.35	DESIGN ROAD FEATURE: VEHICLE BARRIER
RD_DE_VERGE	yellow	Continuous	0.25	DESIGN ROAD FEATURE: VERGE

EXISTING ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_AFNCE	22	FENCELINE1	0.35	EXISTING ROAD FEATURE: ANIMAL FENCE
RD_EX_BICYL	green	Continuous	0.35	BICYCLE LANE
RD_EX_BRDG	yellow	Continuous	0.25	EXISTING ROAD FEA-TURE: BRIDGE FLYOVER
RD_EX_CHNL	red	HIDDEN2	0.18	EXISTING ROAD FEATURE: CHANNEL

RD_EX_CILND	green	Continuous	0.35	EXISTING ROAD FEATURE: ENTRAL/ROUNDABOUT IS-LAND
RD_EX_CLMN	red	Continuous	0.18	EXISTING ROAD FEATURE: COLUMN
RD_EX_CLVT	white	Continuous	0.25	EXISTING ROAD FEATURE: CULVERT
RD_EX_CNRL	red	CENTER2	0.18	EXISTING ROAD FEATURE: CENTERLINE

EXISTING ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_CSLPE	magenta	Continuous	0.35	EXISTING ROAD FEATURE: CONCRETE SLOPE PROTEC-TION
RD_EX_ECWAY	cyan	Continuous	0.5	EXISTING ROAD FEATURE: EDGE OF CARRIAGEWAY
RD_EX_FNCE	green	FENCELINE2	0.35	EXISTING ROAD FEATURE: FENCE
RD_EX_FTPH	11	Continuous	0.35	EXISTING ROAD FEATURE: FOOTPATH
RD_EX_GRAIL	white	Continuous	0.25	EXISTING ROAD FEATURE: GUARD RAIL
RD_EX_ILND	green	HIDDEN2	0.35	EXISTING ROAD FEATURE: ISLAND
RD_EX_JILND	green	Continuous	0.35	EXISTING ROAD FEATURE: JUNCTION ISLAND
RD_EX_KBDD	green	HIDDEN2	0.35	EXISTING ROAD FEATURE: DROPPED KERB
RD_EX_KBED	white	Continuous	0.25	EXISTING ROAD FEATURE: EDGE KERB
RD_EX_KBFL	yellow	DASHED2	0.25	EXISTING ROAD FEATURE: FLUSH KERB
RD_EX_KBRD	cyan	Continuous	0.5	EXISTING ROAD FEATURE: RAISED KERB
RD_EX_LOW	blue	DASHDOT2	0.7	LIMIT OF WORKS

EXISTING ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_EMBK	yellow	Continuous	0.25	EXISTING ROAD FEATURE: EMBANKMENT
RD_EX_MEDIAN	green	Continuous	0.35	EXISTING ROAD FEATURE: MEDIAN
RD_EX_OTHR	red	Continuous	0.18	EXISTING ROAD DATA: OTHER INFORMATION
RD_EX_PBAY	green	Continuous	0.35	EXISTING ROAD FEATURE: PARKING BAY
RD_EX_PDCR	8	Continuous	0.2	EXISTING ROADFEATURE: PEDESTRIAN CROSSING

EXISTING ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_PRAMP	green	Continuous	0.35	EXISTING ROAD FEATURE: PEDESTRIAN RAMP
RD_EX_PRKG	white	Continuous	0.25	EXISTING ROAD FEATURE: PARKING
RD_EX_PTS	yellow	Continuous	0.25	EXISTING ROAD DATA: IPS, CURVE POINTS ETC
RD_EX_PVMT	8	Continuous	0.2	EXISTING ROAD FEATURE: PAVEMENT (BITUMINOUS, CONCRETE ETC.)
RD_EX_RAIL-WAY	white	TRACKS	0.25	EXISTING ROAD FEATURE: RAILWAY
RD_EX_RAMP	yellow	Continuous	0.25	EXISTING ROAD FEATURE: RAMP
RD_EX_RLVL	white	Continuous	0.25	EXISTING ROAD FEATURE: ROAD LEVEL
RD_EX_RNDA	white	Continuous	0.25	EXISTING ROAD FEATURE: ROUND ABOUT

EXISTING ROAD				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_RSTL	white	Continuous	0.25	EXISTING ROAD FEATURE: ROAD SPEED TABLE
RD_EX_SHLDR	green	Continuous	0.35	EXISTING ROAD FEATURE: SHOULDER
RD_EX_SPTR	20	Continuous	0.35	EXISTING ROAD FEATURE: ROAD SEPARATOR
RD_EX_UPSS	yellow	Continuous	0.25	EXISTING ROAD FEATURE: UNDERPASS TUNNEL
RD_EX_URAREA	40	DASHED2	0.35	EXISTING ROAD FEATURE: UTILITY RESERVE AREA
RD_EX_VBAR	magenta	Continuous	0.35	EXISTING ROAD FEATURE: VEHICLE BARRIER
RD_EX_VERGE	yellow	Continuous	0.25	EXISTING ROAD FEATURE: VERGE

A.3.2 Traffic and Safety

TRAFFIC & SAFETY - DESIGN				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_TS_BARL	green	Continuous	0.35	TRAFFIC: BARRIERS, RAILS & BOLLARDS
RD_DE_TS_CTRL-BOX	red	Continuous	0.18	TRAFFIC: CONTROL BOX OR SERVICE BOX
RD_DE_TS_DET-LOOP	8	Continuous	0.2	TRAFFIC: DETECTOR LOOP
RD_DE_TS_DUCT	30	Continuous	0.35	TRAFFIC: DUCT
RD_DE_TS_HMPL	8	Continuous	0.2	TRAFFIC: SPEED HUMP
RD_DE_TS_INCH	12	Continuous	0.35	TRAFFIC: INSPECTION CHAMBER
RD_DE_TS_MNHL	yellow	Continuous	0.25	TRAFFIC: MANHOLE
RD_DE_TS_OHLL	white	Continuous	0.25	TRAFFIC: OVERHEAD CABLE/LINE
RD_DE_TS_OTHR	yellow	Continuous	0.25	TRAFFIC: OTHER
RD_DE_TS_PBDG	31	Continuous	0.35	TRAFFIC: PEDESTRIAN BRIDGE
RD_DE_TS_PGR	40	Continuous	0.35	TRAFFIC: PEDESTRIAN GUARDRAIL
RD_DE_TS_PUP	13	Continuous	0.35	TRAFFIC: PEDESTRIAN UNDERPASS
RD_DE_TS_RDSN	yellow	Continuous	0.25	TRAFFIC: ROAD DIRECTIONAL SIGNS (EX: DIRECTIONS, LIMITS ETC.)
RD_DE_TS_SIGN	white	Continuous	0.25	TRAFFIC: SIGNS (EX: WARNINGS, SPEED LIMITS ETC.)
RD_DE_TS_SIGN-POST	white	Continuous	0.25	TRAFFIC: SIGN POST

TRAFFIC & SAFETY - DESIGN				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_TS_SIGNAL	white	Continuous	0.25	TRAFFIC SIGNAL
RD_DE_TS_SIGNAL-POST	white	Continuous	0.25	TRAFFIC SIGNAL POST/POLE
RD_DE_TS_STNM	green	Continuous	0.35	TRAFFIC: STREET NAME POST/SIGN
RD_DE_TS_STUDS	8	Continuous	0.2	TRAFFIC: STUDS
RD_DE_TS_TEXT	white	Continuous	0.25	TRAFFIC: ANNOTATIONS / DESCRIPTIVE TEXT
RD_DE_TS_TPP	8	Continuous	0.2	TRAFFIC: POLICE PLAT-FORM
RD_DE_TS_UGLL	yellow	Continuous	0.25	TRAFFIC: UNDERGROUND CABLE/LINE

TRAFFIC & SAFETY - EXISTING				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_TS_BARL	green	Continuous	0.35	TRAFFIC: BARRIERS, RAILS & BOLLARDS
RD_EX_TS_CTRL-	red	Continu-	0.18	TRAFFIC: CONTROL BOX OR SERVICE BOX
RD_EX_TS_DET-LOOP	8	Continuous	0.2	TRAFFIC: DETECTOR LOOP
RD_EX_TS_DUCT	30	Continuous	0.35	TRAFFIC: DUCT
RD_EX_TS_HMPL	8	Continuous	0.2	TRAFFIC: SPEED HUMP
RD_EX_TS_INCH	12	Continuous	0.35	TRAFFIC: INSPECTION CHAM-BER
RD_EX_TS_MNHL	yellow	Continuous	0.25	TRAFFIC: MANHOLE

TRAFFIC & SAFETY - EXISTING				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_TS_OHLL	white	Continuous	0.25	TRAFFIC: OVERHEAD CABLE/LINE
RD_EX_TS_OTHR	yellow	Continuous	0.25	TRAFFIC: OTHER
RD_EX_TS_PBDG	31	Continuous	0.35	TRAFFIC: PEDESTRIAN BRIDGE
RD_EX_TS_PGR	40	Continuous	0.35	TRAFFIC: PEDESTRIAN GUARDRAIL

TRAFFIC & SAFETY - EXISTING				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_TS_PUP	13	Continuous	0.35	TRAFFIC: PEDESTRIAN UNDERPASS
RD_EX_TS_RDSN	yellow	Continuous	0.25	TRAFFIC: ROAD DIRECTIONAL SIGNS (EX: DIRECTIONS, LIMITS
RD_EX_TS_SIGN	white	Continuous	0.25	TRAFFIC: SIGNS (EX: WARNINGS, SPEED LIMITS ETC.)
RD_EX_TS_SIGN-POST	white	Continuous	0.25	TRAFFIC: SIGN POST
RD_EX_TS_SIGNAL	white	Continuous	0.25	TRAFFIC SIGNAL
RD_EX_TS_SIGNAL-POST	white	Continuous	0.25	TRAFFIC SIGNAL POST/POLE
RD_EX_TS_STNM	green	Continuous	0.35	TRAFFIC: STREET NAME POST/SIGN
RD_EX_TS_STUDS	8	Continuous	0.2	TRAFFIC: STUDS
RD_EX_TS_TEXT	white	Continuous	0.25	TRAFFIC: ANNOTATIONS /DESCRIPTIVE TEXT
RD_EX_TS_TPP	8	Continuous	0.2	TRAFFIC: POLICE PLATFORM
RD_EX_TS_UGLL	yellow	Continuous	0.25	TRAFFIC: UNDERGROUND CABLE/LINE

A.3.3 Street Lighting Layers

STREET LIGHTING - PROPOSED				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_ST_CBLE	cyan	Continuous	0.5	STREET LIGHTING CABLE

STREET LIGHTING - PROPOSED				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_DE_ST_DUCT	20	Continuous	0.35	STREET LIGHTING DUCT
RD_DE_ST_FDPL	magenta	Continuous	0.35	STREET LIGHTING FEEDER PILLAR
RD_DE_ST_POLE	yellow	Continuous	0.25	STREET LIGHTING POLE
RD_DE_ST_SUBSTN	cyan	Continuous	0.5	STREET LIGHTING SUBSTATION
RD_DE_ST_TEXT	white	Continuous	0.25	STREET LIGHTING ANNOTATION/TEXT

STREET LIGHTING - EXISTING				
Layer Name	**Screen Color**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_ST_CBLE	cyan	DASHED2	0.5	STREET LIGHTING CABLE
RD_EX_ST_DUCT	20	HIDDEN2	0.35	STREET LIGHTING DUCT
RD_EX_ST_FDPL	magenta	Continuous	0.35	STREET LIGHTING FEEDER PILLAR
RD_EX_ST_POLE	8	Continuous	0.25	STREET LIGHTING POLE
RD_EX_ST_SUBSTN	cyan	Continuous	0.5	STREET LIGHTING SUBSTATION

STREET LIGHTING - EXISTING				
Layer Name	**Screen Color**	**Line type**	**Plotted Line weight**	**Description**
RD_EX_ST_TEXT	white	Continuous	0.25	STREET LIGHTING ANNOTATION/TEXT

A.3.4 Road Furniture Layers

ROAD FURNITURE LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_F_BNCH	yellow	Continuous	0.25	ROAD/STREET FURNITURE: BENCH/SEAT
RD_F_LGHT	white	Continuous	0.25	ROAD/STREET FURNITURE: LIGHTING
RD_F_OTHR	white	Continuous	0.25	ROAD/STREET FURNITURE: OTHERS
RD_F_POLE	yellow	Continuous	0.25	ROAD/STREET FURNITURE: POLE
RD_F_TEXT	white	Continuous	0.25	ROAD/STREET FURNITURE: ANNOTATION/TEXT

A.3.5 Roads – Common Layers

(ROADS) - COMMON LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_C_25DASH	white	DASHED2	0.25	HIDDEN DETAILS
RD_C_25HID	white	HIDDEN2	0.25	HIDDEN DETAILS
RD_C_50OUT	cyan	Continuous	0.5	ALL CONCRETE OUTLINES IN SECTION

(ROADS) - COMMON LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_C_50REBARS	cyan	Continuous	0.5	REINFORCEMENTDETAILS
RD_C_CHAIN_TEXT	white	Continuous	0.25	CHAINAGE TEXT
RD_C_CHAIN_TICK	yellow	Continuous	0.25	CHAINAGE TICK MARK
RD_C_CONT_MAJR	8	Continuous	0.2	MAJOR CONTOUR

(ROADS) - COMMON LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_C_CONT_MINR	9	Continuous	0.15	MINOR CONTOUR
RD_C_COORD_GRID	252	Continuous	0.15	COORDINATE GRID
RD_C_CTRLINE	red	CENTER2	0.18	CENTRE LINE
RD_C_HATCH	red	Continuous	0.18	HATCH
RD_C_MATCH_LINE	blue	PHAN-TOM	0.7	SHEET CONTINUATION MATCH LINE
RD_C_PROF	cyan	DASHED2	0.5	PROFILES
RD_C_PROF-LINE	green	Continuous	0.35	PROFILE LINES
RD_C_PROF_GRID_MAJR	8	Continuous	0.2	PROFILE GRIDLINE @ MAJOR STATIONS
RD_C_PROF_GRID_MINOR	9	Continuous	0.15	PROFILE GRIDLINE @ MINOR STATIONS
RD_C_SPT_HGT	yellow	Continuous	0.25	SURVEYROAD FEATURE: SPOT HEIGHT MARKER && TEXT

(ROADS) - COMMON LAYERS				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
RD_C_SPT_NUM	yellow	Continuous	0.25	SURVEY ROAD FEATURE: SURVEY POINT NUMBER
RD_C_TABLE	white	Continuous	0.25	TABLES
RD_C_TEXT	white	Continuous	0.25	COMMON TEXT

A.3.6 Structures – Common Layers

STRUCTURES				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Descrip-tion**
BR_ABT	RED	Continuous	0.3	ABUTMENT
BR_BEARING	GREEN	Continuous	0.25	BEARING
BR_BH	11	Continuous	0.10	HATCH
BR_BR	160	Continuous	0.6	BOUNDARY
BR_CB	9	Continuous	0.25	CRASH BARRIER
BR_CEN	WHITE	Center	0.18	CENTER LINE
BR_DIM	MA-GENTA	Continuous	0.18	DIMENSION
BR_DS	200	Continuous	0.18	DRAINAGE SPOUT
BR_GEN	YELLOW	Continuous	0.30	STRUCTURE
BR_HIDDEN	8	HIDDEN	0.15	DOTTED / HIDDEN LINES
BR_MAIN	RED	Continuous	0.35	HEADING TEXT
BR_MARK	CYAN	Continuous	0.15	HAUNCH LINES

STRUCTURES				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Descrip-tion**
BR_PIER	RED	Continuous	0.25	PIER
BR_REINF	BLUE	Continuous	0.35	REINFORCEMENT
BR_TEXT	GREEN	Continuous	0.3	TEXT IN NOTES & DIMEN-SIONS
BR_TITLE	WHITE	Continuous	0.35	TITLE BLOCK

A.4 UTILITIES LAYERS

A.4.1 Electricity

(ELECTRICITY)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVE_11KV	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELEC-TRICITY): 11KV
SVE_132K	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELEC-TRICITY): 132KV
SVE_66KV	240	ACAD_ISO04W 100	0.35	SERVICES FIXTURES (ELECTRICITY): 66KV
SVE_ABDL	13	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY): ABANDONED LINE
SVE_DUCT	10	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY): ELECTRI CITY DUCT
SVE_ERTH_PIT	8	Continuous	0.2	SERVICES FIXTURES (ELECTRICITY): EARTH PIT

(ELECTRICITY)				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVE_FT_TEE	30	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY): ELECTRICAL FITTING TEE
SVE_LOWV	220	Continuous	0.35	SERVICES FIXTURES (ELEC-TRICITY): LOW VOLTAGE
SVE_MEDV	150	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY): MEDIUM VOLTAGE
SVE_MHLL	White	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): UTILITY/ MANHOLE
SVE_MNHL	White	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): MANHOLE
SVE_MRKR	White	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): MARKER

ELECTRICITY				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVE_OHLL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): OVERHEAD LINE
SVE_OTHR	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): OTHER
SVE_POLE	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): POST/POLE
SVE_PYLN	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): PYLON
SVE_SBOX	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): SERVICE BOX

ELECTRICITY				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVE_SJNT	green	Continuous	0.35	SERVICES FIXTURES (ELECTRICITY): ELECTRICAL STRAIGHT JOINT
SVE_SSTL	yellow	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): SUBSTATION
SVE_TEXT	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): ANNOTATION / TEXT
SVE_TRANSF	Cyan	Continuous	0.5	SERVICES FIXTURES (ELECTRICITY): TRANS-FORMER
SVE_UGLL	white	Continuous	0.25	SERVICES FIXTURES (ELECTRICITY): UNDER-GROUND LINE

A.4.2 Water

WATER				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVW_ABDL	13	Continuous	0.35	SERVICES FIXTURES (WATER): ABANDONED WATER LINE
SVW_BNDL	130	Continuous	0.35	SERVICES FIXTURES (WATER): BUND
SVW_CLR_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER): CHLORINATION POINT
SVW_CPRT	200	Continuous	0.35	SERVICES FIXTURES (WATER): CASING PROTECTION
SVW_DRKL	130	Continuous	0.35	SERVICES FIXTURES (WATER): DRINKING AREA

WATER				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVW_DUCT	30	Continuous	0.35	SERVICES FIXTURES (WATER): DUCT
SVW_FT_ADPTR	150	Continuous	0.35	SERVICES FIXTURES (WATER): FITTING ADAPTER
SVW_FT_BEND	150	Continuous	0.35	SERVICES FIXTURES (WATER): FITTING BEND
SVW_FT_ENDCAP	150	Continuous	0.35	SERVICES FIXTURES (WATER): FITTING ENDCAP
SVW_FT_RDCR	150	Continuous	0.35	SERVICES FIXTURES (WATER): FITTING REDUCER
SVW_FT_TEE	150	Continuous	0.35	SERVICES FIXTURES (WATER): FITTING TEE
SVW_GCHNL	200	Continuous	0.35	SERVICES FIXTURES (WATER): GRAVITY CHANNEL
SVW_GPIPE	200	Continuous	0.35	SERVICES FIXTURES (WATER): GRAVITY PIPE
SVW_HYDR	200	Continuous	0.35	SERVICES FIXTURES (WATER): HYDRANT
SVW_METER	200	Continuous	0.35	SERVICES FIXTURES (WATER): METER
SVW_MNHL	170	Continuous	0.35	SERVICES FIXTURES (WATER): MANHOLE
SVW_MRKR	130	Continuous	0.35	SERVICES FIXTURES (WATER): MARKER
SVW_PIPE	170	Continuous	0.35	SERVICES FIXTURES (WATER): WATER PIPE LINE
SVW_PUMP	200	Continuous	0.35	SERVICES FIXTURES (WATER): PUMP
SVW_SCSR	200	Continuous	0.35	SERVICES FIXTURES (WATER): SCADA SENSOR
SVW_SPIPE	200	Continuous	0.35	SERVICES FIXTURES (WATER): SERVICE PIPE

WATER				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVW_STRG_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER): STORAGE POINT
SVW_TANK	230	Continuous	0.35	SERVICES FIXTURES (WATER): TANK
SVW_TANK_FIL_PT	200	Continuous	0.35	SERVICES FIXTURES (WATER): TANKER FILLING POINT
SVW_TEXT	white	Continuous	0.25	SERVICES FIXTURES (WATER): ANNOTATION /TEXT
SVW_VALV	160	Continuous	0.35	SERVICES FIXTURES (WATER): WATER SLUICE VALVE, AIR VALVE, FLOW CONTROL VALVE, SERVICE VALVE, SYSTEM VALVEVALVE
SVW_WELL	200	Continuous	0.35	SERVICES FIXTURES (WATER): WELL
SVW_WFAC	200	Continuous	0.35	SERVICES FIXTURES (WATER): WATER FACILITY
SVW_WMAIN	170	DASH-DOT2	0.35	SERVICES FIXTURES (WATER): WATER MAIN
SVW_WSCON	200	Continuous	0.35	SERVICES FIXTURES (WATER): WATER SERVICE CONENCTION

A.4.3 Commercial

COMMERCIAL				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVC_TEXT	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): ANNOTATION / TEXT

SVC_SBDL	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): SIGNBOARD

COMMERCIAL				
Layer Name	**Screen Colour**	**Line type**	**Plotted Line weight**	**Description**
SVC_POLE	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): POST / POLE
SVC_OTHR	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): OTHER FEATURES
SVC_BBDL	30	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): BILLBOARD
SVC_BANK	white	Continuous	0.25	SERVICE FIXTURES (COMMERCIAL): ATM AND SIMILAR FEATURES

Appendix B – USEFUL TABLES FOR AUTOCAD

Table-1 Model Space Zoom XP Factors (Meters)

Scale of Drawing	Zoom XP Scale
1: 1000	1
1: 1250	0.8
1: 2500	0.4
1: 5000	0.2
1: 10000	0.1
1: 25000	0.04
1: 50000	0.02
1: 500	2
1: 200	5
1: 100	10
1: 50	20
1: 20	50
1: 10	100
1: 5	200
1: 2	500
1: 1	1000

Table-2 Model Space Zoom XP Factors (Millimeters)

Scale of Drawing	Zoom XP Scale
1: 500	0.002
1: 200	0.005
1: 100	0.01
1: 50	0.02
1: 20	0.05
1: 10	0.1

Scale of Drawing	Zoom XP Scale
1: 5	0.2
1: 2	0.5
1: 1	1

Table-3 Text Heights for use in Model Space (Meters)

Scale of Drawing	Factor (Multiply)	Text Height		
		0.25 Pen	**0.35 Pen**	**0.5 Pen**
1: 1000	1.00	2.5	3.5	5
1: 1250	1.25	3.125	4.375	6.25
1: 2500	2.50	6.25	8.75	12.5
1: 5000	5	12.5	17.5	25
1: 10000	10	25	35	50
1: 25000	25	62.5	87.5	125

Scale of Drawing	Factor (Multiply)	Text Height		
		0.25 Pen	**0.35 Pen**	**0.5 Pen**
1: 50000	50	125	175	250
1: 500	0.5	1.25	1.75	2.5
1: 200	0.2	0.5	0.7	1
1: 100	0.1	0.25	0.35	0.5
1: 50	0.05	0.125	0.175	0.25
1: 20	0.02	0.05	0.07	0.1

Scale of Drawing	Factor (Multiply)	Text Height		
1: 10	0.01	0.025	0.035	0.05
1: 5	0.005	0.0125	0.0175	0.025
1: 2	0.002	0.005	0.007	0.01
1: 1	0.001	0.0025	0.0035	0.005

Table-4 Text Heights for use in Model Space (Millimeters)

Scale of	Factor	Text Height		
		0.25 Pen	**0.35 Pen**	**0.5 Pen**
1: 500	500	500	1250	1750
1: 200	200	200	500	700
1: 100	100	100	250	350
1: 50	50	50	125	175
1: 20	20	20	50	70
1: 10	10	10	25	35
1: 5	5	5	12.5	17.5
1: 2	2	2	5	7
1: 1	1	1	2.5	3.5

Appendix C – DRAWING TYPE AND DRAWING NUMBER SERIES

Appendix C - Project Number

Zone-1	Project Codes
Amaravati Capital City	ACC

Appendix C Originator Code

Originator Code	Name
APCRDA	Andhra Pradesh Capital Region Development Authority
ADC	Amaravati Development Corporation
CH2MHILL	CH2MHill
AARVEE	Aarvee Associates

Appendix C Drawing Type Code

Document Code	Description
DWG	DRAWING
DL	DRAWING LIST

Appendix C Drawing Type and Drawing Number Series

Discipline/ Drawing Type	Title Series	Drawing No.
SK – Sketch Drawings	General Layouts and miscellaneous Drawings	0000 - 0249
	Geotechnical	0250 - 0499
	Highways	0500 - 0999
	Site Clearance	1000 -1499
	Traffic	1500 - 1999
	Street Lighting	2000 - 2499
	Fencing	2500 - 2999
	Grading	3000 - 3999
	Structures	4000 - 4999
	Utility Services Corridors	5000 - 5499
	Surface Water	5500 - 5999

Discipline/ Drawing Type	Title Series	Drawing No.
	Foul Sewer	6000 - 6499
	Treated Sewerage Effluent	6500 - 6999
	Potable Water	7000 - 7499
	Fire Water	7500 - 7999
	Electricity	8000 - 8499
GE - General	Drawing Lists	0001 - 0999

GT - Geotechnical	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999

	Standard & Miscellaneous Details	7000 - 7999
HW - Highways	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, District, Zone & Municipality	0001 - 0999
	Cross Sections (Detailed and Typical), Pavement	1000 - 1999
	Proposed Road Layout & Key Plan	2000 - 2999
	Setting Out Plan (Horizontal Alignment Plan)	3000 - 3999
	Road Profiles	4000 - 4999
	Junction Layout Plan and Levels	5000 - 5999
	Swept Path Analysis For Junctions	6000 - 6999
	Standard & Miscellaneous Details	7000 - 7999
	Detail Road Signs & Markings	8000 - 8999

Discipline/ Drawing Type	Title Series	Drawing No.
SC – Site Clearance	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Site Clearance Layout & Key plan	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999

TR-Traffic/ Transport	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Traffic Flow	1000 - 1999
	Bus Route	2000 - 2999
	Traffic Signal	3000 - 3999
	Traffic Management Plan	4000 - 4999
	Traffic Diversion Plan	5000 - 5999

	Standard & Miscellaneous Details	7000 - 7999

SL - Street Lighting	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Street Lighting Typical Cross Sections	
Discipline/ Drawing Type	**Title Series**	**Drawing No.**
	Street Lighting Layout & Key plan	2000 - 2999
	Electrical Work for Road Lighting and Traffic Signs	3000 - 3999
	Standard & Miscellaneous Details	7000 - 7999
FE – Fencing	General Notes, Abbreviations & Legends, Location plan, General Key Plan, etc.	0001 - 0999
	Fencing Layout & Key plan	2000 - 2999
	Standard & Miscellaneous Details	7000 - 7999

GR - Grading	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Existing Grading and Topographic Survey Layout Plan	1000 - 1999
	Proposed Grading Layout & Key plan	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999

Discipline/ Drawing Type	Title Series	Drawing No.

ST - Structures	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	GAD of Structures	1000 - 1999

	Standard & Miscellaneous Details	7000 - 7999

UC-Utility Services Corridor	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Utility Cross Sections	1000 - 1999
	Combined Utilities Plan Layout	2000 - 2999

	Standard & Miscellaneous Details	7000 - 7999

PW - Potable Water	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Potable Water Network Plan	
	Proposed Potable Water Layout & Key plan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999
	GAD of MBR and Pump Houses, SLD for the pumping arrangement from MBR, GAD of ESRs	4000 - 4999

	Standard & Miscellaneous Details	7000 - 7999
	SCADA system for Potable water distribution network	8000 - 8999
RW - Recycle Water	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Recycle Water Network Plan	1000 - 1999
	Proposed TSE Layout & Key plan	2000 - 2999

Discipline/ Drawing Type	Title Series	Drawing No.
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

	General Notes, Abbreviations & Legends, Location	0001 - 0999
	Sewer Collection Network	1000 - 1999

Discipline/ Drawing Type	Title Series	Drawing No.
FS - Foul Sewer/ Sewerage	Sewer Layout & Key plan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Detail	7000 - 7999
IE- Industrial Effluent	General Notes, Abbreviations & Legends, Location	0001 - 0999
	Industrial Effluent Network Plan	1000 - 1999
	Proposed Industrial Effluent Layout & Key plan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

SW - Surface Water	General Notes, Abbreviations & Legends, Location	0001 - 0999
	Surface Water Network Plan	1000 - 1999
	Proposed Surface Water Layout & Key plan	2000 - 2999
	Longitudinal Sections (Profiles)	3000 - 3999

	Standard & Miscellaneous Details	7000 - 7999

Discipline/ Drawing Type	Title Series	Drawing No.
EL - Electricity	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, Cluster layout, zoning etc.	0001 - 0999
	Sub-station & network Layout, Single line diagram, General Arrangement etc.	1000 - 1999
	Extra High Voltage Electricity Supply Layout & Key plan	2000 - 2999
	High Voltage Electricity Supply Layout & Key plan	3000 - 3999
	Medium Voltage Electricity Supply Layout & Key plan	4000 - 4999
	Low Voltage Electricity Supply Layout & Key plan	5000 - 5999
	Standard & Miscellaneous Details	7000 - 7999
		--

Discipline/ Drawing Type	Title Series	Drawing No.
EN - Environmental	General Notes, Abbreviations & Legends, Location Plan, General Key Plan, etc.	0001 - 0999
	Existing Site Features	1000 - 1999
	Sensitive Receptors	2000 - 2999
	Surveys & Investigations	3000 - 3999
	Monitoring Locations	4000 - 4999
	Standard & Miscellaneous Details	7000 - 7999
		--

Schedule Q- Guideline for Health, Safety and Environment Plan

The Contractor shall provide a General and Administrative HSE Procedures that will engage the welfare of labor, staff and others abiding by the rules and regulations and provide for records to the Authority.

The Contractor shall prepare specific HSE plans based on the specific construction procedures to be adopted specifically for this project to address complexity, safety and welfare of labor/staff/equipment as per the details given below.

Contents

1. HSE Standards

The Contractor shall ensure that all personnel engaged (including sub-contractors) with the project shall be conversant with and at all times comply with the HSE standards for the project. The HSE standards shall include the relevant India HSE legislation, relevant IS (Bureau of Indian Standards) & Project HSE documents. (documents prepared by the AUTHORITY with regards to HSE). See Annexure-I

i. LEGISLATION

For the purposes of the project relevant Indian HSE legislations shall apply to the project as dictated by the various Ministries including but not at the least – Ministry of Labor & Employment; Department of Labor – Government of Maharashtra; Ministry of Environment, Forest and Climate Change.

ii. HSE MANAGEMENT SYSTEM

The Contractor shall ensure that they will have an HSE policy and an HSE Management system (including safe work procedures) that is documented, visibly endorsed by the company's top management and implemented & maintained at the project.

The scope of the contractors HSE Management system (including safe work procedures) shall cover all areas of work on the project and shall include any work to be performed by the contractor personnel or any of their sub-contractor, interfaces with the Authority/Authority Engineer.

iii. HSE RISK MANAGEMENT

The Contractor shall ensure that they employ best practice methods and meet all legal requirements in identifying, assessing and controlling HSE hazards. They shall document these methods and the outcomes.

iv. HAZARD IDENTIFICATION AND CONTROL

The Contractor shall identify hazards and their control measures through a formal hazard identification process. The Contractor shall also ensure that they have a written safe work procedure for all the works to be undertaken on the project.

HSE ENFORCEMENT

The Authority shall have the right at any time to audit or inspect Contractor facilities, procedures, and safety management systems. The Contractor shall fully co-operate in such reviews and shall implement recommendations at its own cost where Project HSE Standards or statutory rules and regulations are contravened. Contractor shall ensure the timely closing out of issues raised via these HSE assessments.

The Authority will bring to the attention of Contractor any situation where the Authority observes, or is informed of, a contravention of the HSE rules and procedures or unsafe acts; or a situation where those contraventions or unsafe acts identified are not considered likely to present an immediate risk, but are likely to lead to injury, ill health or damage to the environment.

If the Authority observes, or is informed of, a contravention of the safety rules and procedures or unsafe acts, and if those contraventions or unsafe acts identified are considered likely to present an immediate risk to personnel, then they shall have the authority to stop such work until remedial actions have been addressed to prevent such unsafe acts from recurring.

If contraventions or unsafe acts persist or present an imminent risk of serious injury or ill health to the persons involved, Authority will have the right to stop work being performed and to order a suspension of the execution of any new work in that part or parts of the Works affected by Contractor's HSE violation or negligence. Contractor shall have no right to claim for any extension of time or to claim for compensation for the suspension of the work or for the waiving of the liquidated damages.

Contractor shall not resume provision of the Works affected until the Authority is satisfied that the non-compliance has been rectified.

all not be employed again on the project or any of the sites without the written approval of the AUTHORITY. The Contractor shall be responsible for enforcing the Site HSE Rules and Regulations upon its Subcontractors and all other persons entitled to be on any work sites.

1. ENVIRONMENTAL MANAGEMENT

The Contractor shall specify in their HSE plan measures applied to avoid harm to the environment.

2. HSE PERSONNEL

The Contractor shall ensure that adequate HSE personnel are appointed on the project. The Contractor shall ensure that all HSE personnel meet the requirements as dictated by the project HSE standards.

3. COMPETENCE AND TRAINING

The Contractor shall ensure that that all personnel are competent, capable and qualified to a level that allows them to work without creating unnecessary risk for themselves and others. All personnel shall have and maintain the necessary HSE competencies to perform work on the project to the required HSE standards.
The Contractor shall ensure that all supervisory personnel have formal training in supervisory activities and specialist HSE training to conduct their duties.

4. HSE ORIENTATION TRAINING

The Contractor shall ensure that all personnel working at the project receive an induction HSE training explaining the nature of the work, the hazards that may be encountered during the site work and the particular hazards attached to their own function within the operation on the first day of work on the project. The training shall cover the contents as detailed within the Project HSE standards.

The contractor shall ensure that any new personnel are informed in an equal manner.

5. INTERVENTION

The Contractor shall have implemented a system that assures competence (including HSE) of personnel...

The Contractor shall establish and agree with the Authority a key list of personnel undertakings taking HSE critical roles. The list shall identify these key individuals by name and by (key) role. For every role on this list, the contractor shall define minimum requirements for HSE competences and qualifications relevant to the work.

The Contractor shall have implemented a system that records the training of personnel. The Contractor shall keep training records up-to-date and shall furnish information about the system and/or records of training upon request by AUTHORITY.

1. MEDICAL FITNESS TO WORK

The contractor shall ensure that all personnel engaged on the project are medically fit for the job to be undertaken. Where required, the Contractor shall be able to demonstrate that personnel, selected for key positions are evaluated for their fitness to work on the project.

2. HSE COMMUNICATIONS AND MEETINGS

The Contractor shall ensure efficient and effective HSE communication and consultation with all personnel involved on the project. This includes but is not limited to toolbox meetings prior to the start of work, regular worksite HSE meetings with all parties involved (including subcontractors).

3. HSE PERFORMANCE REPORTING

The Contractor shall submit on a monthly basis an HSE performance report to the Authority. This report shall contain as a minimum the following data, as related to the project:

- A list, including a brief description, of all incidents (including near misses and potential incidents);
- Number of Fatalities (FAT);
- Number of Lost Workday Cases (LWC);
- Number of First Aid Cases (FAC);
- Number of Environmental Non-conformances;

The format & content for the HSE performance report shall be agreed with the Authority prior to the commencement of the project.

4. TARGET AND OBJECTIVE SETTING

The Contractors HSE goal shall be "Target Zero" to reflect the projects commitment to an accident free workplace. The Contractor's targets and objectives shall be focused on leading indicators and pro-active efforts to reduce the likelihood and severity of incidents.

5. HSE INCIDENT MANAGEMENT

The Contractor shall report any HSE incident and/or accident, related to contractor activities or personnel, to the Authority & National or Local authorities as required by relevant legislation.

The Contractor shall also notify the Authority immediately of any HSE incident, including near misses and significant potential incidents, arising from the contractors or sub-contractor's activities associated with the project, related to:

- Harm to contractor and or Sub Contractor personnel or Third Party;

- Harm to the environment,
- Damage to, or loss of, contractor or sub-contractor /Third party assets;
- Harm to Authority reputation.

The Contractor shall fully investigate any incidents on the project and cooperate with the AUTHORITY and participate as necessary in any investigation of HSE incidents as required by the project HSE standards.

6. EMERGENCY PREPAREDNESS AND RESPONSE

The Contractor shall maintain a documented, robust fit-for-purpose Emergency Response Plan for the project. The Contractor shall also provide fit-for-purpose survival equipment, first-aid equipment, life-saving equipment, fire-fighting equipment and oil/chemical spill equipment. The contractor shall ensure that involved personnel are trained and competent in its use.

The Contractor shall develop and maintain a programme of training and exercises to ensure competency of all individuals and teams involved in the emergency response teams in accordance with the project HSE standards.

7. HSE AUDITS, REVIEWS AND INSPECTIONS

The Contractor shall perform audits, reviews and inspections on the project as required by project HSE standards. During these audits, reviews and inspections, the Contractor shall verify that they have fulfilled any and all legal obligations, including conditions and stipulations in all relevant licenses, consents and permits and that the work on the project is performed in accordance.

The Contractor shall develop a detailed HSE inspection & audit schedule for the project and submit copies of the reports to the Authority.

8. HSE RECORDS

The Contractor shall retain all relevant HSE records resulting from work on the project in line with relevant legislation & project HSE standards.

9. SUB-CONTRACTOR MANAGEMENT

The Contractor shall ensure that all sub-contractors comply with all the HSE standards relevant to the project (including these conditions).

The Contractor shall be accountable for the sub-contractors HSE performance.

10. PROJECT HSE PLAN

The Contractor shall prepare and submit to the Authority a project HSE plan which covers all work under the project. This project HSE plan shall be reviewed by the Contractor at regular intervals of not less than 6 months.

11. SUBSTANCE ABUSE

The Contractor shall ensure that that all personnel working on the project do not at any time partake of, be under the influence of drugs, alcohol, sedatives or other similar intoxicating substances, other than for bona fide medical reasons.

Any personnel found contravening with the above will be removed from the project with immediate effect and handed over to the authorities.

Contractor HSE Plan Template

Contents

Template for Contractor HSE Plan

This plan is provided as a guidance template for the Contractor to include in their HSE plan. The sections mentioned in this HSE plan template will be the minimum standards that the Contractors HSE plan will be assessed against.

Table-1

Section No	Titles of sections	Details of what is required in each section
Contractor must ensure that these sections are included in their Construction HSE plan. The details in the sections are provided as guidance.		
SECTION 1 - PROJECT DETAILS		
1.1	Project Specific Details	Contractor to provide contact information for Key Contractor personnel. Contact information to include Name, Mobile number, email id. Key personnel include: • Contractor Project Director • Contractor Project manager • Contractor Construction manager • Contractor HSE Manager • Contractor General Foremen.
1.2	Details of other Consultants	Details as above of any consultants that the contractor may employ on the project.
1.3	Project Security	Contractor to detail the site security arrangements that will be in place on the project. Suggestions as below: • Site entrance control points • Identity card system • Vehicle barrier types • Visitors to site procedures • Delivery vehicle procedures • Vehicle parking restrictions • Need for 24hr cover etc.
1.4	Welfare Arrangements	Contractor to detail what arrangements will be made on site to ensure that appropriate welfare facilities are provided and maintained according to the size of the workforce and nature of the work.

		As a minimum, an assessment must be carried out to determine specific welfare requirements and arrangements throughout the project, from day one to the last day persons are on site. Consideration must be given to any requirements for male / female changing, showers or disabled facilities, etc. Details to be included: • What type and size of facilities are required, • When they will be operational, • State what the initial set up is and what the subsequent set up will be • Where they are located. Produce clear layout drawing • Who provides and maintains each facility. • Expected standards and monitoring requirements.
1.5	Project Organization Chart	Contractor to include a detailed organization chart with names, designations & contact numbers for the project.
1.6	Arrangements for communication	Contractor to detail how they plan to communicate HSE with the different parties on the project. For example, what kinds of HSE meetings will be held on the project, how often, who will attend etc. Suggestions HSE Communication include: • Regular team meeting. • Tool box talks • Trainings
1.7	Project Goals	Contractor to detail what are the project HSE goals.
1.8	HSE Compliance monitoring	Contractor to detail how HSE compliance monitoring will be conducted, who will conduct, how often this will be conducted.
1.9	Senior Management HSE monitoring	Contractor to detail how Senior management on the project will be involved in HSE monitoring, How often will they be involved, what is the process.
SECTION 2 - INFORMATION AND TRAINING FOR PEOPLE ON SITE		
2.1	Inductions & Trainings	Contractor to detail the methods by which they will check that people on site have been satisfactorily inducted & trained. Suggestions include: - • Arrangements for delivery – i.e. who does the induction? Who does the training? • Arrangements by which management are informed of new starters;

		• Arrangements for recording of inductions/trainings? • Any passes, or other identification issued after induction • Arrangements for re-induction or safety updating as the contract enters a new phase or persons are transferred to a different section. • What are the training arrangements for the project?
2.2	Site Safety Rules	Contractor to detail what site safety rules will be developed or is available for the project.
SECTION 3 - CONTRACTOR MANAGEMENT		
3.1	Selection of Contractors	Contractor to detail how they will select sub-contractors on the project. • How will they ensure that only competent HSE contractors are on site • How do they plan to communicate HSE issues with the sub-contractors • How do they plan to coordinate the works with the sub-contractors
3.2	Selection of Plant	Contractor to detail how they will ensure that only safe plant & equipment is bought to the project. • How will they check the plant & equipment • How often • Who will check
SECTION 4 - EMERGENCY PROCEDURES		
4.1	First Aid	• Contractor to detail what are the first aid arrangements that will be made on site. For example: • Locations of first aid boxes • Names of First aid personnel and their locations • Location of First Aid room • Numbers of First Aider's required • Location of accident book
4.2	Fire and Emergency Procedures	Contractor to detail what are the fire safety arrangements that will be available on site. For example: • Fire points – How many, where will they be located

		• What kind of extinguishers will be available • What kind of training will be available • What will the emergency actions be for the project
4.3	Accident & Incident reporting	Contractor to detail what are the accident & incident reporting procedures for the project. For example: • How will accidents be reported? • To whom? • Who will coordinate? • How will they be recorded?
SECTION 5 - ARRANGEMENTS FOR CONTROLLING SIGNIFICANT SITE RISKS		
5.1	Production of Method Statements	Contractor to detail how method statements will be checked for HSE hazards & risks?
5.2	Risk Assessments	Contractor to detail how risk assessments will be produced? • Who will produce these? • How will they be reviewed? • Methods of communicating to the workforce on the content of the risk assessments? • How will sub-contractor risk assessments be checked for the above?
SECTION 6 - ENVIRONMENTAL MANAGEMENT		
6.1	Environmental Management Strategy	The contractor to detail how they plan to manage the environmental aspects of the project. Suggestions include: • Environmental management plan. • Project specific Environmental processes • Environmental aspects & impact register
6.2	Waste Management Planning	Contractor to detail how they plan to manage waste (construction, hazardous & non-hazardous). Suggestion include: • How will waste be collected on site? • How do they plan to dispose the waste? • Who will dispose it, where?

6.3	Environmental Emergency plans	Contractor to detail what are the environmental emergency plans for the project. Suggestion include: • Who will initiate action? • Who will report? To whom? • What are the foreseen emergencies?

Annexure- I: Construction HSE Management procedures

(Schedule – P)

SECTION 1: INTRODUCTION

This document describes how Health, Safety & Environment (HSE) will be managed on the Project. This document is provided to ensure that the appointed Contractor, understand the HSE standards on the programme. This document should be read along with the ADCL 'Health Safety Environment Execution Plan' (PMC-657466-HSE-S01-PRC-015).

- The standards laid down by this document is mandatory for all on the Project.
- The Contractor must familiarize themselves with these standards and also ensure that these standards are adhered to by any subcontractors/suppliers and any self-employed persons working within their workforce.
- These standards will assist the contractor in their planning and provision of satisfactory HSE resources on projects.
- These standards will be audited in accordance with set performance measurement procedures as per specific audit schedule completed for every project.
- Poor or non-compliance with these standards may result in the contractor being removed from the project.

1.1 PURPOSE

The purpose of this document is to provide a systematic framework to:

- Implement & Manage HSE on the Project.
- Achieve the overall HSE objectives of the Project.
- Ensure open and transparent communication of HSE on Project.

1.2 LEGAL AND OTHER REQUIREMENTS

The Contractor shall comply with all local legislations, and HSE requirements. Where legal requirements conflict with those set out in any other HSE document, the more stringent requirement will apply.

All works will be carried out in compliance with the HSE rules, acts & regulations set out by the following:

- The Government of India, Ministry of Labour & Employment (http://labour.gov.in/)
- Department of Labour – Government of Maharashtra (https://mahakamgar.maharashtra.gov.in/index.htm)
- Ministry of Environment, Forest and Climate Change (http://www.moef.nic.in/)
- Bureau of Indian Standards (http://www.bis.gov.in/index.asp)
- Contractually specified international standards and codes of practice
- Relevant industry standards and guidelines
- Contractual standards, procedures, and work instructions

2. MANAGEMENT STRUCTURE, APPOINTMENTS AND RESPONSIBILITIES

2.1 MANAGEMENT RESPONSIBILITIES

2.1.1 CONTRACTOR SENIOR MANAGEMENT RESPONSIBILITIES

- Ensure and maintain the HSE of all those who are affected by the Project.
- Ensure that the arrangements and resources on the Project are adequate and reviewed as necessary.
- Maintain a reporting structure for HSE matters and ensure that reporting lines and responsibilities of line management are clearly defined.
- Attend or support appropriate HSE management or steering groups as necessary.
- Ensure that HSE is the first agenda point of all meetings
- Ensure that resources are available to maintain an effective HSE performance, including budgetary, suitably trained staff and competent staff with clear lines of command and responsibility.
- Carry out HSE tours on a regularly defined basis.
- Be aware of the principles of the current HSE legislation and developments and ensure that their staffs are aware of their accountability for HSE.
- Ensure that all accidents and incidents reported on the Project are fully investigated and actions closed out.
- Ensure that appropriate support has been offered to those affected by incidents.
- **All Contractor Senior Management will lead by example.**

2.1.2 CONTRACTOR LINE MANAGEMENT RESPONSIBILITIES

- Be aware of the HSE requirements of applicable to the Project.
- Ensure that during planning, construction and production, maintenance and repair, sufficient allowance is made for safe systems of work, adequate welfare facilities & supervision.
- Ensure that the management team is adequately staffed with suitably trained and experienced personnel with clearly understood and defined responsibilities that allow for close and effective supervision of operations.
- Ensure that a competent staff member will be present at all times when work is being undertaken under their control.
- Liaise with their HSE team on Project HSE requirements.
- Ensure that they understand the requirements of the Project HSE Plans & Procedures and that the plan is communicated and implemented effectively on site.
- Ensure that safety critical appointments are made in writing and persons appointed are suitable for the role.
- Arrange/chair/attend the site HSE meetings.
- Ensure that overall and specific risk assessments & method statements are produced, submitted and communicated to relevant parties on time.
- Implement HSE systems to remove confusion over areas of responsibilities.
- Ensure that work is carried out as planned, relevant legislation is complied with and that high standards of professionalism, site tidiness and access are maintained at all times.
- Ensure inspection and monitoring under their areas of control are carried out and any action points raised are closed out.
- Commend those who maintain high standards of HSE and discipline those who consistently fail to achieve the required standard.
- Ensure that legal requirements relating to the involvement of the workforce are implemented to promote HSE compliance.
- Review reporting and investigation of all accidents, dangerous occurrence and environmental incidents in conjunction with HSE staff and ensure that appropriate remedial actions are taken to prevent recurrence

All Contractor Line Management must set and lead by example

2.1.3 RESPONSIBILITIES OF CONTRACTOR SUPERVISORS

- Be familiar with legal principles, safe working practices, method statements, risk assessments applicable to their work and ensure they are enforced.
- Incorporate HSE instruction in their routine orders and see that they are carried out.
- Suitably brief men under their control so that work is carried out in a safe & controlled manner without undue risks.
- Avoid improvisation or deviation from method statements & risk assessments for tasks being undertaken.
- Ensure that all operatives are trained for the task in which they are engaged.

- Ensure that new employees are inducted and made aware of the hazards and controls in their workplace.
- Ensure that project employees not under their direct control are protected from the consequences of the work under them.
- Check plant & equipment and ensure that they are in good working order.
- Ensure that all operatives are provided with appropriate PPE for the tasks they are undertaking.
- Ensure that workplaces are safe, tidy & organised at all times.
- Ensure that plant & equipment is switched off when not in use and kept in a safe condition
- Ensure that welfare facilities are maintained in a clean condition.
- Prevent horseplay and discipline those who consistently fail to consider their own wellbeing and that of others around them.
- Report all accidents/incidents/near- misses to the site HSE department.

All Contractor supervisors must set a personal example

2.1.4 RESPONSIBILITIES OF WORKFORCE

- Take all reasonable care to ensure your own safety and that of any others who may be affected by your work.
- Attend the site induction, tool box talks and other HSE communications as required by the project.
- Avoid improvisations or deviations from approved method statements & risk assessments.
- Use the specified tools and equipment for the job.
- Take personal responsibility for your actions.

3. PLANNING

3.1 RESPONSIBILITY FOR HSE

Contractors shall be responsible for the HSE of all its employees and Subcontractors' employees and the environmental impact of their assigned work. The Contractor shall at all times comply with and ensure that its employees, Subcontractors comply with all HSE rules, regulations and standards (as mentioned in section 1.3).

The e Contractor shall take, or cause to be taken, any additional measures, which the Governmental/Authority may direct to protect against injury or death of any person or damage to or loss of any property or to the environment during/after the Contractor's performance of the works.

Submittal of any documentation to the Authority does not relinquish the Contractor of its direct responsibility for the HSE of persons and the protection of the environment.

3.2 PROJECT HSE RISK ASSESSMENT

Before commencement of an onsite project work, the Contractor shall ensure that a robust 'Project HSE Risk Assessment' of the works to be undertaken is conducted. The Project HSE Risk Assessment shall be a systematic assessment of the HSE hazards & risks that the Contractor could encounter and shall also detail the means to control these.

The Contractor will be expected to recognize HSE hazards, evaluate them with the help of competent people, and to communicate to workers on how to control these hazards during the execution of the works.

The Contractor will be expected to use different types of hazard analyses to ensure that work progresses in a manner that does not endanger persons, property, process and the environment. Examples of these include:

- Hazard Analysis;
- Emergency Procedures;
- Job/Task Hazard Analysis;
- Field Level / Daily Risk Assessment;

The Contractor shall review the Project HSE Risk Assessment upon any change in the scope of work and/or at predetermined intervals during the execution of works.

4. ARRANGEMENT FOR CONTROLLING SIGNIFICANT RISKS

4.1 METHOD STATEMENTS

The P Contractor shall ensure that suitable 'Method Statements' are produced for all significant works. These method statements shall detail the sequence or steps involved in executing the works and also the methodologies...

The Package Contractor shall ensure that no work is started on site without an approved & agreed Method Statement.

4.2 PERMIT TO WORK

Where the risks are high and the use of a method statement and risk assessment alone does not necessarily ensure that a safe system of work is followed, the Contractor shall ensure that a permit to work is implemented. As a minimum, Contractors shall ensure that the following works are controlled by a permit to work:

Permit-to-Dig	Demolition Permit
Hot Works Permit	Confined Space Permit
Electrical and Mechanical Permit/LOTO	General permit to work

The need for a permit to work system will be identified in the risk assessment for the activity. Examples of jobs that are typically covered under a permit shall include but not be limited to hot works (cutting, grinding, welding etc.), elevated works (anything above 4 meters), confined space entry, work on electrical systems, non-routine lifts.

Contractors shall ensure that they nominate a person as the permit coordinator who shall have the responsibility to oversee the permit to work procedure. All permits shall be valid for a single shift only. Records of any permits issued shall be kept in the permit coordinators office for further inspection.

4.3 PERSONAL PROTECTIVE EQUIPMENT

The P Contractor shall ensure that Personal Protective Equipment (PPE) is provided as identified in the Method Statements & Risk Assessments. Notwithstanding the PPE described in the Method Statements & Risk Assessments, the Contractor shall ensure that as a minimum standard Safety Helmet, Hi-Viz Jackets, Safety Goggles, and Safety Shoes (with penetration protection) is available to all undertaking works on the project.

All PPE supplied on the project shall meet or exceed the specifications as dictated by Indian Standards Institute or the Contract documents. Where there is a conflict the more stringent standard shall apply.

5. TRAINING, AWARENESS & COMPETENCE

All project employees must receive appropriate HSE training upon engagement. These trainings shall be delivered by the individual Contractors to their personnel and to any subcontractor/third party engaged by them. HSE trainings will include - Induction Training, Tool Box Talks (TBT's), Work/Topic specific training, which will be determined by the Programme/Project HSE Training Matrix, and will be dependent on the tasks scheduled to be performed.

5.1 MINIMUM REQUIREMENTS

The Contractor shall ensure that all their personnel (including sub-contractors & any third party contracted to them) complete the following fundamental trainings:

- New Project HSE Induction – this module will orient employees in the basic HSE Policies and Procedures relevant at the project.
- Position specific HSE training – this will include training that depends upon the position the individual holds on the project. For example, if the person is designated as a rigger, he will have to attend rigger training and a slinging & lifting training. These trainings can be conducted either in-house by the individual Contractors or by an Approved Third Party. The Contractor shall also be aware that Project employees may be required to complete additional specialized HSE training, provided by commercial training specialists. Such training shall be identified in the project training matrix.
- Tool Box Talks – These will be conducted on daily/weekly basis as dictated by the activities/tasks that groups of people are undertaking.

The Contractor shall ensure that all HSE training conducted on the Project is documented and tracked.

5.2 PROJECT HSE INDUCTION

The Contractor shall conduct an HSE Induction for all project employees (this shall include all personnel employed by the contractor, their sub-contractors, Third Party, Visitors etc.) so that they remain aware of appropriate precautions that apply to them whilst on the work site. This HSE induction shall be conducted prior to being authorization to enter the site and/or commencing work. As a minimum, this training shall include a presentation of the site hazards, safety and security rules and emergency procedures. Depending on the appreciation of the level of risk for the contracted work, other relevant HSE subjects will be presented.

The site HSE induction shall be conducted by the Contractor HSE Manager and shall be conducted in a language understood by the site personnel. All e Contractors shall ensure that their 'Project HSE Induction' training is submitted to the AUTHORITY for review and approval.

As the project progresses, the Project HSE induction shall be reviewed by the Contractor HSE Manager at regular intervals to reflect site conditions.

5.3 TOOL BOX TALKS & DAILY BRIEFINGS

The e Contractor shall ensure that daily/weekly toolbox meetings and other daily briefings are conducted on a regular basis. These where possible shall be conducted by the foreman and site in-charge.

5.4 EMERGENCY RESPONSE PLAN TRAINING

The Contractor shall ensure that all project employees are aware of the Project Emergency Response Plan. The Contractor shall ensure that training to familiarize project employees on the Project emergency response plans is conducted at regular intervals of not less than 6 months. The Project emergency response plan training will include the procedures for reporting to external emergency response organizations (e.g., police, fire department, ambulance services, hospitals, rescue services, and hazardous material response services), building or site evacuation, designated evacuation assembly areas, and methods of accounting for staff upon evacuation. Emergency drills will be performed periodically, but at least twice per year.

5.5 TRAINING DOCUMENTATION

The Contractor shall ensure that all HSE training shall be documented. Documentation and certificates verifying completion will be maintained by the Package Contractor on site.

6. HSE COMMUNICATIONS

6.1 HSE COMMUNICATION PROGRAM

The Contractor shall establish an effective communication network to disseminate HSE information to all Project Personnel, to ensure support to the HSE program.

The table below gives an overview of the HSE communication methods that the Package Contractor shall adopt on the project.

Method	Frequency
Pre-start meetings	Minimum once prior to commencement of works
Progress meetings	As required by the project or as a minimum once a month.
HSE Meetings	As required by the project or as a minimum once a month.
Daily briefings	Daily
HSE Inductions	As required by the project.
Tool Box Talks	As required by the project or as a minimum Weekly.
Safety Alerts	As required.

6.2 HSE MEETING PROGRAM

Safety meetings provide a method for maintaining safety awareness and providing safety-related information and training to employees. The Contractor's shall plan and include/indicate in their HSE Plan the types and frequency of HSE meetings that it will conducted during the Project, including but not limited to:

- Daily Toolbox Meetings;
- Weekly Safety Meetings;
- HSE Committee Meetings.

The P Contractor shall keep records of all matters discussed and decisions made at each meeting, records of Site inspections performed, register of work permits issued, records of attendance of participants, etc.

The Contractors HSE meeting program shall:

- Review and discuss all Site HSE matters of the employees;
- Review safe work practices;
- Co-ordinate jobs so that the work does not pose as a hazard to others;
- Co-ordinate movement and storage of hazardous materials;
- Inform Personnel of potentially dangerous Works operations on the Site;
- Review progress of Works and work permit control;
- Review training requirements;
- Review work procedures and method statements;
- Review incidents and near misses.

The Contractor shall ensure that all major decisions and actions proposed by the meetings are effectively communicated for implementation.

6.3 HSE PROMOTION AND AWARENESS

The Contractor will actively promote HSE awareness amongst the project employees by implementing a HSE awareness programme. HSE awareness will be promoted both generally and specifically as relevant to particular areas or activities. A key feature of the awareness programme will be generating communication on HSE matters across organizational boundaries. These will be achieved through various means including, as a minimum:

- HSE notice boards: HSE specific, regularly serviced and updated;
- HSE incentive scheme: performance acknowledged and rewards communicated;

- Regular bulletins: HSE specific information on any task item, including updates on new hazards, changes to any activity or condition, alteration to procedures, etc.;
- Posting of minutes of meetings on HSE issues: update on action items, current performance, new information, items of general awareness for communication;
- Regular HSE workplace walkabouts by both Senior and Line Management: will be performed on both an informal and formal recorded basis. These will be high profile will include constructive discussion with all personnel as necessary.

7. MONITORING

7.1 HSE INSPECTIONS

The P Contractor shall carry out HSE inspections at regular intervals, covering not only its works on the project but also other areas under their control such as camps/mess facilities. These HSE inspections shall be led by the Contractor HSE team but shall also be attended by the Package Contractor Construction team. The Contractor shall ensure that Project HSE Inspections are carried out at least once a week. Inspections of other areas such as campsites/mess areas shall be carried out at a suitable frequency and agreed with the AUTHORITY. Where necessary, the Authority representatives will join these inspections. The Contractor shall ensure that inspections of temporary works such as shoring of form work, excavation, trenches, cranes and scaffolds shall be carried out after inclement weather. Copies of such inspections reports shall be submitted to the Authority for review & comments.

7.2 SENIOR MANAGEMENT HSE SITE WALKS

The Authority shall conduct a Senior Management HSE site walk once a month with each individual Contractor. The Contractor shall ensure that Senior Members from its Project team are available for these site walks.

7.3 HSE AUDITS

The Contractor shall establish and maintain an HSE audit program to be carried out on its operations to evaluate the efficiency of its HSE management systems in place. The results of audits, identified corrective actions and determined root causes shall be submitted to the Authority for review and comments.

7.4 HSE OBSERVATION PROGRAM

The Contractor will encourage and educate the project staff to observe and identify safe and at-risk conditions and behaviors. Staff are also encouraged to report near misses in order to look for trends and tackle issues before accidents and incidents occur.

7.5 REPORTING UNSAFE CONDITIONS

The following reporting procedures will be followed by Contractor/Project Personnel. Upon detection of any unsafe condition or practice, the responsible worker will bring the unsafe condition or practice to the attention of the worker's direct supervisor, unless the unsafe condition or practice involves the worker's direct supervisor. If so, the e Contractor's HSE Manager needs to be notified at once by the responsible worker.

8. INCIDENT REPORTING & INVESTIGATION

8.1 GENERAL

The Contractor shall in his HSE plan establish procedures to identify, record, investigate and analyze all accidents/incidents, dangerous occurrences, near misses, which occur on the Project. The investigation and analysis shall identify the root cause and contributory causes of these events and formulate measures accordingly to prevent future recurrence of similar incidents. The Package Contractor shall ensure that copies of all such reports are submitted to the AUTHORITY for review and comments.

8.2 REPORTING OF INCIDENTS

Contractors shall ensure that all incidents are reported to the Authority at the earliest. The initial notification time in any case shall not be more than one (1) hour from the time of the incident. Following the initial notification, the Contractor shall (within 24hrs) ensure that a written notification is sent to the Authority. Contractors shall ensure that all accident/incident reports are submitted to the Authority within an agreed timeframe. For the purpose of reporting, on the Project the following definitions shall be adopted by all Package Contractors:

- **Lost Time Injury**: Any accident/incident that results in an employee not being able to work on the day following the accident.
- **Medical Treatment Case**: Any work-related accident/incident where the employee has to receive medical treatment in a facility outside project first aid. This can be a clinic or hospital.

- **First Aid Case**: A minor work-related injury that requires the person to seek medical attention at the project first aid clinic.
- **Near Miss**: An unplanned event or condition that occurred in the project which although didn't not result in an injury or damage property but had the potential to do so.
- **Major Accident/Incident/Near-Miss**: Categorized / defined as one which meets or exceeds the following consequences: -
- **Harm to People:** Major injury or health effects (including permanent disability) - Affecting work performance; on longer term, e.g. prolonged absence from work. - Irreversible health damages without loss of life, e.g. noise induced hearing loss, chronic back injuries.
- **Property Damage:** Damage to any Project property in excess of INR 50000.00 or will take more than 2 days of to rectify.
- **Environmental Effect:** Any damage to the environment which costs an upwards of INR 50000.00 to clean up.
- **Work Related:** Any injury (however small) that has happened to a personnel whilst he was working on the project site.

8.3 REPORT DOCUMENTATION

The Contractor shall ensure that the accident/incident report that is submitted to the Authority as a minimum will have the following described details/sections.

- **Details of the investigation Team:** List of investigation team members
- **Background of the Incident:** The environment of the accident before the accident occurred
- **The Incident:** Detailed description of what happened in detail, the actions taken by the Package Contractor.
- **Immediate Cause:** Direct and indirect causes of the incident.
- **Root Cause:** Complete root cause analysis of what caused the incident/accident.
- **Investigation Findings:** Sketch of the incident scene, photographs, diagrams and physical evidence, persons with information and statements
- **Statements of accident victims**
- **Recommendations:** Immediate and long-term corrective actions, risk mitigation measures and target completion dates
- **Lessons learned**
- **Supporting documents such as any medical records, clean up records.**

9. EMERGENCY RESPONSE

9.1 GENERAL

Contractors shall as a part of their HSE Plan have a written Emergency Response Plan (ERP). The Contractor's ERP will consider potential emergencies that may arise during the performance of the Works and develop procedures to deal with the emergencies. The Contractor shall consider the following emergency scenarios for development in the ERP.

- Fatalities or serious injuries
- Major construction incidents not involving injury (e.g. structural collapse, collapse of excavations, tower crane failure, vehicle collision)
- Fire and explosion
- Bomb alert
- Environmental incidents, including chemical spillage / toxic release
- Security violations
- Property damage
- Extreme weather.

Emergency procedures developed by the Contractor shall ensure that Contractor's Site Manager or most senior supervisor present takes charge and directs the handling of the emergency. Package Contractor shall conduct weekly inspections of escape routes, fire brigade access, firefighting facilities and work areas to ensure that the requirements stipulated in the Emergency Response Plan are complied with.

9.2 EMERGENCY RESPONSE PLAN (ERP)

Prior to commencing work on site, the contractor shall prepare an ERP. The objectives of the plan shall be to:

- Provide a framework for planning for, responding to and recovering from emergency situations that may occur within the Package Contractor's area of responsibility;
- Allocate sufficient resources and facilities to manage and mitigate emergency situations;

When planning ERP's, the Contractor shall ensure that the following shall be taken into account:

- Site size, characteristics of the site and the work being undertaken;

- Means of raising the alarm under those conditions;
- Plant and equipment to be used in the event of an emergency;
- Location of nearest emergency services and their capabilities;
- Access to the site for emergency services.

The ERP's developed by the Contractor shall be specific to the Contractor's Work. Topics to be addressed in the plan shall include, but are not necessarily limited to the following:

- A list of all key emergency response personnel on site showing responsibilities and contact details, including all-hours telephone numbers;
- Details of emergency services (police, fire, ambulance, spill clean-up etc.);
- Communications strategy, including liaison with emergency services and the Authority's representative;
- Emergency provisions on site, including fire prevention, detection and fighting systems, spill prevention and response equipment and first aid facilities;
- Protocols and procedures to be implemented in the event of specific emergency situations;
- Emergency response training;

9.3 EMERGENCY COMMUNICATION

The Contractor shall ensure that the ERP is reviewed at regular not less than every six months. The Contractor shall also bring the contents of the ERP to the attention of the Project personnel during Project Inductions, Tool Box Talks, Safety talks etc. These briefings shall as a minimum include:

- Emergency procedures for different scenarios;
- Location of emergency equipment and supplies;
- Local emergency contacts, hospital routes, evacuation routes, and assembly points;
- Communication methods;
- Names of personnel trained in first-aid and CPR;
- Procedures for contacting Package Contractor and AUTHORITY key personnel.

9.4 REPORTING OF AN EMERGENCY

The Contractor shall ensure that all emergencies are reported to the Authority as soon as reasonably practicable. In any state this time frame shall not exceed 1 hour from the time of the incident.

9.5 EMERGENCY PREPAREDNESS

The Contractor will ensure that an ERP drill is carried out at regular intervals, these intervals shall not be greater than six months. The Contractor shall ensure that emergency drills are conducted for all the scenarios that have been identified in the ERP. The Contractor shall also ensure that emergency staff including first aid and emergency responders are available and that they participate in the emergency drills. Upon completion of each drill, an evaluation shall be made of the ERP to determine its effectiveness. Any problems or concerns identified during the evaluation will be corrected.

9.6 EMERGENCY RESPONSE TEAM

The Contractor shall maintain a nominated team for managing and responding to emergencies throughout the lifecycle of the project. The Emergency Response Team shall consist of project employees who are trained (by a competent third party where required) to respond in emergencies. The Contractor shall also ensure that the Emergency Response Team is available on the project on all shifts and that they have ready access to the emergency equipment at all times. Contact details of key personnel within the response team are to be posted on the project to facilitate communication flow in the event of an emergency.

9.7 EMERGENCY RESOURCES

The Contractor shall ensure that emergency resources including equipment, materials, transport and personnel, for managing potential emergencies on site are available on the project at all times. This shall include an appropriate number of first aid personnel along with a fully equipped first aid room and/or clinic as well as industry standard firefighting equipment, fire/smoke detection systems, alarms and any other emergency equipment as identified by the ERP.

All incident response resources shall be suitable for the site and activity under consideration. Equipment, including emergency response PPE, spill kits and firefighting systems, are to be installed at all locations where high-risk activities are being carried out and must

be inspected, tested and maintained regularly by the Contractor. If any equipment is missing or damaged, it shall be replaced.

10. SITE WELFARE FACILITIES

The Contractor shall ensure that adequate and appropriate arrangements exist for welfare facilities such as first aid, canteen/mess, rest areas, drinking water and toilets. These facilities shall be provided and maintained by Contractors. Welfare facilities onsite must be as close as practical to the working locations. Large sites may require multiple facilities to avoid long distance travel. The Contractor is required to develop a specific temporary facilities and welfare plan detailing specific arrangements.

10.1 FIRST AID ROOM

The Contractor shall make adequate arrangements for a first aid room, equipped and staffed to the extent required. The first aid room as a minimum meets the requirements below but in any case, will meet any requirements as laid down by local regulations.

- Designated first aid room shall not be used for any other purpose other than for first aid or medical purposes;
- The room shall be identified clearly through first aid signage;
- It shall be located in a way to allow easy access and egress during emergency;
- Shall be spacious enough to accommodate a wheel chair or a stretcher;
- Shall be equipped with adequate facilities and equipment, well illuminated, ventilated, sufficient air conditioning and made up of a surface that is easy to clean;
- Arrangements exist for the disposal of refuse;
- Shall be clearly identified in the emergency plan / layout;
- Shall be equipped with a phone or other means of communication to contact ambulance /hospital/ doctor on call/Company representatives.

10.2 FIRST AID BOX

The Contractor shall be depending upon the size and location of the site, ensure that first aid boxes are provided at strategic locations & shall be suitably identifiable, and access to them shall be ensured throughout the working hours. The Contractor shall also regularly inspect these first aid boxes to ensure that it is fully stocked and items inside are not expired. Records of such inspections shall be maintained and produced to the Authority during HSE inspections (as required).

10.3 FIRST AIDER'S

The Contractor shall ensure that adequate personnel trained on first aid through an approved agency are available on the programme. A copy of the qualification certificate shall be maintained by the Contractor for records and this certificate made available upon request from the AUTHORITY (during HSE inspections as required). Names of the qualified first aid personnel shall be exhibited near the first aid box and other prominent locations on the project and site offices with immediate contact details.

10.4 NURSE /DOCTOR ON CALL

The Package Contractor shall make appropriate arrangements to attend to the emergency medical situations through the appointment of a male/female nurse/Doctor onsite (as required contractually). Alternatively, the Contractor shall ensure that provision is made to ensure that medical assistance is given to any injured person as quickly as possible through a contractual arrangement that may be made with a clinic / approved hospital. The name/information about the hospital shall be exhibited at prominent locations within the project/ site offices and shall be bought to the attention of the project personnel at the time of the induction.

10.5 FIRST AID TREATMENT RECORDS

Records of the first aid containing the details of the treatment given, name of the treated person, date and time of accident, place and circumstances, details of injury and treatment given and name of person rendering treatment shall be maintained by the Contractor and provided to the Authority (during HSE inspections as required).

10.6 CANTEEN/MESS

The Contractor shall make adequate arrangements to ensure that project personnel can consume food in a clean & hygienic environment. Canteen/mess facilities shall be established at the site for providing food and beverages to the project personnel. Food may be prepared at the site or pre-prepared food may be made available.

The Contractor shall ensure that eating areas are suitable for the project personnel using them. For example, if the local culture is to consume food whilst sitting on the floor, then the canteen/mess facility shall ensure that there is provision for project personnel to sit on

the floor. The canteen/mess facility shall be adequate for the number of personnel and shall accommodate all users.

The Contractor shall consider the following when setting up a canteen:

Food preparation area	Sinks – for washing up / hand washing
Drinking water supplies as appropriate	Cold / Hot running water
Washing up liquid	Easy cleaning access
Cutlery & Crockery	Shade
Food storage	Fire extinguisher matched to risk and associated training
Means of escape	Rubbish collection
Rubbish bins with liners	Electrical items tested / certificated

10.7 DRINKING WATER

Adequate drinking water shall be provided to the project employees by the Contractor. The Package Contractor shall take into consideration the requirement of drinking water points to be available around the Project site. The drinking water points around the site shall be easily accessible by the project employees. Adequate signage shall be put up to differentiate drinking water from non-drinking water.

10.8 TOILETS

The Contractor shall ensure that toilets are provided to for the project employees. Consideration shall be given to male & female toilets (where required).

Water Tanks

The Contractor shall ensure that all water storage tanks are cleaned on a regular basis. The Package Contractor shall ensure that all portable water tanks are cleaned once every three (3) months as a minimum and that the water quality is tested and deemed fit for consumption.

11. SECTION 0: HSE ENFORCEMENT

The Contractor is fully responsible to ensure that they comply with all the HSE legislations & contractual HSE requirements. However, the Authority have the right at any time to

audit/inspect the Package Contractors facilities, procedures and safety management systems. The Contractor shall fully co-operate in such reviews and shall implement recommendations at its own cost where the Authority or statutory rules and regulations are contravened. The Contractor shall ensure the timely closing out of issues raised via these HSE assessments.

12. HSE STAFF

12.1 HSE PERSONNEL

The Contractor shall appoint only qualified and suitable HSE personnel to the project. The Package Contractor shall ensure that the Curriculum Vitae (CV) and HSE certifications of the HSE Personnel is submitted to the Authority prior to mobilizing the individual to the project.

12.2 CONDUCT AND COMPETENCY

The Contractor shall ensure that all such personnel are competent to perform the job assigned to them...

12.3 PROHIBITION OF PERFORMANCE OF OTHER DUTIES

The Contractor shall ensure that no HSE personnel shall be required or permitted to do any work that is unrelated to, inconsistent with, or detrimental to the performance of the HSE duties.

12.4 FACILITIES TO BE PROVIDED TO HSE PERSONNEL

The Contractor shall provide all HSE personnel with the facilities, equipment, and information that are necessary to allow the HSE personnel to carry out his duties effectively. The Contractor shall ensure that as facilities and equipment as mentioned below is provided to the HSE department as a minimum.

Schedule R - Project Management Requirements

Project Management Requirements:

The Contractor shall perform all the Project Management activities necessary for proper planning, management and control of the work. Below are the Project management requirements which Contractors needs to comply at different stage of the Projects:

1. Participate in the Project kick-off Workshop with Project stakeholders designated by Authority. The kick-off Workshop shall accomplish the following objectives:

- Common understanding of the Project goals and objectives
- Define respective roles and responsibilities and
- Agree on the methods of communication and reporting throughout the Project duration.

2. Participate in monthly Project status review meetings and present the Project progress update in the meeting. The frequency of Project status review meetings may change based on actual requirements.

3. **Schedule**: The Contractor shall submit detailed schedule in **Prima Vera/ MS project** with narration in soft and hard copies that cover's the full scope of Contractor's work within 30 calendar days of date of appointment. This will be reviewed within 15 calendar days by Authority. The Contractor shall incorporate the comments and resubmit the schedule no later than 15 calendar days after receiving the comments from Authority. Upon approval, the above schedule will become the baseline schedule for all the future monitoring and tracking.

The Contractor should keep to the following guidelines

i) Develop and incorporate a detailed Work Breakdown Structure (WBS) for all Project schedules that are submitted.

ii) All schedules shall be created, maintained and submitted to Authority in Oracle Primavera P6 or higher version of Primavera P6 in an electronic format.

iii) All schedules shall follow the Critical Path Method (CPM) of scheduling and shall have meaningful and realistic logical ties and relationships between activities.

iv) The use of negative lags is not permitted in the baseline and all other versions of the schedule.

v) The schedule must contain all the long lead procurement items identified.

vi) Shall exercise reasonableness while assigning constraints in schedule and milestones

vii) The Contractor shall allocate the Contract amount in detail to all the activities. It shall be used as guide for progress (S-Curve) monitoring only. Progress S-Curve to be updated each month and Progress Measurement will be on the basis of Earned Value Management.

viii) The Contractor shall provide narration with all the calculations, reports, forecast, supporting documents and detailed list of assumptions made on the development of the project schedule.

ix) Activities shall comprise of specific and measurable elements of work. Durations for each activity shall be calculated using productivity rates.

x) All schedules shall be resource loaded and Resource Histogram shall be submitted along with schedule.

xi) Upon approval, the copy of the Baseline schedule will become the first Current Schedule. The Contractor shall not change the approved schedule unless instructed in writing by the Authority. It shall be used as basis for measuring progress performance.

xii) The Current schedule shall be actively updated and maintained by the Contractor every month.

xiii) The updated Primavera P6 schedule file should be submitted every month along with Monthly progress report in electronic format. A pdf copy of the updated schedule with all activities also needs to be submitted

xiv) A schedule narrative document shall accompany the updated electronic schedule describing the work performed in the reporting period.

xv) Two month look ahead schedule should be submitted along with the Monthly Progress Report.

4. Cash Flow: Cash Flow shall be extracted from Baseline Schedule and Updated Schedule every month. Cash Flow shall be submitted along with Monthly Progress Report to show the actual versus plan and updated on monthly basis

5. Lessons Learned Database: The Contractor shall develop and actively maintain a "lessons learned" database on a monthly basis (to be included in the monthly Project report) and submit it to Authority at the end of the Project during closeout.

6. Risk Register: Maintain an active risk register addressing the risks and mitigation measures (could be in excel format) that lists the Project risks related to their Scope of Work. Risk Register shall be updated every month and to be submitted every month along with Monthly Progress Report.

7. Inter-Project Links: Identify potential inter-Project links, inter-dependencies or conflicts/ interference to work or work areas and narrate them in the monthly progress report.

8. Monthly Progress Report: Prepare and submit a monthly progress report no later than 7 days of each month (standard format and template will be provided by Authority at a later date). Items 3 to 7 mentioned above shall be the minimum information that will need to be included in the monthly progress report.
9. Monthly payments are subject to timely submission of monthly progress report and the monthly updated electronic schedule file in the required and acceptable format.

Schedule S - Quality Assurance

(See Clause 3.1.7 (o))

1.1 GENERAL:

The Contractor shall implement a Project Quality Management Plan in accordance with ISO-9001 "Quality System – Model for Quality Assurance in Design/Development, Production, Installation and Servicing" or any other system as approved by Engineer to ensure that all materials, workmanship, plant and equipment supplied and work done under the contract meets the requirements of the contract. This plan shall apply to all activities related to the quality of items, including designing, purchasing, inspecting, handling, assembling, testing, storing, and shipping of materials and equipment and different elements of construction work and installations of system components.

The Quality Plan to be prepared by the Contractor and submitted to the Engineer shall follow the requirements of ISO 9001 and address each element therein. This Quality Plan / QA manual, specific to this work must be submitted within one month of award of contract.

Running on account payment will be released after the following milestones are achieved and Engineer has issued a 'Notice of No Objection' or a Notice of No Objection subject to……(specifying the condition).

(a) Release of on-account payment after two months of signing the contract agreement – On submittal of QA Manual duly approved by Engineer (ER). Otherwise 10% of the running bill be withheld till compliance.
(b) Closure of Non-conformance Report – Action taken on non-compliance and its closure to be ensured within 15 days of issue of non-conformance report. In case of non-closure of report, running on-account bill will be withheld @ 1 % of amount for every non-closure, till the same are closed satisfactorily.
(c) Release of on-account payment after four months and thereafter every 3 months from the date of start of work – On submittal of Internal Quality Audit Report duly reviewed by Engineer and Action Taken Report. Otherwise 10% of the running bill be withheld till compliance.
(d) Release of Final bill –

    (i) Closure of all non-conformance reports

(ii) Submittal of all quality documented record pertaining to monitoring and accountability including QA Manual &Procedures Registration of the Contractor's organization, or subcontractors or sub-consultants is not required for this Project but the Project Quality Management Plan as submitted shall meet the intent of the ISO 9001 requirement in that there is a comprehensive and documented approach to achieving the project quality requirements.

1.2 Quality Assurance Management Plan

The Project Quality Management Plan (PQMP) shall as a minimum address the quality system elements as required by ISO 9001, generally noting the applicability to the Contractor's Works Programme for the Project. Procedures or Quality Plans to be prepared by others (Suppliers, Subcontractors, Sub-consultants) and their incorporation in the overall PQMP shall be identified.

The Contractor shall provide and maintain a Quality Assurance Plan (QA) to regulate methods, procedures, and processes to ensure compliance with the Contract requirements. The QA Plan, including QA written procedures, shall be submitted to the Engineer for his review.

Adequate records shall be maintained in a readily retrievable manner to provide documented evidence of quality monitoring and accountability. These records shall be available to Authority at all times during the term of the Contract and during the Defects Liability Period and for a five-year period thereafter.

The Plan shall identify:

(a) **Design Process**: that control, check and verify the accuracy, completeness and integration of the design shall be performed by certified personnel and in accordance with documented procedure that have the written consent of the Engineer.

(b) **Special Processes:** that control or verify quality shall be performed by certified personnel and in accordance with documented procedures that have the written consent of the Engineer;

(c) **Inspection and Test:** Inspection and testing instructions shall provide for reporting non-conformances or questionable conditions to the Engineer; Inspection shall occur at appropriate points in the installation sequence to ensure compliance with drawings, test specifications, process specifications, and quality standards. The Engineer shall designate, if necessary, inspection hold points into installation or inspection planning procedures;

(d) **Receiving Inspection:** These procedures shall be used to preclude the use of nonconforming materials and to ensure that only correct and accepted items are used

and installed; Identification and Inspection Status: a system for identifying the progressive

(e) inspection status of equipment, materials, components, sub-assemblies, and assemblies as to their acceptance, rejection, or non-inspection shall be maintained;

(f) **Identification and Control of Items:** an item identification and tractability control shall be provided;

(g) Handling, Storage, and Delivery: provide for adequate work, surveillance and inspection instructions.

The Plan shall ensure that conditions adverse to quality such as failures, malfunctions, deficiencies, deviations, and defects in materials and equipment shall be promptly identified and corrected.

The Plan shall provide for establishing, and maintaining an effective and positive system for controlling non-conforming material including procedures for the identification, segregation, and disposal of all non-conforming material. Dispositions for the use or repair of nonconforming materials shall require the Engineers consent.

1.3 Plan Implementation and Verification

The Plan shall clearly define the QA Organization. Management responsibility for the QA shall be set forth on the Contractor's policy and organization chart. The Plan shall define the requirements for QA personnel, their skills and training. Records of personnel certifications shall be maintained and monitored by the QA personnel. These records shall be made available to the Engineer for review, upon request.

The QA operations shall be subject to the Engineers, Authority or Authority's authorized representative's verification at any time, including: surveillance of the operations to **determine** that practices, methods and procedures of the plan are being properly applied; inspection to measure quality of items to be offered for acceptance; and audits to ensure compliance with the Contract documents.

The contractor's Quality **Audit** Schedule shall be submitted to the Engineer for consent every three months or more frequently as required.

The results of Quality Audits shall be summarized in the **Contractor's** Monthly progress reports. The Contractor shall provide all necessary access, assistance and facilities to enable the Engineer to carry out on-site and off-site surveillance of Quality Assurance Audits to verify that the quality system which has the consent of the Engineer is being implemented fully and properly.

Schedule T – Reports

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DISCLAIMER:

1. Reference Geotechnical Investigation Report
2. Map showing HFL's of Vaagu's