Chennai Metropolitan Water Supply and Sewerage Board

DRAFT CONCESSION AGREEMENT
For
Selection of Concessionaire for "Rehabilitation and Enhancement of 300 MLD Capacity Water Treatment Plant to 310 MLD At Puzhal Including Comprehensive Operation and Maintenance for 20 years under Hybrid Annuity Model (HAM)"

RFP VOLUME –II
SCHEDULES
E-Tender Notice No.: CNT/WSS/NCB/TNIDB/003/2025-26

AUGUST 2025

SUPERINTENDING ENGINEER (C&M)
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SCHEDULE A: SERVICE AREA OF THE PROJECT

1 The Service Area

The Service Area shall mean and include the existing water treatment facility at Puzhal as identified and described in this Schedule A (including its annexures and appendices)



ANNEXURE I: SERVICE AREA

(Schedule-A)

ANNEXURE II: EXISTING PROJECT FACILITIES

(Schedule-A)

1. **Assets of Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) to be handed over to the Concessionaire (Details of assets in 300MLD WTP & Raw water pump house and its accessories enclosed in annexure).**

SCHEDULE B: DEVELOPMENT REQUIREMENTS

Annexure-1: Scope of Services

The Scope of Services (SoS) described hereunder is neither exhaustive nor complete and is indicative only. The Concessionaire shall undertake detailed investigation of the Project Facilities, study, make assessments and ascertain all by itself the required tasks, interventions, inputs, and all other necessities to determine the complete Scope of Services for achieving the Key Performance Indicators as stipulated in Schedule C.

The Services shall include all technical, managerial, administrative, commercial, social interventions as required in accordance to acceptable, prudent water treatment practices for ensuring safe and sustainable drinking water supply.

The Scope of Services during each Period of the Agreement is detailed hereunder.

1. Study period

The Concessionaire shall make a comprehensive assessment & due diligence of the water treatment plant in the Service Area and prepare a holistic and comprehensive Implementation Plan for rehabilitation and enhancement of the treatment capacity of the water treatment plant to 310 MLD. This will include studying the Detailed project report including design of, asset condition assessment, strategy for improving services with a focus on rehabilitation and enhancement of the Water Treatment Plant.

General

The Concessionaire shall:

a. Establish contact with relevant local agencies and other consultants; and become familiar with the standards and guidelines for water treatment and with past and current work ongoing in the Service Area.
b. Satisfythemselvesastothenatureandscopeofworkandtheprevailingconditions in the Service Area.
c. Liaise with Authority and other Government Agencies regarding laws and regulations governing undertaking studies and construction activities

1.1. Institutional Arrangements and General Compliance

The Concessionaire shall read, familiarize and understand the institutional arrangements and Applicable Laws and determine in detail which roles the Authority, as the asset holding and operating entity play in the following: i) Water intake, (ii) Water treatment and (iii) supply of treated water.

1.2. Assessment of Treatment Plant and Rehabilitation

a. Existing WTP assessment.
b. Design of rehabilitation and enhancement of WTP.

1.3. Flow and Pressure Measurements (FPM)

a. Inlet to Raw water Distribution chamber (From 390MLD intake tower).

b. Raw water pumping main outlet 1.

c. Raw water pumping main outlet 2.

d. Raw water inlet WTP from Poondi Raw water pump house.

e. Clear water outlet 1.

f. Clear water outlet 2.

2. Implementation Plan

The Concessionaire shall submit the Implementation Plan within 60 (sixty) days from the Effective Date for enabling the Authority to undertake thorough review of the Plan and suggest amendments if any and obtains the approval of appropriate authority within 90 (ninety) days from the Effective Date.

The Implementation Plan essentially comprise of the following:

a. Soil investigation, Topo Survey, Raw water quality analysis and Power requirement for the enhanced 310MLD water treatment plant.
b. The conceptual design of WTP containing Process flow, specifications of process units and hydraulic level for the treatment plant process.
c. Plan for Rehabilitation and Enhancement of WTP.
d. Detailed works proposed for rehabilitation of plant.
e. Implementation Plan and methodology proposed during construction period and post COD.

3. Construction Period

The Scope of Services during the Construction Period shall essentially comprise operations and maintenance of the existing water supply facilities along with execution of the Implementation Plan in the Service Area which shall include but not limited to the following.

3.1. Operations and Maintenance of Existing Water Treatment Plant

The Concessionaire shall take over the management responsibilities of the Operations and Maintenance (O&M) of the existing water treatment plant facility. The O&M not limited to the following tasks:

a. O&M plan during implementation.
b. Ensuring treated water quantity not less than the contracted quantity meeting the standard quality norms.
c. Engaging required persons of Skilled and unskilled labours to operate and maintain the facility.
d. Maintaining the required quantity of chemicals and spares required for maintenance.
e. Online monitoring of Water Flow, Pressure, level and quality.
f. SCADA and IoT for operation & monitoring of the facility.
g. Regular preventative maintenance to be done without affecting the quality and quantity of water supply.
h. Information on management and reporting

3.2. Capital Investment Plan

Overview of the CIP

a. Based on the findings during the Study Period, the Concessionaire shall prepare the CIP and the activities to be carried out during the Initial Operation Period and the Construction Period in accordance with Applicable Laws and Good Industry Practice

b. The objectives of the activities presented in the CIP shall include but not be limited to the following:
   (i) To ensure availability of sufficient volume of treated water to meet the growing demands of Users, taking into account the permissible levels of losses in treatment;
   (ii) To ensure optimization of performance of existing pumping machinery for energy consumption;
   (iii) To ensure establishment of utility management systems and processes including standard operating procedures for ensuring sustainable operation of plant timely decision making and attending to emergencies.
   (iv) To establish performance monitoring systems so as to enable: (i) monitoring of Key Performance Indicators as per Schedule C;

c. In preparing the CIP the following design horizons will be adopted for any investments in physical infrastructure required to meet the Key Performance Indicators. No additional investment is expected beyond the Construction Period except for investments to meet network growth beyond that included in the CIP, and for routine replacement of plant, equipment, and computer systems at the end of their design

life.

(i) Pumping Machineries – 20 years
(ii) Treated Water Transmission and Feeder Pipelines – 30 years
Pipeline and its accessories
(iii) Storage Reservoirs – 15 years
(iv) Civil Structures – 30 years

In case additional land is required for the construction of any new facility the Concessionaire shall inform the Authority and the Authority shall accordingly provide the land to the extent required for the construction of new facility.

3.3. Scope of work during Construction

The scope of this work includes but is not limited to:

- Assessing and Conducting studies to rehabilitate the existing 300 MLD Water Treatment Plant and also to enhance the Treatment quantity to 310 MLD.
- Soil Investigation Report, rainfall, wind and temperature.
- Analyse the quality of the raw water and study the characteristics of raw water by lab analysis.
- Study the existing 300 MLD Water Treatment Plant design (Physical and Functional)
  a) The design characteristics of individual units and electromechanical components in the 300 MLD Water Treatment Plant.
  b) Drawings and flow diagrams with retention times
  c) The basis for Design criteria viz. maximum raw water withdrawal from Redhills Lake, quantities estimated, quality of treated water as per standards.
- Analyse the stability of all the Civil & Mechanical structures of the 300 MLD Water Treatment Plant and suggest right type of equipment/ machinery for the 300 MLD Water Treatment Plant to be rehabilitated.
- To assess each and every unit of the existing civil structures and also assess the each and every equipment of the existing Mechanical, Electrical & Instrumentation units.
- To determine/suggest whether every unit of the existing civil structures to be strengthened or reconstructed.
- To determine/suggest whether every unit of the existing equipment of the Mechanical, Electrical & Instrumentation units to replaced or retained and also to specify the conditions and age of the existing equipment.
- Review the detailed project report and Preparation of detailed design including process for all the units including Civil works, Mechanical, Electrical & Instrumentation works that has to be

rehabilitated in 300 MLD Water Treatment Plant in order to treat the raw water received as per the treatment parameters prescribed by ISO 10500:2012 for potable water supply to the public.

- Evaluate various process alternatives taking into account, Cost (Capital and Operation) as well as land requirement and recommend least cost solution.
- The Conceptual design of WTP – should contain
  a) Process
  b) Sizing of additional/altered process units
  c) Freezing of Hydraulic levels for the critical components and appropriate data required for the additional units
- The complete design and detailed engineering drawing for all the Civil & Mechanical components to be strengthened / reconstructed shall be submitted showing the ground levels, size of the pipes, invert level of pipes, route, flow direction, transmission arrangement of treated water including hydraulic design and other required details.
- Suggest items/ machinery/ equipment/ component along with detailed specification, justification, project report, cost and financial & economic analysis.
- Alternate plans for the management of raw water during up-gradation works without affecting treatment process.
- Detailed Design, drawings and Detailed Technical Specifications for all mechanical equipment and offsite piping valves and fittings.
- Detailed Design and Detailed Technical Specifications for all Electrical Equipment and Single Line Diagram (SLD).
- Detailed Design and Detailed Technical Specifications for Instrumentation equipment, Instrumentation control Philosophy and Instrumentation Schematics with drawings and updated operation manuals.
- Detailed specifications for providing SCADA & IIoT and Telemetry system for online monitoring of all the equipment's of Water Treatment plant and process parameters of water in various stage of treatment including inlet and outlet parameters within the control room and also to be accessed remotely through an internet connect on our office computer or laptop and even cell phone or tablet. The SCADA system installed should collect and store information for reporting, troubleshooting, maintenance indications and other relevant data required for efficient operation of water treatment plant.

- Assessment of power requirement for the plant, detailed design and drawings for electrical sub-station and preparation of Yard drawing including distribution arrangements to the process units, lighting etc by energy efficiency method.
- Detailed Design, drawings and Technical Specifications for buildings and all other civil structures.
- Detailed Design, drawings and specifications for in-plant roads, drainage, utilities, gardening and landscaping.
- Detailed Technical specifications for all construction materials, construction methodology and stage wise test to be carried out prior to acceptance.
- Detailed Design, drawings and Detailed Technical Specifications for Sludge Treatment and disposal method as per the advance technology.
- Providing operation manual and Standard Operational Procedures (SOPs) Preparation of the business model for the sustainable operation of the WTP.
- Concessionaire should get necessary approvals from statutory departments like CMDA, TNPCB, TNEB, CEIG and other agencies.

4. Operation &Maintenance period

The Concessionaire shall operate and maintain the whole of the plant under this contract for the entire period specified in the Contract.

The Services shall include but not limited to:

a) Operation and maintenance of all buildings and civil structures associated to the pumping work.

b) Operation and maintenance of Water Treatment Plant including Treated Water Pump house, Raw water pump house, Jones Tower along with its allied structures like Roughing filter, common conduit collection chambers etc. and mechanical and electrical equipments including all the instruments and Pipelines, Valves and other all facilities covered under this contract.

4.1 Operation and Maintenance Plan (O&M Plan)

i. The Concessionaire shall prepare an annual operation and maintenance plan for the Existing Project Facilities and the Project Facilities (the "O&M Plan") with critical and routine operating tasks at each unit of water supply chain with the objective of achieving and maintaining the Required Service Levels.

ii. The O&M Plan shall comprise the responsibilities for unit operations, monitoring and emergency response, related processes, systems, protocols, procedures including detailed costs for each activity of operations and maintenance etc.

iii. O&M Plan will present in detail the monitoring protocol for water quantity and quality measurement in the system. The O&M Plan will also present the on-line water quality reporting system required to meet the Concessionaire's obligations under Key Performance Indicators.

4.2 O&M General requirements: The Concessionaire shall undertake the operations and maintenance activities including but not limited to the tasks detailed in Schedule K.

5 Specific O & M Requirements

SpecificO&MrequirementstobeperformedbytheConcessionairearedescribedasfollowing: -

A. Concessionaire's obligation

A.1 General Obligations

TheConcessionaireshallhavethefollowinggeneralobligationsastheymaybeapplicableduring theterm of the Contract.

(i) The Concessionaire shall perform the Services in accordance with this Contract, and carryout its obligations with all due diligence, efficiency, and economy, in accordance with generally accepted professional techniques and international best practices, and shall observe sound management principles, and employ appropriate advanced technology and safe methods. The Concessionaire shall always acting good faith, in respect of any matter relating to this Contract ' or to the Services, to the Authority and shall at all times support and safeguard the Authority's legitimate interest in any dealings with the Customers, sub-Concessionaires or third parties;

(ii) The Concessionaire shall ensure that all materials and workmanship used in the course of the Contract shall be in accordance with the standard specifications. In absence of and appropriate specification, in accordance with the Indian National Standards or the International Standards Organisation as the case may be.

(iii) The Concessionaire shall permit the persons appointed and/or authorised by the Authority to conduct audit of accounts and records of the Concessionaire and to inspect the project facility from time to time relating to performance of the Concessionaire under the Contract after the Appointed Date subject to receipt of prior written intimation from the Authority in this regard and shall fully co-operate with such auditors in the conduct of audit and review exercises and checks and shall provide all requested information to the auditors;

(iv) The Concessionaire shall on a periodical basis update the record of Facilities.

(v) Neither the Concessionaire nor its employees shall indulge, either directly or indirectly, during the term of this Contract, any business or professional which would conflict with the activities assigned to them under this Contract;

(vi) The Concessionaire shall be responsible for maintaining required quantities of spares for preventive maintenance, periodical maintenance and breakdown maintenance as enlisted hereafter in this document. The Concessionaire must also keep the minimum stock of spares for emergency repairs as required for prudent operational practices.

A.2 Specific Obligations of the Concessionaire for Operations & Maintenance

1. The Concessionaire shall have the following obligations:

a) Review of operating and maintenance manuals if any, spare parts lists, recommended spares, warranty period from equipment suppliers and connected matters;

b) Identifying and procuring workshop equipment and capital spares as may be required, at his cost.

c) Select suitably qualified Suppliers of Spares, Consumables, Chemicals and the external Concessionaires required during Operations.

d) Collect water samples daily, test inside the plant's laboratory and submit the report to the Authority. All results of analysis shall be certified and provided to the CMWSSB Authorities in a timely manner and in accordance with the requirements of this Agreement. The Concessionaire shall also collect water samples related to the system and provide to the CMWSSB for analysis in Authority's laboratory whenever required as directed.

2. Notwithstanding the above obligations the Concessionaire shall have the following obligations during Operation& Maintenance

(a) Provide prudent management, operation and maintenance services as per the prescribed-standards of performance;
(b) Comply with Performance Standards at all times, in accordance with the terms of the Contract;

(c) Operate and maintain all mechanical, electrical, instrumentation and information technology installations, equipment, machinery etc, as per the respective standard operating and maintenance procedures;

(d) Undertake preventive and breakdown maintenance for all pipelines,

mechanical, electrical and instrumentation equipment in relation to the above referred Facilities, along with appropriate documentation to facilitate warranty and insurance claims, if required;

(e) Ensure effective and efficient planning, procurement and inventory management for all spares, chemicals, consumables etc;

(f) Provide robust security arrangements for all the facilities within the scope of this project, including restriction of entry of unauthorised persons;

(g) To organize for monthly updating the records, preparing a bill based on the water pumped and submission of invoice to the authority in the prescribed time;

(h) Comply with all relevant local laws including environmental, industrial and labour laws;

(i) Maintain healthy working relations with all stakeholders including the Authority, Water resources department, Greater Municipal Corporation of Chennai (GCC), State Pollution Control Board, and Power utilities; etc.

(j) Maintain detailed documentation and prepare periodical reports including monthly, quarterly and yearly reports for submission to the Authority including data on quality of raw and treated water, leakage levels, flow and pressure of water at designated check points, service level, etc. complete as set out in.

(k) Training of the operating personnel from the Authority or any other designated authority for taking over the system at the end of Contract Term;

(l) To undertake emergency chlorination measures at times of outbreak of epidemics and any such emergency situations;

(m) Rectify all defects attributable to the Concessionaire and notify the Authority of defects, developed within defect liability period of the commissioned components of Water Treatment Plant;

(n) Follow all reporting requirements;

(o) Maintain the Performance Indicators, Quality Assurance, Safe Operation Procedures (SOPs);

(p) To summarize, the services provided by the Concessionaire shall include the following:

- Operation of all Facilities;
- Provisionfor24hoursadayoperationandemergencycover;
- Maintenance of all the Facilities;
- Ground and buildings maintenance;

- Unscheduled and emergency maintenance;
- Quality control and assurance;
- Data recording and reporting;
- Holding emergency exercises;
- Incident management;
- Safety inspections;
- Supervision of sub-Concessionaires, enforcement of specifications;
- Preparation of all plans, procedures and budgets relating to operational matters, as required within the Contract.
- Any other work necessary to ensure the continued operation and availability of the system.

(q) For the purpose of complying with the requirements of this contract, the Concessionaire will need to provide:
   i) An adequate and skilled work force, supervisors, managers and technical support staff;
   ii) Administrative and financial support staff and computer and business support systems;
   iii) All necessary mobile plant and equipment, vehicles and incidental equipment;
   iv) Health and Safety equipment and staff protective clothing;
   v) Necessary required quantity of chemicals;
   vi) Storessuitablystockedwithadequatesparepartsandreplenishedwithinastore policy that recognizes frequency of use and delivery periods;

(r) The Concessionaire shall carry out the complete cleaning & disinfection of Water Storage reservoirs once in a year.

B. Standard Operating Procedures (SOP)

Operating Instructions and Safe Operating Procedures (SOP) shall be formulated for each Site comprising of process equipment schedules, operation & maintenance data, sampling and analysis with frequencies etc. The operating parameters shall be optimised based on the data collected on commissioning of the facilities. All the activities in the preventive maintenance schedule shall be followed without any lapse. Indicative functions that are expected to be performed at each site are given below:

(a) Check operation of all the preliminary treatment units and pumping systems
(b) To ensure compliance with agreed withdrawals and to bring to notice of the Authority any deviation in performance standards
(c) Check operation of all valves in all the facilities
(d) Flow and pressure measurement in all the units
(e) Checking operations of electrical & mechanical equipment
(f) Check the power factor and power consumption

C. Maintenance and Repairs (Mechanical, Civil, Electrical and Instrumentation)

C.1 Management and Maintenance Plan

A properly designed water treatment plant shall be capable of delivering desired output at all times. Considering that every mechanical system shall have to be given a downtime for maintenance purposes, the Concessionaire shall schedule a plant downtime for the facilities in consultation with the Authority as and when required so as to minimize disruption in services.

A. Routine inspection and maintenance of all equipment;
B. Planned and scheduled maintenance (preventive);
C. Unscheduled maintenance (breakdown);
D. Cost and budget planning.

C.2 Routine Inspection and Maintenance of Equipment

TheConcessionaireshallcarryoutroutinemonitoringoftheequipmentandensurethattheequipmentis properly maintained to meet the desired output. Typical tasks that shall be undertaken are:

(A) Mechanical

(a) Checking the lubrication in various mechanical equipment and necessary follow-up
(b) Replacing of glands that are leaking
(c) Servicing all the pumps as per supplier's instructions
(d) Stripping down of pumps to observe clogging if any
(e) Checking for unusual vibrations and noise

(B) Electrical

(a) Checking electrical contacts and wiring
(b) Checking motor heating and noise level
(c) Assessing efficiency of electrical equipment

(C) Instrumentation

(a) Cleaning and calibration of probe/sensors
(b) Fault diagnosis

(D) Civil

(a) Grouting of the civil structures at required places.
(b) Dismantling and Plastering the damaged wall surfaces.
(c) Painting of civil structures at regular intervals.
(d) Strengthening of civil structures based on the requirement

These maintenance tasks shall be issued on a weekly basis through computer aided management system and the Concessionaire shall incorporate it in the operating work schedule. All observations shall be recorded in the properly designed record system and would be analyzed for initiating corrective actions, if any.

C.3 Planned and Scheduled Maintenance (Preventive)

A work schedule chart listing identification of critical equipment, work assignment, timing shall be prepared. Critical equipment is defined as those items where failure would adversely affect the quality and quantity of output or those that risk the safety of employees or customers. The schedule shall identify the responsible person / agency who shall be intended to complete the task e.g. in - house technician or specialist Concessionaire etc.

The indicative maintenance schedule is provided further in the Schedule K. This shall be finalized during the preparation of the Operation and Maintenance Plan.

C.4 Breakdown Maintenance

The aim of routine and preventive maintenance is to keep breakdown to minimum for items of critical equipment which shall directly affect the performance of treatment processes. However certain breakdowns may occur in spite of proper maintenance. The Concessionaire shall take the breakdown maintenance on top priority to keep disruption to the systems at a minimum level.

TheConcessionaire shallhavetheoptiontocallotheravailablestaffandalsotheservicesofthelocalskilled during the breakdown period.

C.5 Spare Parts

The Concessionaire shall store spares of all the critical equipment on respective sites and the inventory shall be assessed according to anticipated usage and in conformity with Annual Operating and Maintenance Plan and Annual Budget.

The Concessionaire shall obtain consumable items required for maintenance e.g.grease, gaskets etc. from local suppliers, as and when required.

Annual reports on the cost of replacement spare/million litre of water supplied shall be provided to the Authority, for the purpose of monitoring usage and cost control.

C.6 Maintenance Report

To assist the Concessionaire in the management of the maintenance activities, Computer Aided Maintenance Management (CAMM) shall be implemented by the Concessionaire which shall be integrated with the MIS system. Appropriate proprietary CAMM packages shall be utilized by the Concessionaire for maintenance purposes. This package shall incorporate features such as Facility details, maintenance history records, and scheduling of maintenance activities. The use of such package shall allow the Concessionaire to predict when the maintenance activities need to be carried out.

Record of maintenance jobs carried out shall be reported in the record system, which shall provide the Authority the past history, time and cost involved for each category. The

report shall include:

(a)Details of number of jobs completed
(b)Frequency of breakdown, time required repairing and costs involved.
(c)Personnel involved/ Concessionaires used

D. Emergency Action Plan

The Concessionaire shall provide Emergency Plan of Action, as per the following:

(i) The Authority may, at its election, intercede and take, or direct the Concessionaire to take, any and all actions reasonably necessary to respond to an Emergency. The Concessionaire shall, upon learning of an Emergency or the probable occurrence of an Emergency, (1) immediately provide oral notice to the Authority or its Authorized Representative of the same and (2) as soon as possible, but no later than twelve(12)hours, provide Notice to the Authority or its Authorized Representative of such event or probable event; provided however, if Applicable Law shall provide for a more expeditious oral or written notice of any Emergency to the Authority, the Concessionaire shall so comply by providing such notice to the Authority or its Authorized Representative.

(ii) The Authority and Concessionaire or their Authorized Representatives shall coordinate with each another prior to, during and after the occurrence of an Emergency including 1) the planning and implementation of actions designed to prevent or mitigate damage to the System and the environment and (2) the attendance of all meetings related to such planning and implementation.

(iii) The Concessionaire shall interact and cooperate with appropriate departments of the public entities comprising the Authority and other jurisdictions.

(iv) The Concessionaire shall supply stand by employees from normal system staff ready to address an Emergency in an expeditious manner.

(v) Response Times and Emergencies:-

The Concessionaire commits itself to a high standard of effective response. To indicate commitment, the Concessionaire shall establish 'Standards of Service' which shall define the Concessionaire's response to any emergency with the intention of minimizing the possible impact of an emergency or failure on the output of the Facilities. These standards shall be agreed with the Authority and would typically include:

Situation	**Response**	**Target Time**
To any alarm or non-conformity during normal work time, or when the Facilities are being manned.	Any threat to public or personal health.	Immediate
	To attend to and assess the required action and the resources needed to effect remedial action. Effect first call repairs where possible	Immediate

Situation	Response	Target Time
	If the problem requires further resources, to have remedial work on site rectifying the problem.	2Hours
To any alarm Or non-conformity occurring outside normal Operating hours or when Facilities are unmanned	Any threat to public or personal health.	Immediate
	To attend to and assess the required action and there sources needed to effect remedial action. Effect first call repairs where possible.	1Hours
	If the problem requires further resources, to have remedial work on site rectifying the problem	2Hours

A dedicated problem-solving team shall be appointed by the Concessionaire and this team shall have the responsibility of tracking problems through to a satisfactory outcome.

Major events that threaten public, employee or process safety or security shall be managed directly by a Concessionaire's Representative, who shall have full authority to utilise whatever resources he considers fit to rectify any emergency situations. In performing these duties, this manager shall have full responsibility for ensuring proper and adequate communications with theAuthority and other relevant bodies.

E. Permits

Concessionaire will be responsible for obtaining various permits, authorizations and consents to enable them to carry out their duties. These will include, but not be limited to the following:

a) Licenses to store and use chemicals
b) Licenses to use machinery
c) Waste management licenses
d) Health and Safety certificates
e) Fire certificate
f) Approval from Labour Inspector
g) Approval from District Health Officer
h) Insurance as appropriate
i) Licenses to carry out water operations
j) Right to use Electrical power
k) Abstraction licences from various departments
l) Disposal licenses for sludge

F. Water Sampling, Testing, Reporting Requirements

The Concessionaire shall collect water samples at various locations of treatment units and perform water sample testing at Concessionaire's installed laboratory inside water treatment plant as per the requirement or as directed by the Authority. The treated water

should meet the performance standards for drinking water standard norms IS 10500:2012 as described below:

S. No.	Parameters	Acceptable limit	Permissible limit
1	Color Hazen units, Max	5	15
2	Odour	Agreeable	Agreeable
3	Taste	Agreeable	Agreeable
4	Turbidity (NTU), Max	1	5
5	pH @25° C	6.5-8.5	6.5 -8.5
6	Total dissolved solids mg/l, Max	500	2000
7	Total hardness (as CaCo3) mg/l, Max	200	600
8	Calcium (as Ca) mg/l, Max	75	200
9	Magnesium (as Mg) mg/l, Max	30	100
10	Chlorides (as Cl) mg/l, Max	250	1000
11	Residual Chlorine (mg/l), Min	0.2	1
12	Ammonia as N (mg/l), Max	0.5	No Relaxation
13	Nitrate as NO3 (mg/l), Max	45	No Relaxation
14	Fluorides (as F) mg/l, Max	1	1.5
15	Sulphate (as SO4) mg/l, Max	200	400
16	Iron (as Fe) mg/l, Max	0.3	No Relaxation
17	Copper (as cu) mg/l, Max	0.05	1.5
18	Manganese (as Mn) mg/l, Max	0.1	0.3
19	Mercury (as Hg)mg/l, Max	0.001	No Relaxation
20	Cadmium (as Cd), mg/l, Max	0.003	No Relaxation
21	Selenium (as Se), mg/l, Max	0.01	No Relaxation
22	Total Arsenic (as As)mg/l, Max	0.01	0.05
23	Cyanide (as CN), mg/1, Max	0.05	No Relaxation
24	Lead (as pb) mg/l, Max	0.01	No Relaxation
25	Zinc (as Zn) mg/l Max	5	15
26	Anionic detergents (as MBAS mg/l, Max	0.2	1
27	Total Chromium (as Cr_{d}+) mg/l, Max	0.05	No Relaxation
28	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	0.0001	No Relaxation
29	Aluminum (as Al), mg/l, Max	0.03	0.2
30	Bacteriological Quality (Total Coliforms MPN)	Shall not be detectable in any 100ml of sample	

Number of parameters (Tap point at the clear water pump house delivery line) that does not conforming to BIS standard – IS 10500:2012 on daily basis attract penalty as mentioned in Schedule C of Key Performance Indicators..

SCHEDULE C: KEY PERFORMANCE INDICATORS (KPI)

The Concessionaire shall comply with the Key Performance Indicators (KPIs) as below during the Initial Operation Period and Operation Period:

A. Initial Operation Period:

(1) Quality of Water:

If the quality of treated water does not meet the requirement as given in schedule L. The penalty payable to CMWSSB shall be calculated as follows:

Frequency	Daily
Monitored by	An electronic registry maintained by the Concessionaire. The registry shall include detailed database and summary tables for routine water quality tests. The water quality testing database shall include: • Time and Date • Sample Location (at Dispatch point) • Sample Number • Details of water quality tests conducted
Days	the number of days between the date of occurrence of quality parameters which are beyond the prescribed norms till the date of restoration.
Penalty	Penalty shall be 1% of Construction Period Performance Security for every day for which treated water does not meet the quality standards. If the quality of treated water doesn't meet the standards specified, CMWSSB reserves the right not to take any water till the quality is restored and the corresponding penalty shall be applicable. In the event of such occurrences for more than 4 days in a year, the provisions of Article 31 shall apply

(2) Quantity of Water:

Frequency	Daily
Required Service Level	210,000 KLD
Measured by	Quantity of water pumped into the transmission main
Data Requirements	Daily record of water pumped into the transmission main
Penalty Payable	(210,000 KLD– Actual quantity supplied in KLD) x Penalty rate

Monitored by	An electronic registry maintained by the Concessionaire. The register shall contain details of the following: • Output of treated water • Water pumped into the transmission main
Allowable Exclusions	Water shortage period as defined in the DCA
Penalty Rate	Rs. 50 per KL for the shortfall.

Note: If in any part of time during the Construction Period, if the quantity reduced beyond the specified quantity not due to the default of Concessionaire, the same has to be certified by Independent Engineer and accepted by the Authority. The Authority shall not levy penalty in these circumstances.

B. Operation Period

The Concessionaire has to achieve minimum performance standards as detailed here in below. Poor performances below the minimum performance standards shall attract penalties as detailed herein:

Sr. No.	Service Level Benchmark	Target	Targeted performance
1	Quality of Water	100%	From COD
2	Quantity of Water	95%	From COD
3	Energy Efficiency	0.3445 kWh/KL	From COD

Calculation methods:-

Above Service level benchmark shall be calculated using following method and the Performance Parameters, Penalties and the Measurement framework shall be as detailed below:

The penalties will be calculated on a monthly basis and the deductions/additions will be made quarterly when the O&M payments are made.

(3) **Quality of Water:**

If the quality of treated water does not meet the requirement as given in schedule L. The penalty payable to CMWSSB shall be calculated as follows:

Frequency	Daily
Monitored by	An electronic registry maintained by the Concessionaire. The registry shall include detailed database and summary tables for routine water quality tests. The water quality testing database shall include: • Time and Date • Sample Location (at Dispatch point) • Sample Number • Details of water quality tests conducted

Days	the number of days between the date of occurrence of quality parameters which are beyond the prescribed norms till the date of restoration.
Penalty	Penalty shall be 2.5% of Operation Period Performance Security for every day for which treated water does not meet the quality standards. If the quality of treated water doesn't meet the standards specified, CMWSSB reserves the right not to take any water till the quality is restored and the corresponding penalty shall be applicable. In the event of such occurrences for more than 4 days in a year, the provisions of Article 31 shall apply

(4) **Quantity of Water:**

Frequency	Daily
Required Service Level	95% of Contracted Quantity
Measured by	Quantity of water pumped into the transmission main
Data Requirements	Daily record of water pumped into the transmission main
Penalty Payable	(95% of Contracted quantity in KLD – Actual quantity supplied in KLD) x Penalty rate
Allowable Exclusions	Water shortage period as defined in the DCA
Penalty Rate	Rs. 100 per KL of shortfall for the first year post COD, escalated at 5% per year.
Incentive	(Actual quantity supplied in KLD - 105% of Contracted quantity in KLD)/Contracted Quantity) represented in percentage x 0.5% of prorated O&M Payment during the period
Monitored by	An electronic registry maintained by the Concessionaire. The register shall contain details of the following: • Output of treated water • Water pumped into the transmission main The same shall be submitted by the Concessionaire and approved by the Authority

(5) **Energy Efficiency**

Frequency	Monthly
Required Service Level	Energy consumption of 0.3445 kWh/KL
Measured by	Amount of power consumed every month
Data Requirements	Daily record of power consumption
Calculation	Actual power consumption during the month
Monitored by	Daily energy consumption Random check of the energy meters by Independent Engineer
Allowable Exclusions	Period during which the WTP was not in operation
Penalty/Damages	Concessionaire to pay for power charges over and above the stipulated consumption
Incentive	Where the power consumption is less than the stipulated consumption level, savings in energy costs will be shared between the Authority and the Concessionaire in the ratio 50:50.

(6) During the Operations Period, the Concessionaire shall maintain a power factor as prescribed by TANGEDCO, Penalty levied by TANGEDCO for non-compliance of this should be borne by the Concessionaire. Any other penalty such as exceeding maximum permitted demand levied by TANGEDCO shall also be borne by the Concessionaire.

SCHEDULE D: TECHNICAL SPECIFICATION AND STANDARDS

1. Technical Specifications

(Concessionaire needs to provide minimum specifications as given below however Concessionaire is expected to exceed the specifications of material for better performance of System.)

1.1. CONSTRUCTION REQUIREMENTS

Section1

General

The technical specifications governing the Agreement shall confirm to all the relevant guidelines, standards, standard operating procedures detailed in the relevant Standards Codes published by Bureau of Indian Standards and shall be in conformity to the following standard manuals.

a. Manual on Water Supply and Treatment published by Government of India.

b. Ministry of Urban Development, CPHEEO as amended up to date.

c. Manual on Operations and Maintenance of Water Treatment Plant, published by Government of India, Ministry of Urban Development, CPHEEO, as amended up to date.

Section2

Construction Requirements: General

2.1 GENERALTECHNICALSPECIFICATIONS

2.1.1 General

The Concessionaire's site personnel referred to in the Conditions of Contract shall include at least one approved skilled working supervising erector to supervise the erection of the Plant and enough skilled, semi-skilled and unskilled labour to ensure completion of the Works in the time required. The Concessionaire shall not remove any supervisory staff or skilled labour from the Site without the Engineer's approval.

Plant shall be erected in a neat and workmanlike manner on the foundations shown on the approved drawings.

Where the Works are associated with or in physical contact with plant supplied under a separate contract, the Concessionaire shall satisfy himself that the work carried out by the other Concessionaire is consistent with the correct operation of the plant. If the Concessionaire considers any work being done or any work completed, to be detrimental to the plant, he shall report the matter at once to the Engineer.

The Concessionaire shall make all holes and openings in building structures required for fixing small plant items and shall provide any associated supports.

2.1.2 Foundations

Foundations shall comply with the details shown on the Approved Drawings. Where floors and plinths require to be cut away and prepared to accept foundation bolts or mounting frames and plates, the approval of the Engineer shall be obtained before any work begins.

2.1.3 Foundation bolts and fixings

The Concessionaire shall supply all anchor bolts, holding down bolts, fixing bolts, washers, nuts, straps, supports, brackets, spacers and fixtures, which are needed for the satisfactory installation of the Plant.

2.1.4 Fixing to structures

No holes in concrete, brick, timber or structural steelwork for fixing devices shall be drilled without the prior approval of the Engineer. Holes shall preferably be made with a rotary drill of the non-percussion type. A single-shot cartridge tool may be used only at the discretion of the Engineer.

Any damage caused by the Concessionaire to any surface during erection shall be made good by the Concessionaire at his own expense to the satisfaction of the Engineer.

The Concessionaire shall be responsible for the provision of any scaffolding required and the cost shall be deemed to be included in the Contract Price.

2.1.5 Plant protection on Site

Plant shall be adequately protected during and after installation against damage to finished surfaces and fitted components and against ingress of dust, moisture and the effects of humidity. Structural finishing operations may have to be done near installed plant before it is taken-over and the Concessionaire shall take this into consideration in complying with the requirements of this Clause. The cost of all protection shall be included in the Contract Price.

2.1.6 Cleaning and preparing surfaces at Site

On arrival at the Site all Plant shall be examined by the Concessionaire and the Engineer for damage to protective coatings. Damaged portions shall be cleaned down, all rust removed by grit blasting, if instructed by the Engineer, and the coating made good with a similar paint within four hours of surface preparation.

After erection and building-in, appropriate items of Plant shall be thoroughly cleaned to remove all debris and filled where necessary.

2.1.7 Protective coatings applied at Site

The Concessionaire shall apply the protective coatings for the Plant at Site in accordance with the protective treatment system approved by the Engineer.

The first in-situ coat shall be applied immediately the items of Plant have been erected and built-in.

Painting of Plant shall be completed not later than one month after the Plant has been taken over.

Before the end of the Defects Notification Period all damaged paintwork shall be touched up, except where the damage is due to fair wear and tear, and the cost of this shall be deemed to be included in the Contract Price. Where touching up is done, the result shall be uniform in colour with the original paint. If uniformity of colour is not achieved after touching up, to the Engineer's satisfaction, then the entire item shall be re-painted so that uniformity of colour is achieved. The cost of this work shall be deemed to be included in the Contract Price.

2.1.8 Connection of electrical power

The Concessionaire shall check all items of electrical plant for correct phasing and insulation resistance. Motors shall be dried out in accordance with the manufacturer's instructions and checks on the insulation resistance shall be made at regular intervals. Drying out shall continue until the insulation resistance reaches a steady value as recommended by the manufacturer. After all drying out and checking of insulation resistance is complete the Concessionaire shall check that all electrical connections to the plant are correct and any errors shall be brought immediately to the notice of the Engineer.

Electric power shall only be applied to any plant item after the individual tests specified for the plant have been done by the Electrical Inspector and to the satisfaction of the Engineer.

3 SITE WORKS

3.1 The Site

The 'Site' as defined in the Conditions of Contract shall also include the Concessionaire's works areas, the Engineer's compound within the Concessionaire's works area and any temporary working areas described herein.

Possession of the Site, or parts thereof, to be given by the Employer shall be subject to any restrictions mentioned in the Contract.

The Concessionaire shall undertake a survey of the condition and provide detailed digital record photographs of the Site prior to commencement of any site works.

3.2 Site road and access

Except as may be otherwise provided in the Contract the Concessionaire shall arrange for, construct, maintain and afterwards remove and reinstate all temporary site roads and accesses required for and in connection with the execution of the Works. Reinstatement shall include

restoring the area of such roads and accesses to at least the degree of safety stability and drainage that existed before the Concessionaire commenced work.

3.3 Special hazards

The Concessionaires attention is drawn to the following special hazard.

- Intense monsoon season rainfall, lightning storms and consequent flooding.

The above is an example only and is not complete. The Concessionaire shall be deemed to have made, before tendering, his own examinations and inspections of the site and all interpretations of all relevant climatic and physical conditions and their impact on the works.

3.4 Existing services

The Concessionaire shall be responsible for the security of all water, electricity, telephone and other services, drains, pipes and other apparatus belonging to or under the control of any public authority, company or person, which may be, or be liable to be, interfered with, by or in connection with the execution of the Works. The Concessionaire shall be responsible for organising or providing any temporary service diversions. The Concessionaire shall fully indemnify the Employer against any claim, action, expense, loss, damage or injury arising in this respect.

The Concessionaire shall ensure that the location of all existing cables is identified using proprietary cable detection equipment by personnel qualified to carry out such work.

The Concessionaire shall obtain copies of all up-to-date existing services records for the Site prior to commencing the Works.

3.5 Amenities to be preserved

The Concessionaire shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be felled except as authorised by the Engineer and clearance of vegetation of any sort shall generally be kept to the minimum necessary for the Works.

3.6 Security on the Site

The Concessionaire shall provide, maintain and remove secure temporary fences of 2m height around works areas, storage yards and compounds. The Concessionaire shall submit details of the proposed temporary fencing to the Engineer for approval prior to any works.

Access into the Site will normally be restricted to employees of the Employer, the Engineer and his staff and the Concessionaire for the Works. Where one Party wishes to bring visitors on Site, he shall discuss and agree any relevant procedures before such a visit takes place.

The Concessionaire shall be responsible for the security and safety including storage of his own

materials, tools and equipment, protection of completed work in place, site offices and the like.

The Concessionaire shall allow for providing security guards on a 24 hrs basis for the Site. At any time, there shall be at least one guard per part of Site occupied.

3.7 Access and trespass to adjoining property

If the Concessionaire's work will cause unavoidable interference with access to adjoining property the Concessionaire shall first give seven days' notice in writing to the occupier of such property and shall provide temporary means of access for vehicles, animals and pedestrians.

In carrying out the Works due regard shall be paid to the amenities of adjacent property and to the interests of owners, tenants and occupiers. The Concessionaire shall take adequate steps to prevent trespass by his employees and shall be wholly responsible for making good any loss or damage caused by such trespass.

3.8 Claims for damage to persons or property (procedure)

Any claim received by the Employer in respect of matters in which the Concessionaire is required under the Contract to indemnify the Employer will be passed to the Concessionaire who shall likewise inform the Employer of any such claim which is submitted directly to him by a claimant. The Concessionaire shall do everything necessary, including notifying the insurers of claims received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer informed as to the progress made towards settlement, failing which the Employer shall be entitled to make direct payment to claimants of all outstanding amounts due to them in the Employer's opinion and without prejudice to any other method of recovery to deduct by way of set-off the amounts so paid from sums due or which become due from the Employer to the Concessionaire. If the Concessionaire receives a claim which he considers to be in respect of matters for which he is to be indemnified by the Employer under the Contract, he shall immediately pass such claim to the Employer. All information as aforesaid shall be given in writing and shall be copied to the Engineer's Representative.

3.9 Advertisements

The Concessionaire shall not except with the written authority of the Engineer exhibit or permit to be exhibited on the Site any advertisement board. Any such advertisement may also be subject to the approval of the local planning authority before it is put up and it shall be removed if the Engineer so demands.

Site sign boards shall be erected, typically of 2m x 1m, to bear the logos and text as specified by the Engineer. Costs shall be deemed to be included in the site establishment items in the Price Schedules.

3.10 Site Welfare; Sanitation

The Concessionaire shall maintain the Site and all working areas in a hygienic condition and in all matters of health and sanitation shall comply with the regulations of the local authority.

The Concessionaire shall be responsible for providing all sanitary services necessary to keep all offices and stores in a clean, neat and hygienic condition.
The Concessionaire shall provide all proper temporary sanitary facilities for the Concessionaire's employees and sub-Concessionaires. The sanitary facilities provided within the Site shall be of the portable type. The Concessionaire shall provide septic tanks as necessary for the disposal of sewage on sites occupied for a long term. Waste water and septic-tank effluent shall discharge into properly designed French drains. Where the construction of septic tanks or water-borne sewerage is not feasible, the Concessionaire shall construct conservancy tanks and arrange for the removal and disposal of sewage. All such arrangements shall meet all the requirements as stipulated by the local health authority and the Concessionaire's proposals shall be submitted to the Engineer for approval.

In particular, the Concessionaire shall ensure that his employees (and those of his sub-Concessionaires) only use the toilet facilities provided by him as part of his site establishment. Any person found urinating or defecating elsewhere on the Site shall be removed from the Site immediately, and shall not be re-employed on the Site.

The Concessionaire shall also provide for the removal and legal disposal off the Site of all rubbish and solid waste from offices and other areas of the Site, with collections being made at least twice weekly.

3.10.1 General hygiene and medical examination of Concessionaire's employees

Before commencing work on the Site, the Concessionaire shall ensure that all his employees are instructed about the necessity for the prevention of pollution. The Concessionaire shall immediately dismiss and remove from the Site any of his employees or representatives who have been polluting or fouling the Site or any of the water supply installations and shall take appropriate remedial measures to prevent a repetition of the occurrence and to disinfect the areas concerned all to the satisfaction of the Engineer.

During commissioning and subsequent operations, the Concessionaire shall not employ upon the Site, or on periodic visits thereto, persons who are known to have any disease which could be water-borne or who is suffering from an illness associated with looseness of the bowels or who are carriers of typhoid bacillus or other potential pathogenic organisms or who are otherwise unsuited on medical grounds to be employed in or around water supply installations.

The Concessionaire shall if and when required to do so, arrange for his employees to be examined and tested in the manner approved by the local medical officer.

The Concessionaire shall immediately remove from the Site any such employees who as a result of such examination and testing may in the opinion of the medical officer or the Engineer constitute a danger to water supplies or who refuse to undergo an examination.

3.10.2 Works to be kept clear of water

The Concessionaire shall keep the Works well drained and shall ensure that so far as is practicable all work is carried out in the dry. Excavated areas shall be kept well drained and free from standing water except where this is impracticable having regard to methods of temporary works properly adopted by the Concessionaire.

The Concessionaire shall construct, operate and maintain all temporary dams, watercourses and other works of all kinds including pumping and well-point dewatering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary works and plant shall not be removed without the approval of the Engineer.

The Concessionaire shall be responsible for the arrangements to keep the Works free of water notwithstanding any approval given by the Engineer concerning those arrangements. The Concessionaire shall make good at his own expense any damage to the Works that may be attributable to water or flooding resulting from the inadequacy of the arrangements required under this clause.

Costs incurred by the Concessionaire in complying with the requirements of this clause shall be deemed to be included in the Contract Price.

3.10.3 Discharge of water and waste products

The Concessionaire shall make provision for the discharge or disposal from the Works of all water and waste products and the methods of disposal shall be to the satisfaction of the Engineer and of any authority or person having an interest in any land or watercourse where water and waste products are discharged.

3.10.4 Site clearance and disposal

The Concessionaire shall carry out all site clearance works necessary. This shall include but not be limited to: removing rocks, boulders, trees, bushes, shrubs, other sundry vegetation, any man-made materials such as rubble, old equipment, abandoned vehicles etc. Materials removed as part of site clearance shall be disposed of to an approved tip, which may be subject to inspection by the Engineer. The Concessionaire shall provide details of such tips including location and owner, and shall provide certified evidence of each waste delivery. Flammable, non-harmful materials may be burned on site under controlled conditions subject to permission given by the Engineer. The Concessionaire shall apply to the Engineer in advance of each such activity. No materials shall be burned on sites adjacent to state or national highways or if closely surrounded by residential properties.

3.10.5 Dust hazard and nuisance

The Concessionaire shall take necessary measures including the spraying of water in order to keep down dust, which would otherwise be raised by the carrying out of the Works.

3.10.6 Water supplies

All water for use in the Works shall be fresh and free from harmful impurities, to the satisfaction

of the Engineer. The Concessionaire shall make adequate arrangements to deliver sufficient water to the Site for drinking, washing, sanitation and general cleaning down, in addition to any required for the construction, erection, testing, setting to work, testing for performance and guarantees at Site, commissioning and maintenance of the Works. If CMWSSB provides water based on the request of Concessionaire for water tightness tests for reservoir and hydrostatic test for pipeline, the supply shall be billed to the Concessionaire at the rate of Rs 12.60 for 1000 litres, subject to availability of water nearer to the site. The CMWSSB does not undertake any responsibility in this regard.

3.11 Work in the vicinity of electrical equipment

Any permanent fencing or other safeguards to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer's Representative may permit the use of temporary fencing or other safeguards.

If further work adjacent to electrical equipment is necessary after connection has been made to the electricity supply the Concessionaire shall put into operation a "Permit to Work" system to the approval of the Engineer.

3.12 Electricity supplies

The Concessionaire shall install, operate, maintain and subsequently remove temporary supplies of electricity for the heating, lighting and ventilation of all offices, stores and other temporary buildings used by the Concessionaire and by the Engineer's staff in addition to any supplies he may require in connection with the construction testing and maintenance of the Works. Such electricity supplies may be obtained either from Tamil Nadu State Electricity Board or from diesel generating plant provided by the Concessionaire.

The Concessionaire shall, at his own expense, supply, install, maintain and remove on completion, a temporary site electrical distribution system in a safe and efficient manner including wiring, cabling and distribution boards for power services, welding, lighting and all other electrical requirements. The Concessionaire shall submit details of the proposed temporary electrical distribution system to the Engineer. The Engineer may require the disconnection or alteration of any part of the electrical distribution system which, in his opinion, is dangerous or otherwise unacceptable. The Concessionaire shall not remove any of the installation without the approval of the Engineer.

3.13 Cleanliness of the Site

The Concessionaire shall maintain the area of his operations in a clean, tidy and safe condition. All disused materials, packages and other debris in connection with the Works shall be removed expeditiously from the Site by the Concessionaire at his expense. If, in the Engineer’s opinion, at any time the Site or part of it are not sufficiently clean and tidy, the Concessionaire shall take all necessary steps to rectify the situation as directed by the Engineer. This shall be done at the Concessionaire’s own cost.

3.14 Concessionaire's offices etc

For the use of his own staff and work force the Concessionaire shall provide, erect, construct, maintain and subsequently remove all temporary offices, sanitary arrangements, stores, workshops, compounds, parking areas and the like necessary for the completion of the Works and maintenance of the Permanent Works and the siting and layout of these shall be to the approval of the Engineer.
The Concessionaire may if he chooses, include a workers canteen within the Concessionaire's office and storage compound. The Concessionaire shall not erect labour lines and canteens elsewhere on site.
Details and layout of such buildings and services shall be to the general approval of the Engineer's Representative and the Concessionaire shall also obtain any necessary approval from any local or other authorities concerned.

The Concessionaire shall maintain all offices, buildings, tanks etc referred to in this and other clauses in good condition.

3.15 Concessionaire's Site Laboratory

The Concessionaire shall provide a field laboratory with adequate number of qualified Technicians and Assistants and maintain it during the construction period to the satisfaction of the Engineer. The laboratory shall be for doing the testing in accordance with the specification and any additional testing as instructed by the Engineer. The field laboratory shall be located near the Site in a place which shall be proposed by the Concessionaire and be subject to the approval of the Engineer.

The Field Laboratory buildings have effective floor area of not less than 40 sq.m and shall be designed proposed and constructed by the Concessionaire after securing the approval of the Engineer.

The Concessionaire shall supply and finish the Field Laboratory with the following new furniture and equipment.

Description	Quantity
Table 1.5m x 0.75m with six lockable drawers	1
Straight chair	4
Table 1.8m x 3.6m	2
Waste basket large, solid side, no wire	2
Wall board, not smaller than 2.5m x 1.5m	1
Cupboard with shelves and locks	2
File cabinet four drawers, lock type	1

The Concessionaire shall furnish enough equipment and apparatus for the purpose of carrying out the required concrete and soil tests. The laboratory equipment and apparatus shall be approved type and shall be adequate in the opinion of the Engineer to carry out all the tests as listed in the specifications.

The following minimum equipment and apparatus shall be furnished to the laboratory by the Concessionaire.

Laboratory Equipment

Sl. No	Designation	Quantity
1	Modified Proctor Compaction	2 sets
2	Moisture content	2 sets
3	Particle size analysis	1 set
4	Specific gravity	1 set
5	In-situ density	1 set
6	Concrete slump	4 sets
7	Concrete cube moulds	50
8	Cube crushing machine	1
9	Temperature controlled water bath for cube curing	1

The tank for curing shall be of adequate size to accommodate all test cubes at Concessionaire's highest rate of production of concrete.

The Concessionaire shall maintain the Field Laboratory and Technicians for operation of the laboratory throughout the course of the Contract. The Concessionaire shall supply one English Speaking competent laboratory technician, and two labourers for operation of the Laboratory under the Engineer.

The power, water, and gas shall be supplied to the Lab by the Concessionaire. The daily laboratory supplies shall also be supplied by the Concessionaire.

4.CIVIL SPECIFICATIONS

4.1.0 Site Preparation and Earth Works

4.1.1 General

This Section covers requirements for earth works including site preparation, mass excavation, trench excavation, structure excavation, filling and compacting and miscellaneous site works.

IS codes referred

a) IS 3764 Excavation work - Code of Safety

b) IS 2720 Methods of test for soils

(Part-1) Preparation of dry soil samples for various tests

(Part-2) Determination of Water Content.

(Part-4) Grain size analysis

(Part-5) Determination of liquid and plastic limit.

(Part-7) Determination of water content - dry density relation using light compaction.

(Part-8) Determination of water content - dry density relation using heavy compaction.

(Part-9) Determination of dry density – moisture content by constant weight of soil method.

(Part-14) Determination of density index (relative density) of cohesionless soils.

(Part-22) Determination of organic matter.

(Part-26) Determination of pH Value.

(Part-27) Determination of total soluble sulphates.

(Part-28) Determination of dry density of soils in place, by the sand replacement method.

(Part-33) Determination of the density in place by the ring and water replacement method.

(Part-34) Determination of density of soil in place by rubber balloon method.

(Part-38) Compaction control test (Hilf Method).

4.1.2 Definitions

1. **Site**: The site for the work is shown in the drawing and the Concessionaire's working and storage areas, where so specified are within the site.
2. **Fill**: Compacted suitable fill materials in all areas of the site requiring filling and for filling trenches as shown on the drawings.
3. **Structural fill**: Compacted suitable fill materials which will support a structure or some part of a structure.
4. **Structural backfilling**: Compacted suitable fill material placed between the wall of a structure and construction excavation slope up to finished grade or back filling of trenches excavated for laying pipes.
5. **Suitable materials**: As specified herein shall be any materials excavated from the cut areas or imported that in the opinion of the Engineer is suitable for use in constructing fills.
6. **Unsuitable materials**: Materials from project excavations, which is not suitable for use in backfilling or compacted fills.
7. **Surplus materials**: Materials from the Project excavation to excess to that required to be used for backfilling or constructing fills.

4.1.3 Site Investigation

The Trial pit summaries and related information depict subsurface conditions only at the specific locations and at the particular time designated in the logs. Soil conditions at other locations may differ from conditions occurring at these locations.

4.1.4 Concessionaire's Responsibility

The Concessionaire shall take care in order to determine the full extent of the work required to make the completed work conform to the Drawings and Specifications. The Concessionaire shall satisfy himself as to the character, quality and quantity of surface and subsurface materials or obstacles or utilities to be encountered. Any inaccuracies or discrepancies between the actual field conditions and the drawings, or between the drawings and specifications shall be brought to the Engineer's attention in order to clarify the exact nature of the work to be performed.

4.1.5 Safety

The Concessionaire shall familiarize himself with, and shall at all time conform to all regulations on Construction Safety and Trench Construction Safety in force in the State of Tamil Nadu in India.

4.1.6 Quality Assurance

The Concessionaire shall exercise due care to assure procurement, storage and placement of materials from site or off-site sources which will comply with the requirement, specifications and standards set out herein. The Concessionaire may have, at his discretion and cost, such tests and inspections as he may desire performed by qualified personnel or independent specialist testing services, for the determination of soil properties and for the proper control of the works.

4.1.7 By Engineer

The Engineer, through his project representative will be the off-site arbiter and judge of the acceptability of the works done, based on such observation and tests as he may require or perform.

4.1.8 By Employer

The Employer may conduct specialist inspection and testing by independent testing services, engaged and paid for by the Employer.

4.2 Excavation

4.2.1 Earthwork

Earthwork shall include all site preparation, excavation, handling, hauling and compaction of required fill materials, disposal of all excess excavated materials, shoring and protection work, preparation of subgrades, dewatering as necessary, protection of adjacent property, backfilling and embankment to the lines and grades indicated in the drawings for the works described in the Contract Documents and / or shown on the Drawings.

4.2.2 Site Preparation

Site preparation, shall include, within the boundaries of the work as shown on the Drawings, the grubbing stripping and removal of all vegetation, organic materials, and other unsuitable excess materials. Areas

which will be under fills shall be cleared and grubbed to a depth of 12 cm or sufficiently deep to remove large roots, loose rocks, and other unsuitable materials as determined by the Engineer. The materials pronounced useful by the Engineer will be removed and properly stacked as directed within specified lead.

All rock foundation and abutment surfaces shall be cleared of all loose materials by hand or other effective means and shall be free of standing water when fill is placed. Fill immediately adjacent to such rock foundations or not accessible with large compaction equipment shall be compacted to the specified density by means of hand tamping or manually directed power tampers or plate vibrators.

Where ordered by the Engineer topsoil shall be stripped, to such depths and over such areas as a separate operation prior to any further excavation which may be required. Topsoil shall be stored for reuse.

4.2.3 Site Grading Generally

After all unsuitable material has been removed from the site, the existing surface shall be excavated or filled to the elevations and slopes and dimensions indicated on the drawings or as directed by the Engineer and the Concessionaire shall perform all operations related thereto. It will be the responsibility of the Concessionaire to install substantial reference marks, bench marks, etc, and maintain them in position as long as required. Road and drainage work required within the property limits at each site shall be provided as part of the site grading.

4.2.4 Excavation

The Concessionaire shall excavate all materials of whatever nature encountered, to lines, levels, curves and grades as required or as shown on the Drawings. After completion of this excavation and before any further work is done the Engineer will examine the subgrade.

The Concessionaire shall notify the Engineer before starting excavation to enable him to take cross sectional / L-sectional levels for measurement before ground is disturbed. Where excavation is progressive, the cross-sections and L-sections will be demarcated by substantial pillars or stakes. The Concessionaire may be required to carry out excavation deeper than shown on the Drawing.

The entire areas within the limits of earth work as indicated shall be constructed to the lines, grades, elevations, slopes and cross sections indicated on the Drawings with added allowance for the thickness of free draining fills or other special materials such as clay where required. Slopes and drainage features shall present a neat, uniform appearance upon completion of the work and shall be subject to approval by the Engineer.

Excavated materials meeting the requirements of fill materials may be conserved for subsequent use or placed as earth fill immediately after excavation provided the Engineer gives his approval. Large rocks unacceptable as earth fill materials may be stockpiled for use as riprap where required. The suitability of all excavated materials for specific purposes shall be determined by the Engineer. The Concessionaire shall not waste or otherwise dispose of suitable excavated materials. All excavations shall be performed under the limitations and requirements set out in this Specification pertaining to control of water content.

4.2.4.1 Fossils and Other Materials

All fossils, relics, coins, minerals and any other items of archaeological importance found in excavation or dismantling shall be the property of the Employer and shall be handed over to the Engineer's representative. Should any structure be uncovered, the Engineer's instruction shall be obtained before its demolition or removal.

4.2.4.2 Shoring

All excavation shall be suitably and effectively supported at the sides and ends to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Unless specifically provided for in the tender the shoring and strutting shall be deemed to be part of excavation item only and nothing extra shall be paid to the Concessionaire. If for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Concessionaire shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed both within and outside the nominal limits of excavation and such extra excavation shall not be paid for.

The Concessionaire shall submit a detailed plan for review showing the design of shoring, bracing, sloping, or other provisions to be made for worker protection from the hazard of caving ground during the excavation of such trench or trenches or during the pipe installation or any construction therein.

If ordered by the Engineer, the Concessionaire shall provide additional supports or sheeting or modify the arrangements as directed without extra cost.

This shall not exempt the Concessionaire from the liability of damages to persons and property due to failure of the shoring etc.

4.2.4.3 Sloping Faces

Where the Concessionaire elects and is permitted by the Engineer to perform excavations with sloping faces, other than sloping excavations where required by the Engineer or as specified in the Contract and without shoring, the excavated faces shall be stable slopes and heights and the resulting extra excavation shall not be paid for. The decision of required slope (or steps) to be allowed for such open excavation will be that of the Engineer whose decision will be final and binding on the Concessionaire.

4.2.4.4 Trimming Excavations

When excavating to specified levels for the foundation of any structure or to specified limits for the face of any structure or for laying pipelines the Concessionaire shall not excavate the last 150 mm until commencing the constructional work.

Before commencement of any constructional work, all shattered and loose material shall be removed from the excavation by hand, so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

4.2.4.5 Engineer's Inspection

When the specified levels or limits of excavation are reached the Engineer will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable, he may direct the Concessionaire to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, masonry, selected excavated material or selected imported material as directed by the Engineer, and payment for this work shall be made by the Concessionaire.

If through mistake by the Concessionaire excavation is done deeper than shown on plans or ordered by the Engineer, the extra depth shall be made up with concrete or masonry as directed by the Engineer and the cost of excess excavation and the filling by masonry/concrete shall not be paid for.

If the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddle, soft or loose during the progress of the works, the Concessionaire shall

remove such damaged, softened or loosened material and excavate further by hand. Such further excavation and consequent backfilling shall not be paid for. After each excavation is completed, the Concessionaire shall notify the Engineer to that effect and no footing or pipe will be allowed to be laid until the Engineer has approved the depth and dimensions of excavation and nature of foundation material and levels/ measurements are recorded.

4.2.5 Fill Structural

4.2.5.1 Fill Material

When the quantities of suitable materials obtained from excavations are insufficient to construct the specified fills, additional materials shall, if directed by the Engineer, be obtained by the Concessionaire from approved burrow areas. Borrow pits shall be excavated and finally dressed in a manner to eliminate steep or unstable side slopes or other hazardous or unsightly conditions. The extent and depth of burrow pits within the limits of the designated borrow areas shall be subject to approval by the Engineer.

Excess excavated or fill material may be deposited on the Site in accordance with compaction requirements and subject to the approval of the Engineer.

Rocks or other solid material which are larger than 15 cm in greatest dimensions shall not be used as fill without the Engineer's approval. Smaller rocks shall be well distributed throughout the fill area and sufficient earth or other fine material shall be placed around the larger materials as it is deposited so as to fill the interstices and produce a dense, compact fill.

4.2.5.2 Deposition of Fill

Materials for fills may be obtained from the required excavations. Fill material shall be deposited in layers of not more than 20 cm in loose thickness for hand compacted fill, including manually directed power tamping, and compacted to the required densities by suitable compaction equipment. Additional fill may be required and shall be obtained from approved borrow areas. The Concessionaire is responsible for the arrangement and payment for all embankment material and the material selected shall meet approval of the Engineer.

4.2.5.3 Deterioration of Material

If the material being placed as backfilling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become puddle, soft or segregated during the progress of the works, the Concessionaire shall at his own expense remove such material and replace it with fresh approved material.

The Concessionaire shall when placing the backfilling make due allowance for any settlement that may occur before the end of the defect's liability period. Where necessary, the Concessionaire shall at the end of the defects liability period remove any excess material or make up any deficiency of backfilling to the specified level.

4.2.5.4 Control of Compaction

The moisture content shall be controlled as specified herein and the surface materials of the foundation shall be compacted, the surface bounded with the first layer of earth fill. Subsequent layer of earth fill shall be bounded in a similar manner. No ponding or jetting shall be permitted.

Fill material shall be moistened or dried to within two (2) percent of optimum moisture content (Proctor) and compacted to meet or exceed the following listed values when in accordance with these specifications.

1. Fills and backfills under and adjacent to structures shall be compacted to not less than 95 percent of maximum dry density.
2. All other fills shown on the plans shall be compacted to not less than 90 percent of maximum dry density.

All working areas shall be protected from damage by water and site drainage shall be maintained at all times, and water shall be prevented from standing on the top of constructed fills and backfills. Heavy equipment shall not be operated within 1.5m of any structure.

4.2.6 Trench Excavation and Backfill

4.2.6.1 Trenches

Trench excavation means excavation of trenches into which pipes are to be laid and the term pipes shall mean pipes of all kinds and for whatever purpose and shall also include cables and cable ducts. The line and level of trenches shall be as shown on the Drawings or as may be directed by the Engineer. Before commencing trench excavation, the route of the trench shall be pegged out accurately and the natural ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than 40m apart.

4.2.6.2 Trial Pits

The Engineer may direct that trial pits shall be excavated well ahead of the trench excavation to such depths as he shall order to determine the alignment of the trench. Any further trial pits required by the Concessionaire to determine the position of underground services, subsoil drains or for any other reason shall be excavated and reinstated at the Concessionaire's expense.

After the required information is obtained, the Concessionaire shall arrange for the re-filling and reinstatement of trial pit to be carried out immediately to the approval of the Engineer and in accordance with the requirements of the authority or the persons having jurisdictions of the area.

4.2.6.3 Trench Excavation

Trench excavation shall be carried out by such methods and to such lines, dimensions and depths as shall allow for the proper constructions of the works, provided always that, unless the Engineer permits otherwise, no trench excavation shall be less than the nominal widths specified elsewhere in this section.

The sides of trench excavation shall be vertical unless the Engineer permits otherwise. Any widening or deepening of trench excavations necessary to accommodate curves, joints or bends in the pipe or to provide extra working space for the construction thereof shall be held to be allowed for in the Concessionaire's rates for overall linear meters of length.

No length of trench excavation shall be started until the pipe to be laid in that length are available on the site.

4.2.6.4 Roads

Programme of excavation shall be decided in consultation with the Engineer so as to cause least traffic interruption. Appropriate signs for public guidance like "street closed for traffic" etc. shall be exhibited by the Concessionaire. Excavation in roads and other work carried out within the vicinity of any road shall

be completed as rapidly as possible and not more than half of the carriageway shall be obstructed at one time. Road drains shall be kept free from obstruction.

The Concessionaire shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when excavation is begun until the refilling of the trench is placed, to ensure that there is no disturbance of any road or road foundation or structure.

All excavated material shall be stacked in such a manner as not to endanger work or cause obstruction on footpath or driveways. All excavated stuff suitable for bedding or refilling shall be separately stacked. Where excavated materials have temporarily been deposited on a grass margin, the margin shall, on completion of refilling, be restored entirely to its original condition and left free from loose stones.

The Concessionaire shall have particular regard to the safety of traffic, persons and livestock using rights of way through the Site and shall ensure that all open excavations, access routes and steep or loose slopes arising from the Concessionaire's operations in roads or other areas are adequately shored and protected.

4.2.6.5 Trench Beds

The bottom of trench excavations shall be carefully finished and trimmed true to grade with the aid of a straight edge at least 6m long so as to ensure a continuous support for the pipes. Where directed by the Engineer the trench bottom shall then be picked over with a fork and any stone or flints either likely to cause the pipe to bed unevenly or to damage the pipe and its coating shall be removed. Stones greater than 20mm in size shall be picked out of the pipe bed and any holes so formed shall be filled in with the soft material and trimmed to the correct level. Where bedding material is specified, all shattered and loose material shall be removed from the bottom of the trench excavation so that the bedding material rests on a solid and clean foundation.

4.2.6.6 Progress of Trenching

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the contract, the refilling and surface reinstatement of trench excavations shall be commented and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipelaying shall follow closely upon the progress of trench excavation and the Concessionaire shall not permit excessive lengths of trench excavation to remain open while awaiting testing or lining of the pipeline. Availability of pipes and specials required at Site for the work shall be considered before progressing work of excavation. The Concessionaire shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed while awaiting tests of the joints at the approval of the Engineer.

If the Engineer considers that the Concessionaire is not complying with any of the foregoing requirements, he may prohibit further trench excavation until he is satisfied with the rate of laying and testing of pipes and refilling of trench excavation.

4.2.6.7 Refilling Trench

Where granular or other beddings or special procedures are not specified, trench excavations shall be refilled using suitable materials selected from excavation carried out on site, or if such materials are insufficient, imported material may be used.

Soft material free from stones greater than 75mm in size for R.C.C/P.S.C. pipes, 20mm in size for C.I./A.C. pipes and 10mm for steel pipes shall be deposited in 150mm layers shall be thoroughly rammed

after watering under and around the pipe. Suitably shaped rammers shall be working alternatively on either side of pipe, particular care being taken to avoid damage to the pipe and any sheathing. Filling and masonry shall continue until the trench has been refilled up to level of the pipe, and thereafter until the soft filling has been carried upto at least 300mm compacted thickness above the top of the pipe and to the whole width of the trench. The layer of refilling material shall not exceed 150mm.

The remainder of the backfilling may consist of coarse material including broken rock from any excavation in rock, free from boulders and clods of earth larger than 150mm in size provided that the compacted backfill is, in the opinion of the Engineer, sufficiently dense to prevent material from the super-imposed layers being washed into the voids in such backfill. This coarse material shall be spread in layers of not greater depth than 200mm and be thoroughly rammed after watering by an approved mechanical or other rammer. The coarse filling shall be carried up to the level at which in roads and footpaths surface reinstatement is to commence, or elsewhere to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently high to allow for future settlement during the defect liability period so that the original ground level is reached.

Hard material such as broken rock and broken original road metalling shall normally be used only for the surface reinstatement of roads as specified but where it is suitable and available in sufficient quantity, it may be used in place of or as well as coarse material, provided the size, shape and other characteristic of the material are approved by the Engineer. Where necessary the Concessionaire shall adjust the moisture content of the refill material to obtain optimum conditions either by drying out or by adding water to assist the compaction of the material. Under no circumstances will flooding or ponding be permitted.

Should the material being place as backfilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become puddle, soft or segregated during the progress of the works, the Concessionaire shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material. Where directed by the Engineer, pipelines shall be bedded or surrounded with concrete.

If the filled-up trenches sink during subsequent monsoon, responsibilities of making good the sinking by providing additional filling rests with the Concessionaire, even though the measurements of work have been recorded and paid for. The refilling shall be carried out with due allowances for such sinking.

4.2.6.8 Bedding

The bedding backfilling shall be carried out as per standard drawing.

4.2.6.9 Existing Services

Where trench excavation is carried out close to or across the line of sewers, pipes, cables and other services or structures, the Concessionaire shall, where necessary, provide temporary supports or slings and where such sewers, pipes, cables and other services are temporarily disturbed, they shall be replaced.

Where, in the opinion of the Engineer, construction of the pipeline cannot reasonably be carried out unless the sewer, pipes, cables and other services are severed and/or replaced or permanently diverted or permanently supported by concrete he may order the Concessionaire to undertake such work.

Notwithstanding any relevant information furnished by the Employer or Engineer, the Concessionaire shall be responsible for ascertaining from his own inspection of the site and from the respective supply authorities and other public bodies the position of all mains, pipes and cables whether underground or overhead, within or near the site.

4.2.6.10 Trench Refilling

The trench shall not be filled in until the joints have been tested and alignment examined and passed and the level/measurements are recorded by the Engineer.

The Engineer may order refilling of trenches before testing in which case joints shall have to be opened by the Concessionaire during testing at his own cost.

4.2.6.11 Other Structures

The Concessionaire shall carry out further excavation as may be necessary to accommodate structures such as thrust blocks and valve chambers.

4.2.6.12 Surface Reinstatement

The materials excavated shall be separated and stocked so that in the refilling they may be re-laid in the same order and thus least possible damage be done to public roads, fields, etc. The road material excavated shall be stacked separately as directed by the Engineer. The refilling with excavated boulders and metal shall be done in the previous order to original level with allowances for sinking. The concrete/asphalt pavements shall not be done by the Concessionaire unless provided for specifically in the contract.

4.2.7 Structure Excavations

Excavation and backfilling for all structures and appurtenances associated with the structures shall include the entire cost of any required shoring, timbering, stabilization or dewatering unless specifically separately provided for, in the contract, and workmanship shall comply with the appropriate provisions of these specifications. Structure excavation shall include the removal of all materials to such depth as indicated in Drawings, including all obstructions of any nature that would interfere with the proper execution and completion of the work. The removal of such materials shall conform to the lines and grades shown on the Drawings and/ or herein specified. It shall be the Concessionaire's responsibility to provide all required pumping, ditching or other approved measures for the removal or exclusion of water from the excavated space. The item of dewatering shall be taken as included in excavations unless otherwise provided for in the separate tender item.

All excavation works shall be done as per IS 3764 "Code of Safety - Excavation Work"

4.2.7.1 Excavation Side Slopes

Loose cobbles or boulders shall be removed from the sides of the excavation for structures before allowing workmen into the excavation, or the excavation side slopes must be protected with screening or other methods approved by the Engineer. In no case shall surcharge loads due to construction equipment be permitted with 1.5 meters of the top of any excavation slope. If the Concessionaire selects to shore or otherwise stabilize the excavation sides, he shall submit in writing his plans for such proposal to the Engineer for approval before commencing any excavation. Shoring and strutting shall be deemed to be included in the item of excavation, if not specifically provided for separately in the contract.

4.2.7.2 Material for Structure Backfill

Materials for structure backfill shall be non-expansive material selected from on Site material obtained from the excavation and approved by the Engineer. Should on-Site materials prove of insufficient quantity, the material shall be provided at Concessionaire's expense and shall be subject to approval by the Engineer. No rocks larger than 8cm in diameter or trash, roots or detrimental quantities of organic material shall be permitted in structure backfill. The Concessionaire may, at his option and at no cost to the Employer, substitute rock or other material approved by the Engineer for use as structure backfill.

4.2.7.3 Placement of Structure Backfill

Before beginning backfilling, all foreign material, including water, shall be removed from the space to be backfilled and the area to be backfilled shall be inspected and approved by the Engineer. No backfill shall be placed around or upon any structure until the concrete or masonry in the structure has attained the specified compressive strength. The compressive strength shall be determined by test on representative cylinders or cubes made from the same concrete and cured under conditions similar to those prevailing at the site. Backfill shall not begin until after the forms have been removed and patching of the concrete and water proofing has been completed and the work approved.

4.2.7.4 Compaction of Structure Backfill

Structure backfill shall be placed in horizontal layers of such depths compactable to the type of compaction equipment being used, but in no case shall be the lifts exceed 20cms. Each layer shall be evenly spread; the moisture content brought to bear optimum conditions and then compacted.

Permission to use specific compaction equipment shall not be construed as guaranteeing or implying that the use of such equipment will not result in damage to adjacent ground, existing improvements, or improvements installed under the Contract. The Concessionaire shall make his own determination in this regard.

Flooding, jetting or ponding will not be permitted for the compaction of any backfill.

The top surface of all embankments shall be approximately level during construction except that a crown or cross slope (super elevation) of not less than 2 percent shall be maintained for effective drainage. Though not shown on the Drawings, all finish grade embankment top surfaces shall be finished a 2 percent crown or cross-slope as applicable for the Site drainage.

4.2.7.5 Finish Grading

All areas of the work, including excavated and filled sections and transition areas shall be uniformly graded to the elevations shown on the Drawings. The finished surface shall be reasonably smooth, compacted and free from any irregular surface changes. The degree of finish shall be that ordinarily obtainable from scraper operations, though a manual finish to the same standard will be acceptable. The finished surface will be not more than 5 cm above the established grade.

4.2.7.6 Top Soiling and Landscaping

Topsoil shall be evenly spread and trimmed over embankments or areas surrounding structures to the slopes and levels shown on the Drawings or ordered by the Engineer. The depth after spreading and trimming shall be a minimum of 20 cm unless otherwise directed, measured perpendicularly to the surface. All clods and lumps shall be broken up and any rubbish, stones larger than 50 mm, roots and weeds shall be removed.

4.2.8 Miscellaneous

4.2.8.1 Foundation Trenches

The foundation trenches shall be kept dry by resort to pumping alone or pumping in combination with diversion channels, cofferdams, bunds, diversion weirs, drainage channels, or other method suitable for the local conditions, at the choice of the Concessionaire. The responsibility of adequacy of dewatering arrangements and quality and safety of work rests solely with the Concessionaire.

4.2.8.2 Diversion and Protective Works

The Concessionaire shall plan, construct and maintain necessary diversion and protective works, so as to

keep the work safe at all stages. The coffer dam where required shall be built to required depths and heights and safety designed and constructed with suitable dimensions and protection and shall be made watertight enough for construction inside it. The coffer dam shall leave sufficient clearance for construction and inspection facility and permit installation of pumping machinery as required.

Cement grouting or other approved method shall be used by Concessionaire at his choice to reduce seepage, for which no extra payment shall be made.

4.2.8.3 Pumping Arrangement

Adequate pumping arrangement shall be made for dewatering the foundation/pipe trenches and other construction areas so as to keep them dry during the progress of the work until concrete or mortar masonry work has sufficiently set. The dewatering arrangement shall be preclude the possibility of movement of water to fresh concrete or masonry. The Concessionaire shall make his own arrangement for labour, materials and equipment for coffer dams, pumps, engines and other machinery and services required for execution of item. The pumping shall not cause any damage to the adjoining property.

If any foundation pits are filled during the progress of work due to any cause, the pumping required for dewatering pits and for desilting shall be done without extra cost to the Employer.

All protective works required for dewatering shall be designed and provided by the Concessionaire to ensure full safety of work, workmen, machinery and property. The Concessionaire shall be responsible for only damage and injury caused by execution of this item.

The works constructed such as coffer dam, sumps for facility of diversion and dewatering shall be removed after they have served their purpose, in the manner and to the extent instructed by the Engineer. If any excavation is made outside the enclosed area for facility of construction, the Concessionaire shall refill the same with proper ramming of foundation work so as to bring river bed to its original condition similarly any material deposited with the stream or from any excavation shall be removed and the stream is made free from obstruction.

4.2.8.4 Disposal of Water

The water from dewatering shall be disposed of in conformity with the rules in force and as approved by the Engineer.

In cities and towns, the water may be led to nearest road side gutters. In other places water may be led to the nearest natural drain or pond through properly laid and dug channels or pipes. The disposal shall not cause any inconvenience or nuisance to inhabitants of the area and also not cause damage to structures and property.

4.2.8.5 Testing

Testing will be performed when, where, and as directed by the Engineer. The costs of compaction testing shall be borne by the Concessionaire. The Concessionaire shall adjust his operations so as to permit the Engineer time to make tests, and shall excavate and fill such holes as may be required for sampling and testing. Extensive regular testing will normally be required only during the construction of embankments, and side and top fillings for steel pipes.

4.2.8.6 Blasting

No explosives of any description may be used without the Engineer's prior approval in writing. The

transportation, handling, storage, and use of dynamite and other explosives shall be directed and supervised by a person of proven experience and ability in blasting operations. A schedule and materials lists for such transportation and storage and proof of experience must be approved by the Engineer prior to its use.

Blasting shall be done in such a way as to prevent damage to the work or fracturing of foundations or subsurface services. The Concessionaire shall be solely responsible for injury to persons, or property or services that may result from his use of explosives.

4.2.8.7 Lighting and Guarding the Trenches

The excavation rate shall be inclusive for barricading, lighting at night by red lights or a construction sign in charge of a watchman to avoid any accidents till road is safe for traffic. Local Authority's Rules, if any, in this behalf shall be observed. Accidents, if there be any, shall be the responsibility of the Concessionaire.

4.2.8.8 Choice of Blasting & Chiselling

Where the item of excavation in hard strata specifies clearly the mode of excavation, viz, blasting or chiselling the excavation shall be done as per that method and rate payable will be the one for this item specified in the bill of quantities.

Item of chiselling shall be operated only if blasting is not permitted by the Engineer.

4.2.8.9 Sand Bedding

Sand bedding shall be carried out as per drawing provided to the Concessionaire.

4.2.9 Rules for Blasting Operations

4.2.9.1 General

The Concessionaire shall acquaint himself with all the applicable laws and regulations concerning storing, handling and the use of explosives. All such laws, regulations and rules etc. as are current from time to time shall be binding upon the Concessionaire.

The provisions detailed in these rules are supplementary to the above laws, rules and regulations etc. and are applicable except where they conflict with the aforementioned laws etc. from time to time. The Engineer may issue modifications, alternations or new instructions from time to time and the Concessionaire shall comply without these being made a cause for any claim.

4.2.9.2 Materials

All materials such as explosives, detonators, fuse, tamping materials etc. that are proposed to be used in the blasting operations shall have the prior approval of the Engineer.

Black powder and safe explosives (as commonly current in India) shall be used wherever possible. Explosives with Nitro-glycerine shall only be used in exceptional circumstances, and where the above explosives are not effective.

The use of a fuse with only one protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for thirty minutes. The rate of burning of the fuse shall be uniform and not less than 4 seconds per 2.5cms of length with 10% tolerance on either side.

Before use, the fuse shall be inspected and the moist, damaged or broken one discarded. The rate of burning of all new types of fuses or when they have been in stock for long shall be tested before use.

The detonators used shall be capable of giving effective blasting of the explosive, Moist or damaged detonators shall be discarded.

4.2.9.3 Personnel

Excavation by blasting will be permitted only under personal supervision of competent and blasting work licensed persons and trained workmen.

All supervisors and workmen in charge of makeup, handling, storage and blasting work shall be adequately insured by the Concessionaire.

The storage shall be in charge of a very reliable person, approved by the Engineer, who may, if necessary, cause police enquiries being made as to his reliability, antecedents etc. The Concessionaire shall have to produce a security for the person in charge of the explosives if required by the Engineer, or the Civil authorities of the District.

The Concessionaire shall make sure that his supervisors and workmen are fully conversant with all the rules to be observed in storing, handling and use of the explosives. The Supervisor in charge shall be thoroughly acquainted with all the details of the handling and blasting operations.

4.2.9.4 Storage of Explosives

The Concessionaire shall build a magazine, for storing the explosives. The site of the magazine, its capacity and design shall be subject to approval by the Engineer, and the Inspector of Explosives before the construction is taken up. The explosives shall be stored in a clean, dry, well ventilated, and fire- proof building, on an isolated site.

The explosives, detonators and fuses shall each be separately stored.

A crateful and day-to-day account of the use of explosives shall be kept by the Concessionaire in an approved register and in an approved manner. The register shall be produced by the Concessionaire for the inspection of the Engineer when so required. The Engineer may also pay a surprise visit to the storage magazine. In case of unaccountable storage of explosives or if the account is not found to have been maintained in the manner prescribed by the Engineer, the Concessionaire shall be liable to be penalized with forfeiture of security deposit lodged by him with the Employer or his Contract shall be liable to be cancelled in which case he shall not be entitled to any compensation for the losses etc. The action taken under this clause shall be in addition to that which might be taken by the competent civil authorities in a court of law.

The magazine shall at all times be kept scrupulously clean. No unauthorized persons shall at any time be admitted inside the magazine.

The magazine shall, when not in use of authorized persons, be kept well and securely locked.

The magazine shall on no account be opened during or on the approach of a thunder storm and no person shall remain in the vicinity of the magazine during such period. The magazine shoes, without nails, shall at all times, be kept in the magazine, and a wood tub or cement trough about 30cms high and 42cms in diameters filled with water shall be fixed near the door of the magazine.

Persons entering the magazine must put on the magazine shoes which shall be provided by the Concessionaire for the purpose and be careful.

1. Not to put their feet on the clean floor unless they have the magazine shoes on;

2. Not to allow the magazine shoes to touch the ground outside the clear floor.
3. Not to allow any dirt or grit to fall on the clean floor.

Persons with bare feet shall, before entering the magazine, dip their feet in water and then step direct from the tub over the barrier (if there be one) on the clean floor.

A brush or broom shall be kept in the lobby of the magazine for clearing out the magazine on each occasion it is opened, for the receipt, delivery or inspection of explosives

No match or inflammable materials shall be allowed in the magazine. Light shall be obtained from an electric storage battery lantern

No persons having articles of steel or iron on him shall be allowed to enter the magazine.

Oily cotton rags, waste and articles liable to spontaneous ignition, shall not be allowed inside the magazine.

Workmen shall be examined before they enter the magazine to see that they have none of the prohibited articles on their person.

No tools or implement other than those of copper, brass, gunmetal or wood shall be allowed inside the magazine. All tools shall be used with extreme gentleness and care.

Boxes of explosives shall not be thrown down or dragged along the floor and shall be stacked on wooden trestles. Where there are white ants, the leg of the trestles should rest in shallow copper, lead or brass bowls containing water. Open boxes of dynamite shall never be exposed to the direct rays of the sun.

Empty boxes or loose packing materials shall not be kept inside the magazine.

The magazine shall have a lightning conductor which shall be tested at least once a year by an officer authorized by the Engineer. The test fee shall be paid by the Concessionaire at actual cost as charged by the appropriate authority. The Concessionaire shall within 15 days comply with all the recommendations made by the officer testing the lightning conductor, failing which the Engineer shall be entitled to comply with the same at the Concessionaire's expense.

A notice shall be hung near the store prohibiting entrance of unauthorized person.

The following shall be hung in the lobby of the magazine:

a) A copy of rules both in English and the languages which the workers concerned are familiar with;

b) A statement showing the up-to-date stock in the magazine;

c) A certificate showing the last date of testing of the lightning conductor;

d) A notice that smoking is strictly prohibited.

The Magazine will be inspected at least twice a year by an officer representing the Engineer who will see that all the rules are strictly complied with. He will notify all omissions etc. to the Concessionaire, who shall rectify the defects within a period of 15 days from the date of receipt of the notice, failing which the Engineer may take whatever action he considers necessary.

4.2.9.5 Use of Explosives

For the transport of the explosives and detonators between the store and the Site, closed and strong containers made of soft material such as timber, zinc, copper, leather and the like, shall be used. The

explosive and detonators shall be carried in separate boxes and transported separately. For the conveyances of primers, special containers shall be used.

The boxes and containers used shall be kept well closed.

Explosive shall be stored and used chronologically to ensure the ones received earlier, being used first.

A makeup house shall be provided at each working place in which cartridge will be made up by experienced men as required. The make-up house shall be separated from other buildings. Only electric storage battery lamps shall be used in this house.

No smoking shall be allowed in make-up house.

Disposal of deteriorated explosives: All deteriorated explosives shall be disposed of in an approved manner. The quantity of the deteriorated explosives to be disposed of shall be intimated to the Engineer, prior to its disposal.

Preparation of primers: The primers shall not be prepared near open flames or fires. The work of preparation of primers shall always be entrusted to the same personnel. Primers shall be used as soon as possible, after they are ready.

Charging of holes: The work of charging shall not commence before all the drilling work on site is completed and the supervisor has been satisfied to that effect, by actual inspection.

While charging, open lamps shall be kept away. For charging with powdered explosives, naked flames shall not be allowed.

Only wooden tamping rods without any kind of metal on them shall be used.

Boreholes must be of such size that the cartridges can easily pass down them.

Only one cartridge shall be inserted at a time and gently pressed with the tamping rod. The sand clay or other tamping materials used for filling the holes completely shall not be tamped too hard.

4.2.9.6 Blasting

Blasting shall be carried out during fixed hours of day, which shall have the approval of the Engineer. The hours, once fixed, shall not be altered without prior written approval of the Engineer.

The site blasting operations shall be prominently demarcated by red danger flags. The order to fire shall be given only by the Supervisor in charge of the work and this order shall be given only after giving the warning signals three times, so as to enable all the labourers, watchmen etc. to reach safe shelter and after having ascertained that nobody is within the danger zone.

A bugle or a whistle with a distinctive note shall be used to give the warning signal. This bugle shall not be used for any other purposes. All labour shall be made acquainted with the sound of the bugle and shall be strictly warned to leave their work immediately at the first warning signal and make for safe shelters, and not to leave the shelters until the all clear signal has been given.

All the roads and foot-paths leading to the blasting area shall be watched

In special cases, suitable extra precautions shall be taken. The Engineer may however permit blasting for underground excavation, without restriction of fixed time, provided that, he is satisfied that proper precautions are taken to give sufficient warning to all concerned and that the work of other agencies on

the site is not unduly hampered.

For lighting the fuses, a lamp with a strong flame such as a carbide lamp shall be used.

The supervisor shall watch the time required to the fixing of the fuses and shall see that all workmen are under safe shelters in good time.

4.2.9.7 Electrical Firing

Only the supervisor in charge shall keep the firing apparatus, and he shall keep it always with himself.

Special apparatus shall be used as a source of current for the blasting operation. Power lines shall not be tapped for the purpose.

All the detonators shall be checked before use.

For blasts in one series, only detonators of the same manufacture and of the same group of electrical resistance shall be used.

Such of the electrical lines as could constitute danger for work of charging shall be removed from the site.

The firing cable shall have a proper insulating cover so as to avoid short circuiting due to contact with water, metallic parts of rock.

The use of the earth as a return line shall be permitted. The firing cable shall be connected to the source of current only after ascertaining that nobody is in the area of blasting.

Before firing, the circuit shall be checked by a suitable apparatus.

After firing, whether with or without an actual blast, the contact between the firing cable and the source of current shall be cut-off before any persons are allowed to leave the shelters.

During storm, charging with electrical detonators shall be suspended. The charges already placed into the holes shall be blasted as quickly as possible, after taking all the safety precautions and giving necessary warning signal. If this is not possible, the site shall be abandoned till the storm has passed.

4.2.9.8 Precautions after Blasting

After the blast, the supervisor shall carefully himself confirm that all the charges have exploded.

After the blast takes place in underground works the workmen shall not be allowed to go to the place till all the toxic gases are evacuated from the place.

4.2.9.9 Mis-Fires

If it is suspected that the part of the blast has failed to fire or is delayed, sufficient time shall be allowed to elapse before entering the danger zone. When the fuse and blasting caps are used, a safe time should be allowed and then the Supervisor alone shall leave the shelter to see that misfire. Drilling near the hole that has misfired shall not be permitted until one of the following operations has been carried out by the Supervisor.

The Supervisor should very carefully (when the tamping is of damp clay) extract the tamping with wooden scraper or jet of water or compressed air (using a pipe of soft material) and withdraw fuse with the primer and detonator attached. A fresh primer and detonator with fuse shall then be placed in this hole and fired.

The Supervisor shall get one of the tamping cleared and indicate the direction by placing stick in the hole.

Another hole may then be drilled at least 23 cm. away and parallel to it; this hole should then be charged and fired. The balance of the cartridge and detonators found in the muck shall be removed.

Before leaving his work, the Supervisor should inform the Supervisor of relieving shift of any case of misfire and shall point out the position with a red cross denoting the same and also state what action, if any, he has taken in the matter.

The Supervisor shall at once report to the office, all cases of misfire, the steps taken in connection therewith.

The names of the Supervisor in charge of day and night shifts must be noted daily in the Concessionaire's office.

If a misfire has been found to be due to defective detonator, or dynamite, the whole quantity of box from which the defective article was taken, must be returned to the authority as may be directed by the Engineer in charge for inspection to ascertain whether the whole box contains defective materials.

Redrilling the holes that have misfired either wholly or partly shall not be permitted.

4.2.9.10 Accidents

The Concessionaire shall be solely responsible for any accident during the entire procedure of handling explosives and blasting shall pay necessary compensation to the persons affected or for damage to lands or property etc. without claims.

4.3 Formwork

4.3.1 General

4.3.1.1 Description

Requirements specified herein are for providing formwork along with supporting scaffolding therefor for cast-in-situ concrete as indicated, specified, and required.

4.3.1.2 Quality Assurance

A. Requirements:

All formwork shall be constructed of timber, sheet metal or other approved material. It shall be firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. Design of structures shown on the Engineer's drawings does not include any allowance or consideration for imposed construction loads. One copy of the Concessionaire's shoring and formwork drawings shall be submitted to Employer for record purpose only and not for review or approval. Forms, shoring and false work shall be adequate for imposed live and dead loads including equipment and men, height of concrete drop, concrete and foundation pressures and stresses, wind pressures, lateral stability, and other safety factors during construction. The Concessionaire shall be responsible for the calculations and designs for the formwork. The Concessionaire shall be held solely responsible for any failure and for the safety of work and workmen. He shall pay necessary compensation, if need be, for damages to work, property and injuries to persons. The scaffolding, hoisting arrangements and ladders shall have easy approach to work-spot and afford easy inspection.

B. Standards and Tolerances:

All formwork shall be fabricated in compliance with the best modern practice, so that the finished surface is even, unblemished, free of fins and true to line, level and shape as shown by the drawings. The forms

shall comply with the requirements of IS: 456.

i Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Joints shall be water-tight to prevent the escape of mortar and cement slurry or the formation of fins or other blemishes on the face of the concrete.

ii Openings for inspection of the inside of the formwork and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete. Before placing concrete, all bolts, pipes or any other fixtures which are to be built in shall be fixed in their correct positions and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without the approval of the Engineer.

4.3.1.3 Shop Drawings

Concrete construction joints and expansion joist shall be of the types and at locations indicated and shop drawings for approval shall be submitted showing proposed location and type of construction for any joints not shown on the drawings, and sequences of forming and concrete placing operations. Shop drawings shall be submitted at least 15 working days in advance of form fabrication.

4.3.2 Materials

4.3.2.1 Formwork Coating

The coating on all formwork shall be of non-staining mould oil that will not leave residual matter on surface of concrete or adversely affect bonding to concrete of any subsequent paint, plaster, mortar or other applied materials. Coatings containing mineral oil, paraffin, waxes or other non-drying ingredients are not permitted. For concrete surfaces contacting potable stored water, the coating and formwork release agents shall be completely non-toxic. Care shall be taken to prevent the coating from coming into contact with reinforcement or with concrete at construction joints.

4.3.2.2 Timber

Timber shuttering shall be fabricated from partially seasoned timber which shall not warp under the effects of the ambient temperature and humidity. Boards shall be strong enough to withstand the stresses imposed on the shuttering without flexing. The planks shall be sawn straight and all edges and planes shall be straight and free from warp.

4.3.2.3 Joints

All jobs shall be bonded to prevent loss of grout during concreting.

4.3.2.4 Plywood

Plywood shall confirm to IS: 4990 and shall be braced as necessary. Wooden forms shall be lined with plywood.

4.3.2.5 Metal Forms

Metal forms shall be true to detail, in good condition, clean, free from dents, bends, rust and mineral oils. They shall be of adequate gauge with appropriate angle frames.

4.3.2.6 Moulds

For grooves, drips, rebates, profiles, chamfers and similar items, smooth finished timber coated with specified form coating shall be used.

4.3.3 Execution

4.3.3.1 Shoring on trenches and false work for concrete

The loads shall be properly distributed over base area on which shoring is erected, either concrete slabs or ground; if on ground, it shall be protected against undermining or settlement, particularly against wetting of soils, and near excavations. The forms shall be constructed to produce in finished structure all lines, grades and camber as required. Jacks, wedges, or similar means shall be used and firmly anchored to take any settlement in formwork which may occur before placing of concrete. Camber for beams and slabs shall be as indicated.

4.3.3.2 Form Construction

Forms shall be built to exact shapes, sizes, lines and dimensions as required to obtain accurate alignment, location and grades, and level and plumb work in finished structures. Provision shall be made for openings, offsets, keyways, recesses, mouldings, reglets, chamfers blocking, joint screeds, bulkhead, anchorages, and other required features. Forms shall be made for easy removal without hammering or prying against concrete. Metal spreaders may be used to provide accurate spreading of forms. Construction of form shall be such that there will be no sagging, leakage, or displacement occurring during and after pouring of concrete. Forms shall be coated with specified coating material only prior to placement of reinforcing steel; and coating material shall not come into contact with reinforcing bars.

A. Slopes:

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded finish) and shall be anchored to enable the concrete to be properly compacted and to prevent floatation care being taken to prevent air being trapped.

B. Chamfers:

All exterior horizontal angles on the finished concrete of 90 degrees or less along the top of walls shall be given 20mm x 20mm chamfers; columns are required to have chamfers on vertical angles, which run out 125mm from the bottom and top of the column; other exterior angles shall be left sharp, unless otherwise ordered by the Engineer.

C. Ties:

No ties or blots or other devices shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50mm from the surface in the case of reinforced concrete and 150mm in the case of un-reinforced concrete. Holes left after removal of such supports shall be filled with 1:3 dry-pack mortar which shall contain just sufficient water to make it plastic. It shall be well rammed into the hole and finished flush.

D. Form Windows:

Windows shall be provided in the formwork wherever directed or necessary for access for concrete placement and vibration. Windows shall be of size adequate for tremies and vibrators; spaced at maximum 1.8m centres horizontally, and shall be tightly closed and sealed before placing higher concrete.

E. Cleanouts and Cleaning:

Temporary openings shall be provided in wall, column and slab formwork for cleaning and inspection. Prior to poring, all forms and surfaces shall be cleaned and coated to receive concrete.

F. Re-Use:

Form material shall be cleaned and reconditioned before re-use.

4.3.3.3 Embedded piping, conduits and anchors

All trades which require openings for the passage of pipes, electrical conduits, and other inserts shall be consulted and the necessary pipe sleeves, anchors, or other required inserts shall be properly and accurately installed. Openings required by other trades shall be reinforced as indicated and required. Conduits or pipes shall be located so as not to reduce the strength of the construction, and in no case shall pipes other than conduits be placed in a slab 120 mm or less in thickness. Conduit buried in a concrete slab shall not have an outside diameter greater than 1/3 of the thickness of the slab nor be placed below bottom reinforcing steel or over top reinforcing steel. Conduits may be provided they are not larger in outside diameter than 1/3 the thickness of the wall, are not spaced closer than three diameters on centre, and do not impair the strength of the structure. Electrical conduits shall be placed with due regards to allowable bend radii continuity in its length from outlet to outlet, and shall be equipped with pull-cord. The outlets shall be temporarily plugged to totally avoid ingress of concrete or grout.

4.3.4 Field Quality Control

A. Control during Concrete Placement:

Required slab and beam cambers shall be checked and correctly maintained as concrete loads are applied on forms. Workmen shall be assigned to check forms during concrete placement and to promptly seal any mortar leaks.

B. Defects in Formed Surfaces:

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted and smooth. If any blemishes are revealed after removal of formwork, the Engineer's decisions concerning remedial measures shall be obtained immediately. These measures may include, but shall not be limited to the following:

i. Fins, pinhole bubbles, surface discoloration and minor defects may be rubbed down with sacking immediately as the formwork is removed.

ii. Abrupt and gradual irregularities may be rubbed down with carborandum and water after the concrete has been fully cured. These and any other defects shall be remedied by; methods approved by the Engineer which may include using a suitable epoxy resin or where necessary, cutting out to a regular dovetailed shape at least 75mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail.

C. Removal of Forms and Shoring:

Formwork shall be so designed as to permit easy removal without resorting to hammering or levering against the surface of the concrete. The periods of time elapsing between the placing of the concrete and the striking of the formwork shall be as approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall be in any case be not less than the periods shown below, depending on the ambient temperature.

	Location of form	**Time for striking using ordinary Portland cement**

a)	Walls, Columns & vertical faces of all structural members	24 to 48 hrs
b)	Slab props left under	3 days
c)	Removal of props under slab I) Spanning upto 4.5 m II) Spanning over 4.5 m	 7 days 14 days
d)	Beams soffits (Props left under)	7 days
e)	Removal of props under beams and arches I) Beam soffit upto 6m II) Beam soffit over 6 m	 14 days 21 days

Sequence of striking formwork shall be approved by the Engineer in important structures.

Notwithstanding the foregoing the Concessionaire shall be held responsible for any damage arising from removal of formwork before the structures is capable of carrying its own weight and any incidental loading. The Concessionaire shall be wholly responsible for repairing or reconstruction as directed by the Engineer the section of the Works so affected.

1. Shoring and falsework removal: In retaining wall construction shoring and falsework shall not be removed until 21 days after concrete placement or until concrete has attained at least 90 percent of the 28 days design compressive strength as demonstrated by control test cylinders, whichever is earlier.

2. Restriction: Construction equipment or permanent loads shall not be imposed on columns, supported slabs or supported beams until concrete has attained the 28 days design compressive strength as demonstrated by control test cylinders.

3. Concrete curing during removals: Concrete shall be thoroughly wetted as soon as forms are first loosened and shall be kept wet during the removal operations and until curing media or sacking is applied. Potable water supply with hoses or buckets shall be ready at each removal location before removal operations are commenced.

4. Form Finished Concrete: wherever no plaster is specified the concrete surfaces shall be fine finished utilising steel or ply wood shuttering.

4.4 Reinforcement

4.4.1 General

4.4.1.1 Description

Requirements specified herein provide for reinforcing work complete as indicated, specified and required, and including supply and delivery of reinforcing bars and mesh, binding, wire brushing and cleaning, steel fixing and the attendance of a fitter during concreting. Wherever mention of IS codes is made, the latest editions thereof shall be applicable.

4.4.1.2 Quality assurance

A. Code Requirements:

Unless otherwise stated herein all work specified herein and as shown on the Drawings shall conform to the applicable requirements of IS: 456, IS 4926, IS 10262, IS 2502, IS 516, IS 7251, IS 1786. In case of water retaining structures IS: 3370 - parts 1 & 4 shall be applicable.

Standards

Steel for reinforcing shall be the following kinds as may be specified in the Drawings.

a. Mild steel & medium steel bars & hard drawn steel wire conforming to IS: 432-part 1 & 2.

b. High strength deformed steel bars and wires for concrete reinforcement conforming to IS: 1786.

c. Hard drawn steel wires fabric conforming to IS 1566 AND IS 4948.

d. Fusion bounded epoxy coated reinforcing bars conforming to IS: 13620.

B. Field Quality Control:

All continuous inspections shall be performed by the Engineer's representative or his authorized assistant or a specialist called by the Employer or the Engineer. Reports as required by code or authorities concerned shall be prepared and submitted to the owner and such authorities.

1. Cleanliness of Reinforcement:

The Concessionaire shall ensure that all reinforcing bars are thoroughly wire brushed and cleaned free of loose mill scale loose rust, coats of paints, oil mud or other coating.

2. Concreting operations:

During concrete placing, a fixer shall be in attendance to inspect fixed reinforcing bars and maintain bars in correct positions at each pour locations.

4.4.1.3 Submittals

A. Drawings:

The Engineer will supply detailed drawings of reinforced concrete works. Working drawings and bar bending schedules shall be prepared by the Concessionaire from drawings supplied to him by the Engineer.

B. Samples:

At least one month in advance of placing an order by him the Concessionaire shall submit four samples of reinforcing bars which he intends ordering in case the steel is to be supplied by the Concessionaire. The samples shall confirm to IS:10790 part 2. The Engineer may carry out any test he may require, to satisfy himself that the steel to be brought by the Concessionaire complies with the test specifications.

4.4.2 Materials

4.4.2.1 Welded wire mesh

Mesh reinforcement, shall conform to IS: 1566.

4.4.2.2 Binding wire

Binding wire shall be 0.90 mm diameter annealed wire conforming to IS: 280.

4.4.2.3 Support and accessories

Spacers for reinforcement shall be provided as per 7.4 of IS: 2502. The cover blocks as per 7.3 of IS: 2502 shall be made so as to provide the exact specified cover to reinforcement. Stays, blocks, ties spacers or

other supports as approved by Engineer shall be provided at appropriate intervals to avoid sagging of bars between supports. Broken stones, brick pieces, wooden blocks shall not be used.

4.4.2.4 Dowels

Where shown on the Drawings, steel bar dowels shall be provided for anchorage to previously cast concrete. For anchorage where shown or required to existing construction, an approved non-shrink epoxy type grout or approved deferred bolting devices shall be used.

4.4.2.5 Delivery

Reinforcement shall be transported, stacked and stored at site away from soil contact and protected from rain so as not to damage or rust the material. The bars shall be stored above ground surface upon platforms or supports to avoid distortion and sags of long length. Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, earth, paint, or any other material which may impair the bond between concrete and the reinforcement.

4.4.2.6 Execution

A. Bending:

Unless otherwise indicated or specified, bars shall be bent and fixed in accordance with the provision of IS: 2502. All bending shall be done cold with the use of an approved bending machine. Incorrectly bent bars shall not be permitted to be used by re-bending.

B. Cleaning:

Before placing reinforcement and again before concrete is placed, reinforcement shall be wire brushed and cleaned of loose mill scale, oil, or other coating that might destroy or reduce bond.

C. Concrete cover:

Cover over reinforcing bars shall be as indicated. Correct concrete cover to reinforcement shall be maintained with the aid of approved cover blocks. Top reinforcement in slabs shall be maintained in position by means of chairs made out of mild steel, the diameter and quantity being sufficient to ensure security of the reinforcement in shape and position.

D. Securing in Place:

All reinforcement shall be securely and accurately fixed in positions shown on the Drawings, care being taken to prevent contact with coated shuttering and forms, by using approved support or spacer blocks, or chairs where necessary. All intersections of bars shall be secured with approved clips or with wire, the ends being turned into the body of the concrete. The Concessionaire shall ensure that all reinforcement is maintained in position at all times, particular care being taken during placing of the concrete.

E. Splices:

Splices shall be wired contact lap splices unless otherwise indicated or approved. Splices at points of maximum tensile stress shall be avoided and shall be staggered elsewhere. The lap length and other provisions shall conform to 25.2.5 IS:450.

1. Vertical bars: Splicing of vertical bars in concrete shall be only at approved positions.
2. Horizontal bars: Unless otherwise shown, lap splices shall be made with at least one continuous bar between adjacent splices. Where double mats or bars occur in walls, lap splices in opposite mats shall be offset at least 1.5m

F. Welding:

Welding of reinforcing bars is not permitted unless indicated or approved by the Engineer in writing. Where permitted, reinforcement which is specified to be welded shall be welded by any process after which the Concessionaire can demonstrate by bend and tensile tests that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that of the parent metal The welding procedure established by successful tests welds shall be maintained and no departure from this procedure shall be permitted. Welds in positions other than those shown on the Drawings shall not be permitted. Welding shall be carried out only by qualified welders with experience of similar works. The standard for welding will be those required by IS: 2751code of practice for welding of mild steel bars used in reinforced concrete construction and IS: 9417 recommendations for welding cold worked steel bars for reinforced concrete construction.

G. Misuse:

No part of the reinforcement shall be used to support access ways, working platforms, or placing equipment or for the conducting of an electric current.

H. Additional Reinforcement:

Additional reinforcing bars shall be provided at sleeves and openings as indicated or required. Where additional bars are not shown for such locations, Engineer's instructions shall be obtained and additional bar shall be provided as directed.

I. Welded wire mesh:

All necessary supports and chairs shall be provided to hold in place during concrete pours. Care shall be taken to prevent contact between the mesh and coated shutters. Mesh shall be straightened to lie flat before placing it and mesh shall be bent as shown or required to fit the work. Development of stress in reinforcement shall be as per clause 26.2 of IS 456.

J. Access:

Where reinforcing mats have been fixed, access for concreting purposes shall, where necessary, be provided by timber benches or similar approved devices supported by the falsework. Under no circumstances shall such access ways be supported by reinforcement bars or mats.

K. Substitution:

If sizes of bars other than specified ones are permitted to be used, the C/S area of steel shall be not less than the designed area provided further that bond stress is not exceeded and criteria for minimum and maximum spacing of bars as per IS: 456 are not violated.

4.5 Concrete

4.5.1 General

4.5.1.1 Description

Requirements specified herein include concrete mixes and placing procedures, finishing and curing procedures for both cast in situ and precast cement concrete and including reinforced concrete. The item also includes necessary sampling and testing of materials and cubes, compensation for injury to persons and damage to work or property.

4.5.2 Reference standards

Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest editions including all applicable official amendments and revisions shall be referred to.

Materials

IS:8112 Specification for 43 grade ordinary Portland cement.

IS:12269 Specification for 53 grade ordinary Portland cement.

IS:12330 Specification for sulphate resisting Portland cement.

IS:383 Specification for coarse and fine aggregates from natural sources for concrete.

IS:432 Specification for mild steel and medium (tensile steel bars and hard-drawn steel) wires for concrete reinforcement. (Part 1 & 2)

IS:1786 Specification for high strength deformed steel bars and wires for concrete reinforcement.

IS:1566 Specification for hard-drawn steel wire fabric for concrete reinforcement.

IS:9103 Specification for admixtures for concrete.

IS:2645 Specification for integral cement water- proofing compounds.

IS:4990 Specification for plywood for concrete shuttering work.

Material Testing

IS.4031 Methods of physical tests for hydraulic cement (Parts 1 to 15)

IS:4032 Method for chemical analysis of hydraulic cement.

IS:650 Specification for standard sand for testing of cement.

IS:2430 Methods for sampling of aggregates for concrete.

IS.2386 Methods of test for aggregates for concrete (Parts 1 to 8)

IS:3025 Methods of sampling and test (physical and chemical) for water used in industry.

IS:6925 Methods of test for determination of watersoluble chlorides in concrete admixtures.

Material Storage

IS:4082 Recommendations on stacking and storing of construction materials at site.

Concrete Mix Design

IS:10262 Recommended guidelines for concrete mix design.

SP:23 (S&T) Handbook on Concrete Mixes

Concrete Testing

IS.1199 Method of sampling and analysis of concrete.

IS:516 Method of test for strength of concrete.

IS:9013 Method of making, curing and determining compressive strength of accelerated cured

concrete test specimens.

IS:8142 Method of test for determining setting time of concrete by penetration resistance.

IS:9284 Method of test for abrasion resistance of concrete.

IS:2770 Methods of testing bond in reinforced concrete.

Equipment

IS:1791 Specification for batch type concrete mixers.

IS:2438 Specification for roller pan mixer.

IS:4925 Specification for concrete batching and mixing plant.

IS:5892 Specification for concrete transit mixer and agitator.

IS:7242 Specification for concrete spreaders.

IS:2505 General Requirements for concrete vibrators: Immersion type.

IS:2506 General Requirements for screed board concrete vibrators.

IS:2514 Specification for concrete vibrating tables.

IS:3366 Specification for pan vibrators.

IS:4656 Specification for form vibrators for concrete.

IS:11993 Code of practice for use of screed board concrete vibrators.

IS:7251 Specification for concrete finishers.

IS:2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).

IS:2750 Specification for steel scaffoldings.

Codes of Practice

IS:456 Code of practice for plain and reinforced concrete.

IS:3370 Code of practice for concrete structures for storage of liquids (Parts I toIV)

IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement.

IS:5525 Recommendation for detailing of reinforcement in reinforced concrete works.

IS:2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.

IS:9417 Specification for welding cold worked bars for reinforced concrete construction.

IS:3558 Code of practice for use of immersion vibrators for consolidating concrete.

IS:3414 Code of practice for design and installation of joints in buildings.

IS:4014 Code of practice for steel tubular scaffolding (Parts 1 & 2)

IS:2571 Code of practice for laying insitu cement concrete flooring.

IS:7861 Code of practice for extreme weather concreting: Part 1 Recommended practice for hot weather concreting.

IS:1893 Criteria for earthquake resistant structures subjected to seismic forces.

IS:13920 Code of Practice for Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces.

Construction Safety

IS.3696 Safety code for scaffolds and ladders. (Parts 1 & 2)

IS:7969 Safety code for handling and storage of building materials.

IS:8989 Safety code for erection of concrete framed structures.

Measurement

IS 1200 Method of measurement of building and Engineering works

IS 3385 Code of practice for measurement of Civil Engineering works

Except as herein modified, reinforced concrete work shall conform to the requirements of IS: 456 and to those of IS: 3370 Parts I & IV in case of water retaining concrete structures.

Design mix concrete shall alone be used. The procedure given in IS: 10202 Recommended guidelines for concrete mix design and SP:23 (S&T) shall be followed.

4.5.3 Quality assurance

4.5.3.1 General practice

A. General: In order to achieve the required strength and associated properties of concrete, proper control of the water / cement ratio by weight shall be enforced. The strength shall be prime consideration and water-cement ratio as prescribed by Engineer shall be observed.

B. Operators: The Engineer requires that at no time will the mixer operator or those supervising or inspecting the works be permitted to alter the quantity of water specified by the Engineer for mixing the concrete. Batching shall be accurate and as specified by the Engineer.

C. Water - Cement Ratio: The water - cement ratio will be determined after mix trials by the Concessionaire in the presence of the Engineer or his representative. If batching is by volume, the Concessionaire shall be required to fabricate such volumetric batchers and water containers as the Engineer may require so as to simulate the ideals of the trial mix without recourse to assessments by site staff and workmen.

D. Weighing: The Concessionaire shall make available a weighing machine if so required by these documents, guaranteed by the Concessionaire for its accuracy, for weighing cement and batches of aggregate as and when the Engineer may require. The machine shall be capable of weighing up to 75 kilograms and shall be accurate to half (0.5) kilogram.

E. Compaction: All concrete shall be thoroughly compacted & fully worked around the reinforcement by vibration just sufficiently so that the appearance of laitance is kept to a minimum and in such manner as directed by the Engineer's representative. Under no circumstances shall concrete be compacted by trowels

or the like.

F. Transport and Placing: Fresh concrete from the mixer shall be transported to formwork where required by the quickest and most efficient means so as to prevent pre-set or segregation or any loss of ingredients & maintaining the required workability. Any laitance from previous mixes shall be removed.

4.5.3.2 Testing

Materials shall be tested as hereinafter specified and unless specified otherwise all sampling and testing shall be performed by Engineer-approved Testing Laboratory, at the Concessionaire's expense.

A. Cement:

Cement shall, whether supplied by the Employer or not, shall comply with the requirements of IS: 269, IS: 8041, IS: 455, IS: 8112, IS: 8043, IS: 6909, IS: 1489, IS: 12269, IS: 12600 and IS: 12330. The testing laboratory at the discretion of the Engineer shall perform such tests as are deemed necessary. Cement bags or bulk silos shall be tagged for identification at location of sampling. Tests will include tensile tests and weighing the cement supply to check for net weight received at site and used in the works.

1. On arrival at the site, cement shall be stored in weather-proof silos designed for the purpose or in dry weather-tight and properly ventilated structures with floors raised 15 to 20cm above ground level, 30cm away from walls and with adequate provision to prevent absorption of moisture or flooding. All storage facilities shall be subject to approval by the Engineer and shall be such as to permit easy access for inspection and identification. Each consignment of cement shall be kept separate and the Concessionaire shall use the consignments in the order in which they are received. Any cement in drums or bags which have been opened shall be used immediately. Different types of cement shall be kept in clearly marked separate storage facilities. Not more than 15 bags shall be stacked vertically in one pile. Cement shall be stored in double locking arrangement, so that cement transactions can be with the knowledge of supervisory staff. Daily account of cement shall be maintained by Concessionaire in the prescribed register and shall be made available to inspecting authorities for store verification.

2. The Concessionaire shall provide from each consignment of cement delivered to the site such samples as the Engineer may require for testing. Any cement which is in the opinion of the Engineer, lumpy or partially set shall be rejected and the Concessionaire shall promptly remove such cement from the site.

3. Cement which has been stored on the site for more than ninety (90) days and cement which in the opinion of the Engineer is of doubtful quality shall not be used in the works until it has been retested and test sheets showing that it complies in all respects with the relevant standards have been delivered to the Engineer.

A. Water for concrete mixing and curing:

Water shall be clean reasonably clear and free from injurious quantities of salt, traces of oil, acids, alkalies, organic matter and other deleterious materials. The source of water shall be approved by the Engineer and the containers for conveyance, storage and handling shall be clean. If necessary, standard cement tests shall be conducted using the water intended to be used, in comparison with those adding distilled water to check quality of water. Water shall meet the requirement of clause 5.4 of IS 456. Generally potable water is fit for mixing and curing.

B. Aggregate for Concrete

Aggregate shall comply with the requirements of IS: 383. It shall be tested as per IS 2386(Part 1 to 8)

Fine aggregates: Sand for concrete work shall be clean, well graded and shall consist of strong, dense, durable gritty particles, free from veins, injurious amounts of disintegrated pieces, alkali, vegetable matters and other deleterious substances and subject to the approval of the Engineer. Maximum size of particle shall be restricted to 5 mm minimum being 0.15mm. IS:650 Specification for standard sand for testing of cement

Coarse aggregates: The coarse aggregates shall generally be cubical in shape broken generally from best trap/ granite / quartzite/ gneiss stones as available and generally used in the region. It shall be hard, strong, dense, durable, clean and of proper gradation, veins, free from skin and coatings.

The maximum size of coarse aggregate shall be as large as possible but not greater than ¼ of the minimum thickness of concrete member provided that in case of R.C.C the size presents no difficulty to surround the reinforcement thoroughly and fill up the corners properly.

In plain cement concrete, the maximum size may be 80 mm subject to above limitations in absence of any special provision.

For heavily reinforced beams the maximum size shall be restricted to 5mm less than minimum lateral distance between the bars. Generally, for R.C.C works 20 mm nominal size of aggregate shall be satisfactory.

Aggregate will be tested before and after concrete mix is established and whenever character or source of material; is changed. Tests will include a sieve analysis to determine conformity with limits of gradation.

1. Samples of aggregates 50 kg. in weight will be taken by the Concessionaire at source of supply and submitted to the Engineer before placing orders. These samples if approved shall remain preserved in the Engineer's care for reference and the type of aggregate used in the works may not be altered without the Engineer's prior approval.

2. Aggregate shall be obtained from an approved source and shall conform to the requirements of IS: 383.

For fine aggregate grading in table of IS: 383 shall be applicable. Aggregate shall not be flaky curvaceous or elongated particles, defined as particles having a maximum dimension greater than five times the minimum dimension. Aggregate shall have a water absorption not exceeding two percent when tested in accordance with IS:2386 (Part1 to 6).

3. The Concessionaire shall sample and carry out a mechanical analysis in the presence of the Engineer's representative of the fine aggregate and each nominal size of coarse aggregate in use employing the methods described in IS: 383 and 2386 at least once in each week when concreting is in progress and at such more frequent intervals as the Engineer may require. The grading of all aggregates shall be within the respective limits specified in the codes. If aggregates vary more than IS from the approved fineness modulus the Engineer may instruct the Concessionaire to alter the relative proportions of the aggregates in the mix to allow for such difference, or may require further trial mixes.

4. Storage of aggregate shall be provided at each point where concrete is made such that each nominal size of coarse aggregate and the fine aggregate shall be kept separated at all times. Contamination of the aggregates any foreign matter shall be effectively prevented at all times, and each heap of aggregate shall be capable of draining freely. The Concessionaire shall ensure that graded coarse aggregates are dumped, stored and removed from store in a manner that does not cause segregation.

5. Wet fine aggregate shall not be used until, in the opinion of the Engineer, it has drained to constant and uniform moisture content, unless the Concessionaire with the knowledge of the Engineer measures the moisture content of fine aggregate and adds water in each batch of concrete mixed to allow for the water contained in the fine aggregate.

4.5.4 Concrete Mixes

Design mix concrete shall be provided in case of R.C.C. works of important structures like Intake Works, Treatment Works, Reservoirs and Bridges, etc.

4.5.4.1 Mix design

Mix design is a prerequisite to any concreting job and will be required on all works. If required by the Specification, an approved testing laboratory shall, at the Concessionaire's expense, design a mix for each class of concrete and shall submit full details of the mix designs to the Engineer for his approval. The Engineer's Representative and the Concessionaire shall clearly code each approved mix with a number and date, and file all details for identifying and reproducing exactly the same mix.

A. General: Each mix design shall be such that the aggregate shall comprise fine aggregate and coarse aggregate of the size specified and the combined aggregate grading shall be continuous. Aggregate shall be calculated by weight, and batching procedures shall be established. The cement content by weight shall not be outside the minimum and maximum limits calculated from minimum and maximum dry aggregate to cement ratios specified. The mixes shall be designed to produce average concrete cube strength at twenty-eight days after manufacture not less than the trial mix test strength specified. The water / cement ratio shall be in the region of 0.45 to 0.55 and shall never exceed 0.60

B. Preliminary mix: The proportions of cement, aggregate and water determined by the Concessionaire in his mix design shall be used in preliminary mix of concrete made and tested for strength and workability under laboratory conditions observing the appropriate requirements. These preliminary mixes shall be repeated with adjusted proportions as necessary until concrete mixes meeting the requirements of the preliminary and trial mix tests specified and with the workability defined herein have been produced. If at any time during construction of the works, the source of cement or aggregates is changed or the grading of the aggregate alters, then further preliminary mixes shall be undertaken.

C. Trials: After the Engineer's approval of the preliminary concrete mix design for each class of concrete, and during or following the carrying out of the preliminary test, the Concessionaire shall prepare a trial mix of each class in the presence of the Engineer. The trial mixes shall be mixed for the same time and handled by means of the same plant that the Concessionaire proposes to use in the works. The proportion of cement, aggregate and water shall be carefully determined by weight in accordance with the approved mix design (or modified mix design after preliminary tests) and sieve analyses shall be made, by approved methods of the fine aggregate and each nominal size of coarse aggregate used.

D.Water: Water for mixing concrete, mortar or grout shall satisfy the recommendations of IS: 456 If required to do so by the Engineer, the Concessionaire shall take samples of the water and test them for quality.

E.Admixtures: Admixtures shall mean material added to the concrete materials during mixing for the purpose of altering the properties of normal concrete mixes. If the Concessionaire wishes to use admixtures, otherwise than as expressly ordered by the Engineer, he shall first obtain the Engineer's written permission. The methods of use and the quantities of admixture used shall be subject to the

Engineer's approval, which approval or otherwise shall in no way limit the Concessionaire's obligations under the contract to produce concrete with the specified strength and workability. Concrete of any class containing an admixture shall be separately designed and have separate preliminary tests and trial mixes made and tested for approval by the Engineer as if it were a separate class of concrete.

4.5.4.2 Waiver of mix design and weigh batching

On certain works the Engineer may waive the requirement of designing mixes and may allow the use of established nominal mix proportion, provided always that preliminary trials are made to establish the volumetric batching procedure and mix strengths. The Concessionaire shall ensure that any established procedure approved by the Engineer is strictly adhered to, so as to achieve consistent strength, durability and economy of the concrete while ensuring approved workability of the mix. Any waiver of mix design or weight batching will not relieve the Concessionaire of his obligations to produce concrete of the specified and approved strength and durability as determined by works tests defined hereafter. The nominal mix concrete shall be provided generally for the items excluding those mentioned in para 4.3 above. However in any particular work/ part of the work the Engineer may decide to adopt mix design (mix) concrete and this decision shall be final and binding.

4.5.4.3 Workability

The workability of each class of concrete shall be such that satisfactory compaction can be obtained when the concrete is placed and vibrated in the works. There shall be no tendency to segregate when it is handled, transported and compacted by the methods which the Concessionaire proposes to use for that class of concrete in the works.

4.5.4.4 Grades of concrete

The concrete shall be in grades designed in Table 2 of IS : 456.

4.5.4.5 Concrete Mix Design

Procedure for designing concrete mixes shall be as per IS: 10262 Recommended guidelines for concrete mix designs and SP:23 (S&T).

4.5.5 Batching

4.5.5.1 Cement

All cement used in making concrete shall be measured by weight with an approved weighing machine the size of each batch of concrete such as to require an integral number of complete bags of cement of weight consistent with the requirements of C 1.9 of IS: 269. For ordinary mixes the cement bag shall be taken to be 50kg (35 litres).

4.5.5.2 Aggregate

The fine and coarse aggregates shall be measured separately either by volume in gauge boxes made as specified or by weight using machines with weigh batching attachments. For high grade concrete the fine aggregate shall be measured singly or cumulatively by weight. The Engineer will rule on this requirement.

4.5.5.3 Gauge boxes

Gauge boxes shall be soundly constructed by the Concessionaire, with the approval of the Engineer and shall be of timber or of steel to contain exactly the volume of the various aggregates required for one batch of each mix. Each gauge shall be clearly marked with the mix code and the aggregates for which it is intended. When calculating the size of the gauge box for fine aggregate an allowance shall be made for the bulking of the fine aggregate due to the average amount of moisture contained in the stockpiles on the

site. Before the Concessionaire puts any gauge box into use on the site he shall obtain the approval of the Engineer of the size and construction of such gauge box.

4.5.5.4 Water containers

Containers for measuring water shall be soundly constructed of metal to contain the exact quantity of water required for a batch of mix, due allowance having been made for the moisture content of the aggregates, as hereinafter specified, or such fractions of the quantity as are approved by the Engineer. Containers shall have spouts, the spill levels of which determine the quantity. Fixed containers shall be elevated and have overflow pipes which determine the quantity held in the container, and shall have an outlet valve and hose fixed to the bottom of the container. Before any container is put into use, the approval of the Engineer shall be obtained.

4.5.5.5 Weigh-batching

Weigh- batching machines shall provide facilities for the accurate control and measurement of the material either singly or cumulatively and shall be capable of immediate adjustment by operators in order to permit variations if ordered by the Engineer. All weight dials shall be easily visible from the place at which filling and emptying of the hoppers is controlled.

4.5.5.6 Addition of Water and Mixing

A. Water: The addition of water to a mixer shall be such that between five and ten percent of the water enters the mixer before the cement and aggregate are added and a further five to ten percent of water enters the mixer after the said material have been added. The remaining water shall be added at a uniform rate with the said materials. The water measuring device shall also be readily adjustable so that the quantity of water added to the mixer can, if necessary in the opinion of the witnessing Engineer's Representative be varied. The natural moisture content of the aggregates shall be determined before the commencement of concreting or at such intervals as may be necessary or as requested by the Engineer. The Concessionaire shall make the allowance for water contained in the aggregate when determining, in consultation with the Engineer's Representative, the quantity of water to be added to each mix, and shall adjust the amount of water added to each mix to maintain the consistent approved water/ cement ratio of the mixed concrete. All-important concrete shall be machine mixed to give complete coating of cement mortar on each coarse aggregate particle and to produce uniform coloured concrete with uniform distribution of materials. The mixer shall be run minimum 1½ minutes. If for a minor job, hand mixing is permitted by the Engineer, it shall be done on smooth watertight platform not allowing the added water to flow out. The fine aggregate shall be spread in uniform thickness layer over which cement as required shall be placed and shall be mixed thoroughly to give dry mortar. Water shall then be added gradually in required proportion, turning the mass, to give desired consistency mortar. The required quantity of coarse aggregate shall then be placed on mixing platform, wetted and mortar added. The entire mass shall be turned and re-turned to give uniform concrete of required consistency. 5% additional cement shall be used for hand mixed concrete.

B. Admixtures: Any admixtures approved by the Engineer, which may be used shall be measured separately in calibrated dispensers and shall be added to the mixture together with the water. Admixtures if used shall comply with IS: 9103

C. Uniformity of mix: Concrete shall be mixed in batches in plant capable of mixing the aggregates, cement and water (including admixtures, if any) into a mixture uniform in colour and consistency and of discharging the mixture without segregation.

D. Concessionaire's returns: The Concessionaire shall render to the Engineer, not more than twenty-four hours in arrears, a daily return for each class of concrete of the number of batches mixed, and total volume of concrete placed, the number of batches wasted or rejected and the weight of cement used. In case of ordinary mixes, where permitted the cement bags consumed for quantities for various classes of concrete shall be furnished. In addition, daily details of time of starting concrete, closure, no. of batches through mixer, water cement ratio, slump, date of striking from works etc. shall be maintained. This day-to-day record shall be authenticated by responsible supervisory staff.

4.5.5.7 Plant and Equipment generally

All mixing and batching plant boxes containers and other equipment shall be maintained free of defects and of set concrete or cement and shall be cleaned before commencing mixing. At such intervals as may be directed by the Engineer the Concessionaire shall provide weights, containers and equipment necessary for testing the accuracy of the weighing plant, water measuring plant and admixture dispenser.

4.5.6 Concreting

4.5.6.1 Preparation

The Concessionaire shall clear from the surface of the foundations or previously placed concrete all oil, loose fragments of rock, earth, mud, timber and any other foreign matter and shall clear standing water and wash the surface of a previous lift of concrete to the satisfaction of the Engineer.

A. Laitance: Where laitance on a lift of concrete is evident or if a substantial bond between this lift or bay of concrete and the next is required, in the opinion of the Engineer's Representative, the Concessionaire shall have the surface wire-brushed after initial (one day) set of the concrete or have it bush-hammered at no extra cost to the Owner. Any reinforcing bars covered in laitance shall be wire brushed to clean the surface of the metal.

B. Blinding: As ordered by the Engineer, or as shown on the Drawings the formation surfaces on which concrete is to be placed shall be covered with either blinding concrete not less than 75 mm thick, or waterproof building paper, or polythene sheeting immediately after completion of the final trimming of the excavation.

4.5.6.2 Inspection

Concrete shall not be placed until the Engineer has inspected the formwork and the reinforcing steel, and taken necessary measurements of the latter, and has approved the surfaces upon which the concrete is to be placed.

A. Transporting: Fresh concrete shall be transported from the mixer to its place in the works as quickly and as efficiently as possible by methods which will prevent pre-set or segregation. If segregation has nevertheless occurred in any instance the materials shall be remixed or discarded at the opinion of the Engineer.

B. Placing: Fresh concrete shall be placed and compacted before initial set has occurred and, in any event, not later than thirty minutes from the time of mixing. Concrete shall be carefully placed in horizontal layers which shall not be allowed to slide or flow down sloping surfaces but shall be placed in its final position from skips, or similar devices. If this is impracticable, it shall be shovelled into position care being taken to avoid segregation. No concrete shall be dropped more than 1.5 m. If greater drops are necessary approved chutes may be used. If the concrete abuts against earth or any other material liable to become loose or to slip, care shall be taken to avoid material falling on to the surface of the wet concrete.

As far as possible, concrete for any particular portion shall be powered section in one continuous operation leaving construction joints, if shown on the by Drawings.

Before commencing subsequent concrete on incomplete section all the loose particles, laitance etc. shall be removed and surface shall be covered with thick cement slurry. The concrete compacted manually shall be laid in layers not more than 15 to 20cm thick. The successive layer shall follow within 30 minutes or earlier.

4.5.6.3 Compaction

All concrete placed in- situ shall be compacted with power driven or pneumatic internal type vibrators unless otherwise approved by the Engineer in writing, and shall be supplemented by hand spading and tamping where required. Screed type vibrators may be used for thin slabs. There shall be sufficient and spare vibrators of adequate capacity to compact the work in hand.

A. Vibration: Vibrator shall be inserted into the uncompacted concrete vertically and at regular intervals. Where the uncompacted concrete is in a layer above freshly compacted concrete the vibrator shall be allowed to penetrate vertically for about 75 mm into the previous freshly compacted layer. The vibrators shall not be allowed to come into contact with the reinforcement or formwork nor shall they be withdrawn quickly from the mass of concrete but shall be drawn back slowly while in motion so as to leave no voids. Internal type vibrators shall not be placed in the concrete in any arbitrary manner nor shall concrete be moved from one part of the work to another by means of the vibrators. The vibrators shall have minimum 3600 (and preferably 5000) impulses per minute.

B. Duration: The duration of vibration shall be limited to that required to produce satisfactory compaction of the concrete without causing segregation. Vibration shall on no account be continued after the appearance of water or grout on the surface.

C. Hand compaction: This shall be permitted exceptionally for small jobs by the Engineer. In such cases, compaction shall be attained by means of rodding, tamping, ramming and slicing with suitable tools. The thickness of concrete layers will also be suitably reduced when hand compaction is resorted to.

4.5.6.4 Underwater concreting

No concrete shall be placed in water without the Engineer's written permission, which may be granted only if in his opinion it is not practicable to place the concrete in the dry. Concrete shall not be placed in running water nor shall concrete be allowed to fall through water. Any water entering the area where concrete is being placed shall, at the Concessionaire's expense, be kept clear of the concreting works. If underwater concreting is permitted, the specified mix of concrete shall be strengthened by increasing the cement content by at least 10% and reducing the water / cement ratio to not more than 0.45, and the placing shall be only through a tremmie approved by the Engineer. The volume or mass of the coarse aggregate shall not be less than $1^1/_2$ tonnes nor more than twice that of the fine aggregate. The material shall be so proportioned as to produce a concrete having a slump of not less than 100 mm. & not more than 180 mm.

4.5.7 Curing

All concrete shall be protected from the effects of sunshine, rain, running water or mechanical damage and cured by covering with jute, hessian or similar absorbent material kept constantly wet. A layer of sand kept covered with water is also permissible. Covering shall be for a continuous period of fourteen days at least from the date of placement. If the Concessionaire fails to water concrete continuously, the Engineer

may provide labour, materials required for watering and recover the cost from the Concessionaire.

4.5.8 Finishing

Immediately after removal of forms any undulations, depressions, cavities, honey combing, broken edges or corners high spots and defects shall be made good and finished with Cement Mortar 1:2, but the necessity of such finishing must be exceptional and total surface requiring finishing shall not exceed 1%. Where concrete surface is to receive plaster, the surface shall be roughened immediately after removal of forms and within a day thereof to secure a hold for the plaster. The rate of concrete is inclusive of this roughening and finishing. Concrete after finishing shall be cured for the full period.

4.5.9 Joints

4.5.9.1 Construction joints

Construction joints are defined as joints in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

C. **Submittal:** No concreting shall be started until the Engineer has approved the method of placing, the positions and form of the construction joint and the size of lifts.

B. Jointing: The face of a construction joint shall have all laitance removed and the aggregate exposed prior to the placing of fresh concrete. The laitance shall whenever practicable be removed by spraying the concrete surface with water under pressure and brushing whilst the concrete is still green. Where the laitance cannot be removed whilst the concrete is green, the whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate. Where aggregate is damaged during hacking, it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, and washing down, and the surface to which fresh concrete is applied shall be lean and damp.

4.5.9.2 Expansion joints

Expansion joints are defined as joints intended to accommodate relative movement between adjoining parts of a structure special provision being made where necessary for maintaining the water tightness of the joint.

A. The joint location and type will be as indicated in the drawings.

1. The Concessionaire shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer, demonstrate that the jointing materials can be applied satisfactorily and will last the life of the structure.

2. Flexible water stops shall be fully supported in the formwork, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place the concrete so that water stops do not bend or distort.

B. Jointing: The surface of set concrete shall not be disturbed and concrete shall be placed against the dry finished surface.

1. If ingress of water or corrosive agents in the joint is possible, the steel, where such steel is continued, shall be cleaned and coated with two coats of an approved bituminous paint to a distance not exceeding

10 mm.

2. Where specified, the surface of the set concrete shall be painted with two coats of an approved bituminous paint which shall be allowed to dry before placing new concrete against it. Care shall be taken to prevent paint getting on the water stop, if any.

3. Expansion joints shall be formed by a separating strip of pre-formed compressible unperishable joint filler, to be approved by the Engineer.

4.5.10 Building

4.5.10.1 General

The Concessionaire shall build in pipes, fittings and other items including any plant supplied by the Employer or by other Concessionaires under the project or supplied by himself. The Concessionaire shall also build in any plant supplied and erected by others. The Concessionaire shall also erect all formwork, struts, ties and other temporary works to enable the pipes, fittings or plant to be built in, and such formwork shall be designed to allow placing of the concrete or grout so as to fill the voids completely, and to enable air to escape from any cavities during the filling. The spaces around pipes and machinery shall be filled with concrete, cement/sand mortar or cement grout as directed by the Engineer.

4.5.10.2 Concrete

Concrete shall be of the same class mix as the concrete of the member into which the plant is being built, except that the maximum aggregate size shall be as agreed with the Engineer for each particular situation. Where required by the Engineer the mix shall also incorporate an approved expending grout additive used in accordance with the manufacturer's instructions. In specific situations, the Engineer will require the filling in to be done with cement/ sand mortar or with cement grout.

4.5.11 Testing

Sampling and strength test of concrete shall be as per IS 456.

4.6 Pipes for Potable Water

4.6.1 Manufacturer's experience

In order to prove that the Goods offered are of acceptable quality and standard, the bidders shall furnish documentary evidence that the Goods offered have been in production for at least 'X' years and that a minimum of 'Y' units of similar capacity have been sold and have been in operation satisfactory to end users for at least 'Z' years, as indicated in the table below.

Sl. No.	Goods	Manufacturer's Experience Criteria		
		Minimum No. of years the goods offered are in production (X)	**Minimum quantity of similar capacity goods sold (Y) in 'X' No of years as in col 3 preceding the due date of**	**No. of years in satisfactory operation to the end users (Z)**

			tender	
1	2	3	4	5
1	Pumps, Electrical & Mechanical equipment			
1.1	Pumps:			
	Vertical Turbine			
	Below 150 KW	10	20 units	2
	150 KW to 500 KW	10	20 units	2
	Above 500 KW	10	10 units	2
	Centrifugal Pump			
	Below 50 KW	10	40 units	2
	50 KW to 150 KW	10	40 units	2
	Above 150 KW	10	20 units	2
1.2	Electrical Transformer			
	Below 1000 KVA	10	20 units	2
	1000 KVA to 2500 KVA	10	10 units	2
	Above 2500 KVA	10	5 units	2
1.3	Crane (E.O.T)			
	Up to 7.5 MT	10	15 units	2
	Above 7.5 MT	10	10 units	2
2	Valves			
	Below 200 mm size	10	100 units	2
	200 mm to 500 mm size	10	100 units	2
	550 to 900 mm size	10	50 units	2
	Above 900 mm size	10	10 units	2
3	Pipes			
3.1	Mild Steel:			
	Up to 1000 mm diameter	10	100% of total length required or 20 Km whichever	2

			is higher	
	Above 1000 mm diameter	10	100% of total length required or 10 km whichever is higher	2
3.2	Ductile Iron:			
	Up to 400 mm diameter	10	100% of total length required or 80 km whichever is higher	2
	Above 400 mm diameter	10	100% of total length required or 40 km whichever is higher	2
3.3	PE (Polyethylene):			
	Up to 400 mm diameter	10	100% of total length required or 100 km whichever is higher	2
	Above 400 up to 800 mm diameter	10	100% of total length required or 80 km whichever is higher	2
	Above 800 mm diameter	10	100% of total length required or 40 km whichever is higher	2
3.4	GRP:			
	Up to 1000 mm diameter	10	100% of total length required or 50 km whichever is higher	2
	Above 1000 mm diameter	10	100% of total length required or 25 km whichever is higher	2
3.5	uPVC:			

	Up to 160 mm diameter	10	100% of total length required or 600 km whichever is higher	2
	Above 160 mm diameter	10	100% of total length required or 400 km whichever is higher	2
4	Electromagnetic/ Ultrasonic Flow Meter, Electronic and ICA equipment	5	10 units	2
5	Bulk Flow Meter	5	50 units	2

The Concessionaire shall furnish guarantees from manufacturers for all equipment against faulty or inadequate design, improper assembly or erection, defective workmanship or materials, and leakage, breakage or other failure. The manufacturers guarantee shall be in addition to the warranty that shall be furnished by the Concessionaire till the expiry of the Defects Liability period. Under this guarantee the Concessionaire agrees to replace, correct without delay at no expense to the employer any such fault including the failure of any equipment or any part thereof to successfully perform within the limits of the specification and further shall make good any damage caused by such failure. The Concessionaire will be held liable for all expenses incurred by the Employer in replacing or getting the defects remedied and for all other losses.

All equipment shall be designed, fabricated, assembled, and installed in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard size and gauges so that spare parts, furnished at any time can be installed in the field.

Facilities and labour for the handling and inspection of all materials and equipment shall be provided by the Concessionaire. If the Engineer requires, either prior to beginning or during the progress of the work, the Concessionaire shall submit samples of materials for such special tests to demonstrate that they conform to the specification. Such samples shall be furnished stored and tested as directed at the Concessionaire's expense.

The Concessionaire shall submit details of material to be procured sufficiently early and in any case not less than twentyone (21) days prior to placing of orders, required data to permit considerations and approval by Engineer in consultation with Employer before materials are ordered. Any delay of approval resulting from the Concessionaire's failure to submit samples or data timely shall not be used as basis of a claim against the Employer.

4.6.1.1 General

The internal coating / lining and external coating / painting / should be done at factory only for pipes and specials.

Reference Standards applicable to various types of pipelines include the following Indian & International

Standards:

IS 3589: 1991 Seamless or electrically welded steel pipes for water.

IS 5822: 1994 Code of practice for laying of Electrically welded steel pipes for water supply.

IS 814: 1991 Covered electrodes for manual metal arc welding of carbon & carbon manganese steel. (Specification for electrodes used for welding)

IS 816: 1969 Metal arc welding for general construction in mild steel (Welding of pipes in the field)

IS 3600 Part1:1985 Welding joint testing.

IS 4853: 1982Recommended practice for Radiographic inspection of fusion, welded button joints.

IS 4260: 1986Recommended practice for ultrasonic method test.

IS 3114: 1994Code of practice for laying of cast iron pipes. (Backfilling material specification)

IS 2720 Part 7 1980 Method of test of soils. (Compaction test for backfilling consolidating)

IS 4081.1986Safety code for blasting & related drilling operation. (Code of practice for laying of electrically welded steel pipe for water supply.)

IS 10221 : 1982External lining of MS pipes with coal tar asphaltic enamel reinforced with fiber glass fabric yarn

IS 780 : 1984Specification for sluice valves for water works (50-300mm)

IS 1200 Part1 : 1992 Method of measurements of building & Civil engineering works : Earth work part 1.

IS 2062 : 1992Steel for general structural purpose.

IS 3600 part1 1985 Methods of testing fusion welded joints and welded metal in steel part1 cruciform fillet weld tensile test.

IS 5330 : 1984Criteria for design of anchor block for penstocks with expansion joints.

IS 5555 : 1970Code of practice for conducting studies on atmospheric corrosion of metal.

IS 7808 : 1975Code of practice for conducting studies on atmospheric corrosion of metal on underground mild steel pipe lines.

IS 1608 : 1995Methods for tensile testing of steel products.

IS 228 Methods of chemical analysis of steels.

IS 2328 : 1983Method for flattering test on metallic tube.

IS 3803 Part1 1989 Methods for elongation conversion for steel: Part1 carbon and low alloy steels.

IS 4711 : 1974Method for sampling of steel pipes

IS 4736 : 1986Hot dip zinc coating in mild steel tubes.

IS 432 part1 Specification for steel wire

IS 1566Specification for welded wire fabric.

IS 1916 : 1982For cement lining of steel pipes

4.6.1.2 Compliance with standards

Subject to the further requirements of this Specification, the pipes and specials under this Contract shall be of approved manufacture and shall comply with the requirements of IS 3589. Pipes and specials meeting any other internationally accepted standard ensuring a quality equal to or higher than the standards mentioned above will also be accepted.

4.6.1.3 Certificate of quality of pipes and specials

With every consignment of pipes and specials delivered under this contract the Concessionaire shall furnish a certificate worded as follows: -

"This is to certify that the quality of pipes and specials delivered in this consignment is not inferior to the quality laid down in the Specification".

No payment shall be made in respect of any consignment of pipes and specials which is not accompanied by such certificate.

The Concessionaire shall operate a Quality Assurance System, including: -

Records of Tests performed by suppliers on materials brought in;

Testing of materials for this Contract at various stages of

manufacture as herein specified, and preservation of the results of such testing;

Sequence numbering of pipes and fittings.

The Quality Assurance System records shall be open to inspection by the Engineer, and shall be maintained in such a way that any pipe or fitting is identified by a unique sequential production number and can be uniquely related to each stage of its manufacture including material origin and quality, date and time of each operation, operator(s) involved and results of relevant quality control tests.

On completion of the Contract, the Concessionaire shall pass a complete set of the Quality Assurance records to the Engineer.

4.6.1.4 Marking of pipes and specials

All pipes and specials supplied shall bear the following markings in triplicate on the outside of the pipe or special. The three sets of markings shall be painted on the item at 120 degrees to each other, such that at least one set can always be seen.

Manufacturer's distinguish mark

Outside Diameter (in mm).

The Letters ""

Length of the pipe/angle of the bend (mm. degrees)

Approximate weight of the pipe or special (Tonne)

Sequential manufacturing number

Plate Thickness (mm)

The letters shall be painted on only after the pipes or specials have been found to satisfy the tests and all other requirements of the Specification. The sequential manufacturing number shall not only be painted on the pipe, but shall also be stamped indelibly onto the inside of the socket.

Approved, clearly identifiable colored bands shall be used to differentiate between sized and unsized pipes.

4.6.1.5 Grade of steel

The pipes and specials shall be made by submerged-arc welding from carbon steel with an ultimate tensile stress of not less than 430 N/sq. mm. and a lower yield stress of not less than 275 N/sq. mm.

4.6.1.6 Process of manufacture

The pipes shall be made at the factory by either

a. Longitudinally butt welding internally and externally performed carbon steel plate or strip by an automatic submerged metal-arc welding process and circumferentially butt welding these shells internally and externally by the same process into standard length of pipes with a maximum of four circumferential welds or,
b. Rolling a strip, sheet or plate so that a helical seam is formed around the circumference of the pipe. The helical seam shall be butt welded internally and externally by an automatic submerged arc welding process.

The weld metal shall have a smooth finish with no abrupt edges and shall not stand more than 1.5 mm proud of the pipe shell internally or externally.

Mismatches of adjacent surfaces at sectional welds shall not exceed 2 mm, and shall be faired out on the outside of the pipe or fitting only.

4.6.1.7 Thickness and diameter

The thickness of the steel plates and diameter of the pipes shall be as shown below, except as otherwise specified

Pipe Outer Dia(mm)	**Material**	**Wall Thickness (mm)**	**Cement mortar lining(mm)**
1219	MS	10.0	9.5
1118	MS	8.8	9.5
1067	MS	8.8	9.5
1016	MS	8.8	9.5
914	MS	8.0	6.4
813	MS	7.1	6.4

4.6.1.8 Effective length

The Effective Length (the actual length that a pipe contributes when assembled in a run of piping) of each

pipe shall be as the Concessionaire chooses provided that the Constant Length is not less than 8 meters or greater than 13.5 meters and that all full-length pipes are of the same Constant Length. Certain details of the Drawings are based on an assumed Effective Length for the purposes of illustrating the Work, and the Concessionaire shall be responsible for designing and constructing at his own cost and to the Engineer's approval any additional or revised supports, restraints or other details necessitated by the Concessionaire's choice of Effective Length. The variation of pipe length from the agreed or specified length shall be kept to the minimum possible and shall in any case not exceed 50mm.

4.6.1.9 Specials

Specials shall conform to the appropriate dimensions given in IS 3589-2001 Puddle flanges shall be fixed to fittings by smooth, continuous welds on both sides of the flange, and the completed puddle flange shall be capable of withstanding the stated axial force.

4.6.1.10 Sized pipes

Where stated in the Bills of Quantities sized pipes shall be supplied truly circular throughout their length for cutting to provide closing lengths. The tolerances on the outside diameters of such pipes shall be as set out shall be as per IS 3589.

4.6.1.11 Pipe ends

At the ends of all "spigot and socket" ended pipes the weld metal shall be machined externally on the spigot end and internally on the socket of the pipe.

The Cement mortar lining and the external coating of pipes and specials to be joined by welding shall be omitted for a sufficient distance at least 150mm from the ends to prevent damage to the protection during site welding. The external coating of pipes and specials to be joined by mechanical couplings or flange adapters shall be omitted for such additional distance from the ends as is necessary to permit assembly of the joints. The internal surfaces from which the concrete lining is omitted shall be protected with a suitable approved rust inhibitor during manufacture so that extensive cleaning of the surface is not required after jointing on site.

Care shall be taken to ensure that butterfly valve discs will not foul cement mortar linings of adjacent pipework.

4.6.1.12 Sleeve joints

Sleeve Joints shall comply with following:- IS 3589-2001

Type 1 joints: The pipes shall be supplied with spigot end parallel and sleeve end with diameter tapered to approx. 0.8 mm per 25 mm length of sleeve. The minimum length of sleeve shall be 75 mm.

The sleeve shall be sized to ensure that the spigot will enter the sleeve freely and be engaged by the socket when fully home.

4.6.1.13 Slip joints

The slip joints shall be designed to allow the pipes to be laid with an angular deflection of not less than two degrees between adjacent pipes. The minimum lap shall be 75mm. The Concessionaire shall supply with his Tender a drawing showing the details of the type of joint included in his Tender.

The ends of pipes shall be machined so that fillet welds can be used for jointing. The spigot shall fit accurately into the socket so that the amount of metal required to form the weld is reduced to a minimum.

The sleeve end of the pipes shall have a suitable tapped hole provided with matching plug to permit an air pressure test of the joint to be carried out on completion of welding.

4.6.1.14 Flexible couplings and flange adapters

Flexible couplings and flange adapters shall be of mild steel and shall be Viking-Johnson type couplings as manufactured by the VictualicCo.Ltd or Dresser Couplings as manufactured by the Dresser Manufacturing Division in the U.S.A, or other similar approved type suitable for making a watertight flexible connection between plain ended pipes, or between a plain ended pipe and a flanged fitting.

Flexible mechanical coupling shall be without the centre register. Unless otherwise specified, the external surfaces of couplings and adapters shall be cleaned down to metallic finish and primed and painted with two coats of red lead oxide paint. The internal surfaces shall be similarly treated and protected with two coats of non-toxic approved epoxy bituminous paint.

All mechanical couplings shall be of appropriate internal diameter and shall be capable of withstanding the maximum works test pressure specified for the pipes they are to connect, at a joint deflection of up to 3 degrees in any direction.

All mechanical couplings and flange adapters shall be supplied complete with all necessary couplings, rings, nuts, bolts, washers and rubber rings.

Bolts and nuts shall be hexagonal with dimensions in accordance with IS1363- 1992.

4.6.1.15 Flanged joints

All flanges shall be of steel, welded to the pipe by the electric arc process or other approved method. Flanges shall be square to the longitudinal axis of the pipe and truly faced over their whole width. The bolt holes, which shall be drilled off-centre, shall be truly in line end-to-end with the longitudinal axis of the pipe.

Flanges shall be in accordance with IS 6392-1971.

Each set of flange jointing materials shall be complete with nuts, bolts, washers and rubber sheet. Bolts and nuts shall be hexagonal and shall be in accordance with IS 6603.

4.6.1.16 Special joints

Where a joint occurs between a steel pipe (or special) and a valve the internal diameter of the steel pipe or special shall be finished to match the bore of the valve by gradually decreasing or increasing the thickness of the concrete lining in the steel pipe or special. However the lining shall be nowhere less than 6 mm thick. Any increase or decrease in the thickness of the concrete lining along the length of such a pipe or special shall be gradual and smooth and the Contract Rates shall be deemed to include for all costs incurred in providing such a lining.

4.6.1.17 Control tests

Control tests as defined in IS 3589:2001 shall be carried out as follows before pipes are lined or coated: -

Test	
Tensile Test	once every 50 pipes
Submerged-arc weld test	once every 50 pipes
Hydraulic Test	Every pipe

Radiography of Welds 3% of welds in every pipe & 25% for specials

All pipes which pass the hydraulic test shall be stamped with the Concessionaire's test stamp.

The minimum length of weld to be radiographed at any location shall be 300 mm each end. The execution and interpretation of weld radiography shall be to API Standard.

4.6.1.18 Defects and method of rejection

Materials which show injurious defects at the place of manufacture or at Site, or which prove to be defective when properly applied in service shall be completely repaired or shall otherwise be replaced at no cost to the Employer.

Injurious defects shall include cracks, leaks, laminations, lack of complete penetration, lack of complete fusion, dents exceeding one eighth of the specified wall thickness and under cutting or reduction in the pipe wall thickness adjacent to a weld exceeding 0.8 mm in depth.

Slag inclusions and gas pockets or voids shall be considered to be minor imperfections and may be affected if the maximum size and distribution does not exceed the limits. Every pipe or special which fails to pass the Hydraulic Pressure Test shall be rejected. Any pipe or special which has been rejected shall be marked in a distinctive manner which will preclude any possibility of its use for purposes of this contract. Such pipes and specials may be submitted for re-test following the correction of any defects, where such correction is permitted.

4.6.1.19 Cleaning

After hydraulic testing of each pipe has been completed satisfactorily, pipes and specials shall be thoroughly descaled by acid pickling or grit blasting in order to remove all mill scale, rust, paint, grease and loose dirt. After cleaning, the pipes and specials shall be protected from and maintained free of all oil, grease and dirt from whatever source until they have received their internal and external coatings.

4.6.1.20 Internal lining

All steel pipes and specials shall be lined internally to the required thickness of Cement Mortar made from Ordinary Portland Cement and fine aggregate. The materials used for lining, the method of lining and curing of the finished lining and the manufacture and testing of test cubes shall comply with IS 3589:2001 and shall be carried out to the approval of the Engineer.

4.6.1.21 Centrifugally applied cement mortar lining

The pipes shall be lined at plant with centrifugally applied cement mortar made from Ordinary Portland Cement and specially graded washed silica sand. The cement mortar shall have a minimum cement content of 100 kg / m^3 and water cement ratio of between 0.3 to 0.45.

4.6.1.22 Methods

The cement mortar lining shall be applied by centrifugal spinning process for pipes and by manual application for fittings.

The mortar shall be applied by high speed spinning centrifugal process. The consistency of the mortar mix and the speed and duration of the spinning shall be such that the segregation of the aggregates from the cement is minimized. After the mortar has been evenly distributed, the pipe shall be spins at high speed to produce a dense lining with smooth surface and a minimum of shrinkage. Water centrifuged from the mortar shall be a removed.

After being lined, the pipes shall be marked with the date of lining and stored undisturbed for 7 days for

maturing when Water curing is used. Means shall be employed to prevent the lining from drying too rapidly, particularly during the 48 hour period after lining operation. The lining shall be kept damp by spraying with water or by other means. Method & period of curing other than water shall be accepted if approved by the Engineer.

The surface of the lining shall be smooth and free from irregularities.

Fine surface crazing, hair cracks or cracks upto 0.25 mm wide in saturated lining and not over 300 mm in length shall not be a cause for rejection.

Cracks over 0.25mm in width and over 300 mm in length in saturated lining, shall be made good using compatible material.

Lining thickness shall not be less than the required thickness with tolerance of +3 mm. and -0 mm

Hand finishing of the end of the bore of the pipe for not more than 100 mm shall be permitted to rectify the thinning of linings. Fittings and specials shall be lined by centrifugally process and the same requirements as straight pipes, or if this is precluded by their shape, they shall be hand finished and cured so as to achieve comparable results.

The lining materials thickness end tests shall comply with the requirements for continuously applied cement mortar linings

The pipe shall be charged in a single operation and spun at a suitable speed to achieve a minimum rate of radial acceleration of 250m/s^2 until uniform layer of lining has been attained over the whole of inner surface with the exception of stop backs for joining.

The spinning of the pipe shall continue until the surplus water has been dispersed and the greatest possible density of lining is obtained. Any damage caused to the end rings shall immediately be made good by hand before the lining is set. No more than one hour shall elapse between the removal of lined pipe from the lining machine and commencement of the approved curing procedure.

4.6.1.23 Tests on cement mortar lining

Test blocks of the same material as used for pipe lining shall be made in 100 mm moulds and subjected to cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under conditions of temperature and humidity identical with in which lining of the pipe is cured.

The cube strength of the test cube shall not be less than 31 N /mm^2 after 28 days of curing or 17 N/mm^2 after 7 days of curing. The density of the test cube shall not be less than 2100 kg/m^3

4.6.1.24 Stop backs of protection at ends

Pipes and specials supplied with cement mortar lining which are to be joined together by internal welding shall have the lining stopped back at the ends a distance of 250 mm. to permit welding of the joints without damage to the lining.

4.6.1.25 Protection of lined pipes against damage in storage, transport & handling

The ends of all lined pipes and special shall be sealed to exclude foreign matter giving transit and storage. This protection may be in the form of plugs, discs or plastic sheeting.

4.6.1.26 Field joint

After the welding is completed the gap between C.M lining of two pipes shall be made up manually using C.M 1:2 and cured by curing compound.

4.6.1.27 External coating for underground pipes;

This specification covers the cleaning, priming, coating and wrapping of steel line pipe for external protection.

Concessionaire shall furnish all materials equipment, labour, supervision at job site necessary to coat and wrap pipe as described in these specifications.

All works to be done under these specifications by Concessionaire shall be conducted diligently, continuously and in good faith in a through careful, skillful and workman like manner in full accordance with accepted pipeline coating practices and as approved by the Engineer. The Engineer will inspect the result of the work and determine acceptability. Concessionaire shall provide to the Engineer access to all phases of the work.

4.6.1.28 Material and equipment:

Primer shall be Type B, synthetic primer conforming to BS: 4164-section 2.2

Coal tar enamel shall be Type-IV Grade 120/ 5 in accordance with BS: 4164 and shall be suitable for a design temperature of 200^0 F ($93\ ^0$ C).

Primer and enamel shall be obtained from the same manufacturer in accordance with AWWA C 203-73 Section 2.4.4.

Glass fiber reinforcement material shall be reinforced in the longitudinal direction, shall have any thickness and have minimum thickness of 0.5 mm (0.020inches) and shall conform to AWWA C 203-73 Section A. 2.

The outer wrap material shall be a coal tar impregnated (15 lb) perforated fiber glass with coal tar enamel in accordance with ASTM–D 146 and shall confirm to the requirements of AWWA C 203-91 section 2.10.

The Concessionaire shall demonstrate that the coal tar enamel proposed to be used will form a firm bond to the primer proposed to be used and shall receive approval from the Engineer prior to the start to priming operations.

The Concessionaire shall submit samples of proposed glass fibre reinforcement and fibre glass with coal tar enamel outer wrap to the Engineer and receive approval prior to the start of coating operations.

All equipment, tools and supplies furnished by Concessionaire must be of good quality, adequate design, must be maintained in good condition during use and shall be subject to the approval of the Engineer.

Coating materials shall be properly handled and stored by Concessionaire to prevent determination. Any coating or wrapping materials, which are damaged or condemned by the Engineer because of Concessionaire's negligence, shall be replaced at Concessionaire's expense.

All cleaning and priming machines, coating machines and combination cleaning and coating machines shall be equipped with rubber or hard fiber crawler wheels. Knurled steel or other type crawler wheels, capable of marking of indenting the pipe shall be prohibited. Concessionaire shall employ only competent, skilled and careful workmen experienced in the operation of cleaning, priming, coating and wrapping machines.

If requested by the Engineer, Concessionaire shall secure at no expense to the Employer, the services of manufacturer's service representative for any machine not functioning properly.

Concessionaire shall furnish suitable kettles for heating the enamel. Kettles shall be equipped with the following

i) Continuous mechanical agitation devices.
ii) Dial type indicating thermometers of a suitable range (60 degree to 200 degree C) and mounted with the build 100 mm from the bottom of the kettle and the dial plainly visible.
iii) 1.6 mm (1 /16 – inch) mesh strainer boxes that can be easily cleaned.

All kettles shall be clean and may not contain any coating residues, dirt water or other foreign matter before starting work. Kettles shall be cleaned periodically during the work at the Engineer's request. If kettles or other equipment have previously been used with a coating material that is not compatible with the material to be used in these specifications, the Engineer may require the Concessionaire to burn out the kettles and other equipment or remove all traces of the old material.

4.6.1.29 Surface preparation:

The outside surface of the pipe shall be thoroughly cleaned to the satisfaction of the Engineer with approved sand or steel shot blast cleaning. The pipe shall be cleaned to Swedish Standards SIS 2-1/2 as shown Swedish Standards and the procedure to be used shall be approved by the Engineer prior to being used.

Before cleaning, oil and grease shall be removed from surface by wiping with clean rags saturated in a suitable solvent approved by Engineer.

The compressed air for blasting shall be free of water and oil. Adequate separators and traps shall be provided.

Blast cleaning operations shall not be conducted on surfaces that will be subject to becoming wet after blasting and before coating; when the pipe surfaces are less than 2.5^{o}C, above dew point; or when the relative humidity of the air is greater than 85 per cent, unless preheating of the pipe is employed. Blast cleaning under these conditions can be conducted provided the pipe can be warmed to a temperature sufficient to perform the blasting operations without visual appearance of moisture on the pipe surface. Preheat pipe temperature shall not exceed 65°C.

After cleaning, the pipe surfaces shall be bare metal free of all mill scale, lacquer, old coatings, oil, grease, moisture, rust, mud, dust, welding residue other foreign or deleterious matter.

4.6.1.30 Priming:

The primer shall be a material that is recommended by the enamel manufacturer as compatible for use with the enamel coating. Primer shall be kept at a warehouse and only the daily requirements shall be brought to the job site. Primer shall be thoroughly agitated in its container before use. Only the amount of primer required for immediate use shall be emptied from the drums into open container. After obtaining the quantity required, bungs shall be immediately replaced to prevent the loss of solvents by evaporation. Primer which has become contaminated with foreign matter or has thickened because of evaporation of solvents shall not be used. The primer shall be cold applied to a clean, dry surface, immediately after the cleaning operation.

The primer shall be applied as received from the manufacturer unless, in the opinion of the Engineer, a thinner should be used to speed up the drying time. The thinner when used, shall be mixed with the primer in the manner and proportions recommended by the manufacturer of the primer.

Primer shall be machine applied at a rate recommended by the manufacturer on new pipe in a uniformly

thin film which shall be free from runs, bubbles, sags, dust, grass or foreign matter. Primer shall completely cover the circumference of the pipe and all surfaces which are to be enamel coated. All missed spots or areas covered with insufficient primer shall be touched up immediately by hand brushing. Primer which has been applied too heavily, such as at the base of welds, shall be brushed out before the primer sets. Any runs or sags which have dried shall be scrapped off and reprimed. Hand brushing of primer where required shall be done in a neat and workman like manner using only good quality paint brushes. Care shall be taken to prevent damage to the primer film prior to enamel application.

The pipe shall be reprimed at Concessionaire's expenses, if in the opinion of the Engineer deterioration of the primer has occurred before the application of the enamel. Only two applications of primer are permitted. If the enamel is not applied before the second coat or primer has lost its effectiveness, the pipe shall be cleaned to bare metal by a cleaning machine or solvents and reprimed.

Primer once used shall not be re-used either by recycling or otherwise. Removal of primer from the primed pipe due to abrasion from any metallic contact will be reprimed properly and allowed adequate curing time before flood coating.

The primer coat shall be exposed for curing before flood coating, only within the time limits recommended by the manufacturer. It shall be shielded from dust impingement while curing. Dust and other contamination shall be removed from the primed surface before flood coating. Enamel shall not be applied until primer has cured. Concessionaire shall test the dryness of the primer at the bottom of the pipe.

4.6.1.31 Coating and wrapping

After the premier has been properly applied and adequately cured the pipe shall be coated by successive layers of coaltar enamel, glass fibre reinforcement coaltar enamel, glass fibre reinforcement and impregnated fibre glass with coal enamel outer wrap.

The coating and wrapping shall terminate 250 mm from the ends of each length of pipe. The finished thickness of the coating and wrapping shall be a minimum of 4.75 mm throughout.

The surface preparation, priming, coating and wrapping shall meet the requirements of the following sections of AWWA Standard C-203-91.

Preparation of Surfaces

Priming

Pre-heating of Primed Pipe

Coal-Tar Enamel Application

Electrical Inspection

Transporting and Handling (except that A.R.A. loading rules will not apply)

Field Bond Test Procedure for Primer and enamel

The enamel shall be furnished in expendable sheet metal or paper drums. The enamel will be chopped or cut on a suitable platform to prevent the enamel from coming into contact with dirt, weeds, cinders, grass and other contaminants. The chopped or cut pieces of enamel may not weigh more than 10 kg. The pieces of enamel shall be covered when they are in danger of contamination because of atmospheric conditions.

Care shall be taken to prevent contaminants from mixing with the enamel at any time. The enamel shall be

slowly heated to the temperature recommended by the manufacturer in a clean kettle.

When the enamel has reached the recommended temperature, the flame under the kettle shall be reduced to prevent overheating. Only batch heating of the enamel will be permitted. The kettle shall be emptied of one charge of enamel and cleaned, if necessary, before the next charge of enamel is added. All enamel taken from the kettles shall be strained.

During the time that the enamel is in a molten condition, it shall be continuously agitated. Small kettles or batch pots not equipped with mechanical agitators shall be stirred with steel paddles every fifteen (15) minutes. Kettle lids shall be kept tightly closed at all times except for small kettles when the lid may be opened for stirring. Wooden sticks or paddles may not be used for stirring the enamel. Enamel heated in excess of the maximum temperature specified by the manufacturer shall be condemned and dumped. The temperature of enamel required to produce the thickness of coating specified shall be maintained at all times during application.

In case of an interruption or short shutdown due to weather conditions or other unavoidable circumstances, the temperature of the enamel charge shall be reduced approximately to 55°C lower than the application temperature until coating operation resume.

The enamel shall be applied with an approved combination coating and wrapping machine. The enamel shall be applied in such a manner that it will adhere tightly to the primed pipe in a continuous unbroken film of specified thickness. Machine operators shall be required to make all necessary adjustments to assure a continuous film of enamel without undue loss of temperature at point of application. Defects, such as bubbling or foaming, shall be cause for shutting down operations until air pockets if any have been removed from pumps and supply lines, and required coating shoe adjustments have been completed. The pipe ambient temperature during application of the enamel shall be within the limits specified by the manufacturer.

Coating shoes shall be kept evenly centered on the pipe and shall not be allowed to drag or thin the enamel below specified thickness at any point due to improper bridling. Shoes which are not round or are damaged shall be immediately replaced. One or more auxiliary spray rings shall be used if necessary. Thickness of the coating applied shall be frequently tested with an approved pit gauge. The coating punctured by the pit gauge shall be repaired.

A reasonable even coating of hot tar enamel shall be applied over the entire surface of the pipe. The minimum thickness of the enamel at this stage shall be 2.4 mm.

Immediately following application of the hot tar enamel to the pipe and before the enamel has cooled appreciably the glass fibre reinforcement material shall be applied over the enamel in a uniform spiral wrap, in such manner that the wrapper is drawn into the hot enamel causing enough of it to penetrate through the glass to furnish a proper bond with the next layer enamel. A second application of hot coal tar enamel shall then be applied of such thickness that the composite thickness of two layers of enamel and reinforcement shall be minimum of 4.75 mm.

A second layer of glass fibre reinforcement material shall then be applied immediately behind the second coat of enamel in uniform spiral wrap and pulled into the enamel. The fibre glass with coat enamel outer wrap shall then be applied immediately behind the glass fibre reinforcement in a tight uniform spiral. The overlap at the edges of all wrapping shall be not less than 12 mm not more than 25 mm. The tension of the wrapper should be so adjusted that it does not pull through the hot enamel and come in contact with

the metal surface. This may be checked by cutting out a section of the coating at the lap in the wrapper and making a physical examination. The size of the bead formed at the lap indicates whether the tension is correct or not. If the bead is 15 percent higher than the felt, it indicates that the felt has been pulled in too tightly, thus squeezing the enamel out of the lap.

No wrinkling in the wrapping will be allowed and the outer wrapping shall be completely bonded to the enamel.

The coating shall be continuous for the full length of the pipe, except that a length of at least 250 mm but not more than 300 mm on each end of the pipe shall not be coated. This uncoated position near the pipe ends shall be applied with temporary coating as specified elsewhere after concrete coating if any, and before stock pilling the line pipes.

All foreign substance, dirt, steel short and other debris shall be removed from inside pipe before stockpiling or shipping. All primer and enamel inside the pipe shall be removed with solvents and wiped clean. The coated pipe shall be placed in such a manner that the enamel can set, cool and harden without damage.

4.6.1.32 Inspection, testing and repairs

All records of inspection and testing of material received by Concessionaire and all manufacturer material certificates shall be submitted to the Engineer.

All materials shall be certified by means of the manufacturer's certificate of analysis for each batch of material supplied. Representative samples of material may be tested by the Engineer. The cost of testing shall be borne by the Concessionaire.

Pipe identification shall be preserved by Concessionaire by maintaining identify of each joint of pipe.

All stages of the work shall be subject to full time inspection by the Engineer. Such inspection shall not relive the Concessionaire of his responsibility to provide materials and workmanship to this specification.

The Field Bond Test Procedure, Section 2.9 of AWWA C 203-91 shall be applied to each pipe in the initial production, until such time as the Engineer is satisfied that the bond is satisfactory, when he may relax the test to one pipe in ten, chosen at random.

The Engineer shall be permitted to test the coating and any repairs subsequently made to it, in compliance with this specification. He will from time to tome cutout 25 square cm samples from the coating for determination of thickness. Concessionaire shall repair such cut outs and other defects in the coating at no extra compensation.

Concessionaire shall furnish high voltage electronic holiday detectors of a type acceptable to the Engineer and shall test all coating applications immediately after coating and wrapping. The holiday detector shall be low impedance high voltage holiday detector such as Spy model S-120 or equivalent. Testing for coating flaws shall be in accordance with NACE Standard RP-0274, "Recommended Practice High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation", latest edition. The minimum detector voltage required may be determined by the following formula.

$1250(t)^{0.5}$ Voltage setting, where "t" is the specified minimum coating thickness expressed in mils.

While deciding upon the test voltage due consideration has to be given to perforated fibre glass with coal enamel wrap application and thickness.

Calculated test voltage shall be checked against the test voltage arrived at by following the procedure prescribed in Section 2.13.12.4 of AWWA Standard C-203-91 and use higher of the two voltages for regular inspection work.

The crest voltage of the holiday detector shall be set as high as practicable and operating voltage set as specified earlier. Concessionaire shall provide necessary devices for calibrating the holiday detector.

All coated pipe under test shall be positively grounded by a means satisfactory to the Engineer. The detector electrode shall be periodically cleaned to continuously provide full contact with the surface of the coating. The approved electronic holiday detector shall be passed over the coated and wrapped pipe as coating progresses. The detector shall be passed at a sufficient distance behind the coating and wrapping machine to permit the enamel to set. The initial inspection is made to provide prompt warning of coating machine maladjustments or other conditions preventing a proper coating application as specified, in order that immediate corrective adjustments may be made.

Any defective part of the coating shall be clearly marked by Concessionaire immediately after it is detected.

All pin holes, voids, holidays, air bubbles, cracks, and other breaks shall be carefully marked. Repairs may be made immediately following the coating and wrapping operation or may be differed, but in any case, shall be repaired and reinspected prior to storing or shipping. Repairs to enamel coating shall be made by removing the wrap over the damaged coating in a manner that will not disband the adjacent coating. The repair area shall be primed and hot enamel shall then be poured or "ragged" over the area, with the felt wrap embedded and bonded to the enamel. All coating repairs shall be made with the wrap smoothly applied and without wrinkles or buckles. Repair shall be at least equal in effectiveness to the coating applied to the principal part of the line. All repairs must successfully pass a test by the electronic holiday detector.

Any pipe joints shall be rejected if three (3) or more holidays are detected in its length. Similarly, a pipe joint shall be rejected and no repair allowed to it if any one holiday is bigger than 0.1 square meter in size.

Concessionaire shall repair all coating damage and defects at no additional cost to Owner. All coating operations shall be subject to physical examination and samples shall be cut from the coating as required by the Engineer. Pipes shall be handled in such a manner as to prevent damage to enamel and wrapper.

If the coated pipe is to be stored it shall be coated with a spiral wrap of Kraft paper or a water resistant while wash as per AWWA C 203-91 Section 2.11 or 2.12.

Prior to final stacking of pipe, the unprimed ends shall be cleaned by wire brushing and coated with as per recommendation of the manufacturer of coating. Such temporary protective coating should not require removal while marking field-joints and applying corrosive protective coating later while laying the line. The type and film thickness is to be agreed by the Engineer.

4.6.1.33 Handling coated pipe

Concessionaire shall develop the method of stock piling or trucks and barges and shall furnish special loading spacers, bolsters and the like, approved by the Company's engineer, to protect the pipe during transport.

Coated pipe shall be handled at all times with wide nonabrasive or leather belts or other equipment designed to prevent damage to the coating. All such equipment shall be kept in repair so as to prevent injury to the coating. The use of tongs, bare pinch bars, chain slings, protruding rivets, pipe hooks without

proper padding, or any other handling equipment that may be injurious to the coating shall not be permitted. The coated pipes will be padded while being transported. It should be noted that the road's condition may not be very conductive for such transport.

Yard coated pipe shall be raised or lowered to or from stock pile, ground, barge, rail car, or truck by means of brass lined or padded pipe end hooks engaging the ends of the pipe and carried by wire rope on chain slings with "Spreader bar" between lifting lines. The bolster of the rail car, trailer, or barge shall have a bearing surface not less than 30 mm to give necessary support to the padding which protects the coating. Sacks partly filled with sand or sawdust should be placed on the bolster and between the outside bottom pipes and the bolster stakes. All chains, cables, or other equipment used for fastening the load must be carefully padded.

The maximum pilling heights for various types of coated pipe shall be limited to such heights as will prevent damage to pipe nested with regular coated pipe.

4.6.1.34 Field joints

After the welding is completed, tested and approved, the procedure as described for parent pipe will be strictly adhered to. If the pipe trench is flooded with water, the same will be pumped /bailed out. The filed joint will be allowed to dry before cleaning operation commences. The backfilling will be applied in sufficient quantity so that coating and subsequent wrapping do not leave and void. The filler will be to match the coating specification.

4.6.2 Ductile Iron Pipes and Specials

4.6.2.1 General

The internal coating / lining and external coating / painting / should be done at factory only for pipes and specials.

Reference Standards applicable to various types of pipelines include the following Indian & International Standards: —

IS 8329: 2000 Centrifugally cast (spun) Ductile iron pressure pipes for water – specification

IS 9523: 1980 Ductile iron fittings for pressure pipes for water.

IS 13382:1992 Cast iron specials for mechanical and push on flexible joints for pressure pipelines for water.

IS 455 : 1989 Portland slag cement (fourth Edition)

IS 638 : 1979 Sheet rubber jointing and rubber insertion joints.

IS 1387 : 1993 General requirements for supply of metallurgical materials

IS 1500 : 1983 Methods for Brinell hardness test for metallic materials.

IS 1608 : 1995 Mechanical testing of steels.

IS 5382 : 1985 Rubber sealing ring for gas mains water mains & sewer.

(Rubber Gasket for push-on-joints or mechanical joints for DI pipes lines)

IS 6452 : 1989 Specification for high alumina cement for structures.

IS 6909 : 1990 Specification for super sulphated cement

IS 8112 : 1989 43 grade ordinary Portland cement

IS 12330 : 1988 Sulphate resisting Portland cement

IS 11606 : 1986 Methods of sampling of cast iron pipes and fittings.

IS 2405 Part2/1980 Specification for Industrial sieves Part2 perforation.

IS 1200 Part1/1974 Specification for "rock" classification.

IS 12258 – 1987 Code of practice for use and laying of ductile iron pipes

IS 1536 – 1976 Cast iron pipes

IS 1538 – 1987 Cast iron fittings

4.6.2.2 Compliance with standards;

Subject to the further requirements of this specification, the pipes under this contract shall be of approved manufacture and shall comply with the requirements of IS 8329 – 2000 and further amendment to this code. Pipes meeting any other internationally accepted standard ensuring a quality equal to or higher than the standards mentioned above will also be accepted. The general requirements relating to supply of material shall be as laid down in IS.1387:1993.

4.6.2.3 Manufacture

The metal used for the manufacture of pipe shall be of good quality, commensurate with the mechanical requirements laid down in clause 10 of IS 8329 – 2000. 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 imperfection 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 requirements of class K 9 or any other respective class of pipe 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 retreat treatment to ensure that Brinell hardness does not exceed the specified value and the other mechanical properties specified in the standard are achieved.

Types of joints

Push on flexible joint.

In case of push – on flexible joints, the spigot ends shall be suitably chamfered or rounded off to facilitate smooth entry of pipe in the socket fitted with the rubber gasket.

Mechanical flexible joint

Flexible joint in which sealing is obtained by applying pressure to the gasket mechanical means, for example a gland.

C Flanged joints

The dimensions and tolerances of the flanges of pipes and fittings shall be such, so as to ensure the interconnection between all flanged components (pipes, fittings, valves) of the same diameter and pressure and adequate joints performance.

Rubber gasket

Rubber gasket used with push-on-joints or mechanical joints shall conform to IS 5382 and for use with flanged joints shall conform for IS 638. While conveying potable water the gaskets should not deteriote the quality of water and should not impart any bad taste or odour. Shape and dimensions shall conform to the manufacturer's standard.

4.6.2.4 Quality assurance

The manufacturer shall be able to demonstrate the conformity of the product to the requirement by controlling the manufacturing process and by carrying out the various tests as specified in IS wherever possible, statistical sampling techniques should be used to control the process so that the product is produced within the specified limit.

4.6.2.5 Fitting for D.I pipes

Fittings shall be manufactured as per IS 9523:1980

4.6.2.6 Hydro Static test at factory

All pipes shall be tested hydrostatically at a minimum pressure specified as below at factory/ manufacturing yard.

Nominal diameter D.N	**Centrifugally cast pipes with flexible joints class K9,**
80 – 300	5.0 MPa
350-600	4.0 MPa
700 – 1000	3.2 MPa
1100-2000	2.5 MPa

Test shall be carried out before the application of surface coating and lining.

4.6.2.7 Internal cement mortar lining for D.1 pipe

The cement used for the lining shall be Portland cement conforming to the IS 8112 or 455.

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, 125 mm shall not be more than 10 percent by mass. The fraction comprising grains up to 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 coarsest fraction (comprising particles which do not pass through as sieve of the aperture size closest to half the normal thickness of the mortar lining) shall not exceed 5 percent by mass.

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.

The mortar of the lining shall be composed of cement, sand and 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.

All foreign bodies, loose scale or any other material shall be removed from the surface to which the lining is to be applied. The inner surface of pipe shall also be free of any metal projection likely to protrude beyond 50 percent the thickness of the lining.

The cement mortar lining at works 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 temperature greater than 4^0 C. Any loss of water from the mortar by evaporation shall be sufficiently slow so that hardening is not impeded.

Repairs to damaged or defective areas are allowable. The damaged mortar shall be removed and repaired by using a trowel with fresh mortar. 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.

4.6.2.8 Thickness of the lining

The normal thickness of the lining and the minimum permissible mean and local values are given as per IS-8329 as below.

DN in mm	**Thickness of the lining in mm**		**Max. crack in mm**	
	Nominal value	**Tolerance**	**Width**	**Radial Displacement**
80-300	3.0	- 1.5	0	8
350-600	5.0	- 2	1	0
700-1200	6.0	- 2.5	1	2

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 50 mm.

4.6.2.9 Determination of lining thickness

The thickness of the lining is checked on the fresh by centrifuged mortar by the insertion of a steel pin, or on the hardened mortar by means of a non-destructive method of measurement, at both ends of pipe in at least one section perpendicular to the pipe axis.

4.6.2.10 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 corrugation or ridges. The cracks are acceptable up to a width given in the above clause of 4.12.8. Minimum bore clearance cement mortar lining of ductile iron pipe is 13mm less than the nominal diameter (DN) up to 300 mm and 15 mm for above 300 mm D.N.

4.6.2.11 External coating of pipes.

The pipe surface shall be dry and free from rust or any non-adhering particles or foreign matter such as

oil or grease.

The coating materials are metallic zinc with content of at least 99 percent by mass.

The metallic zinc coating shall be applied by a spraying process in which metallic zinc material is heated to a molten state and projected in small droplets by spray guns on to surface. The zinc rich paint coating shall be applied by a spraying or a brush process on to the pipe surface in case of repair only.

i) The metallic zinc coating shall cover the outside diameter of pipe and shall be free from such defects as bare particles or lack of adhesion.

ii) Damaged areas of zinc coating caused by handling are acceptable provided that the damage is less than 5 cm^2/m^2 of coated surface and provided that the miner dimensions of the damaged area do not exceed 5 mm.

The average mass of zinc coating shall be not less than 130g/m^2 with a local minimum of 110g/m^2

Manufacturing process control system shall specify the frequency of this test. A rectangular token is attached along the pipe axis before passing it through the zinc coating equipment. After coating and trimming the minimum token sizes shall be either 250mm x 100 mm or 500 mm x 50 mm. The average mass of zinc coating M expressed in grams per square metre, is calculated by mass difference of the token before and after zinc coating.

Areas left uncoated, for example under the test token and coating damaged in excess of 5 cm^2/m^2 of coating shall be repaired by either:

a metallic zinc spray.

by application of zinc paint containing more than 90% zinc by mass in the dried film: mean mass of the applied paint shall not be less than 150g/m2.

Flanges of welded flanged pipes and welded parts of the flanges shall be coated with zinc rich paints (90 percent)

4.6.2.12 Finishing layer

After metallic zinc coating or zinc rich paint coating, the pipe shall be given a finishing layer of bituminous paint compatible with the zinc coating. Application of this finishing layer may be done by any proven process such as spraying or brush coating at the manufacturer's choice. It shall uniformly cover the zinc coating and be free from bare patches or lack of adhesion. The mean dry film thickness of the finishing layer shall not be less than 70 µm with nowhere less than 50µm.

4.6.3 Unplasticized PVC pipes & specials

4.6.3.1 General

Reference standards for uPVC pipelines include the following Indian and International standards:

IS 4985: 2000 Unplasticized PVC pipes for potable water supplies - specification

IS 12235 Part 1 to IIMethods of test for Unplasticized PVC pipes for potable water supplies specifications.

IS 12818: 1992 Specification for uPVC casting pipes of tube wells & screens

IS 12231: 1987 Specification for uPVC suction & delivering of agricultural pumps.

IS 10148 Specification for additives to be used on pipes.

IS 727 – 1985 (E) Specification for the dimensions of sockets (for solvent cement joints)

IS 5382: 1985 Specification for rubber sealing rings for water mains.

IS 13360 (Part3/sec1) Specification for plastics method of testing (density)

IS 4669: 1968 Methods of test for poly vinyl chloride resins

IS 14182 :1994 Solvent cement for use with u PVC pipes and fittings.

IS 4905: 1968 Methods for random sampling.

IS 6307: 1985 Specification for rigid PVC sheets

IS 10148: 1982 Positive list of constituents of poly vinyl chloride resins for safe use in drinking water pipe.

IS 10151: 1982 Specification for poly vinyl chloride (PVC) and its copolymers for its safe use in contact with drinking water.

IS 7634 (Part 3) Code of practice for plastic pipe work for potable water suppliers laying and jointing of uPVC pipes.

IS 7834 (Part1- 8) Injection moulded PVC socket fittings with solvent cement joints for water supplies.

4.6.3.2 Compliance with standards for pipes:

Subject to the further requirements of this specification, the pipes under this contract shall be of approved manufacture and shall comply with the requirements of IS 4985:2000. Pipes meeting any other internationally accepted standard ensuring a quality equal to or higher than the standards mentioned above will also be accepted.

4.6.3.3 Fittings

Fittings shall be of approved manufacture and shall comply with the requirements of IS-7834 and IS 1021.

4.6.3.4 Terminology

1) The material from which the pipe is produced shall consist substantially of unplasticized poly vinyl chloride to which may be added only those additives that are needed to facilitate the manufacture of the pipe and the production of sound and durable pipe of good surface finish, mechanical strength and opacity under conditions of use. None of these additives shall be used separately or together in quantities sufficient to constitute a toxic, organoleptic or microbial growth hazard, or materially to impair the fabrication or welding properties of the pipe, or to impair its chemical and physical or mechanical properties (in particular long-term mechanical strength and impact strength) as defined in IS 4985. The additives to be used shall be selected from IS 10148 and shall be uniformly dispersed.
2) The monomer content (VCM content) in the resin shall be within the limits specified in 3.3.1 of IS 10151, when tested as per Annex A of IS 10151.
3) The composition shall be based on PVC resin having a K-value of 64 or greater when tested in accordance with IS 4669. (A test report or conformity certificate may be obtained from the resin manufacturer for the VCM content)
4) The addition of the manufacturer's own rework material is permissible. No other rework material shall be used.

4.6.3.5 Visual appearance

The colour of the pipes shall be light grey.

Opacity

The wall of the plain pipe shall not transmit more than 0.2 percent of the visible light, falling on it when tested in accordance with IS 12235 (Part 3)

Density

When determined in accordance with IS 13360 (Part 3 / sec 1), the density of the pipe shall be between 1.40 and 1.46.

Sulphated ash content test

When tested as per Annex B of IS 4985, the sulphated ash content in the pipe shall not exceed 11 percent.

4.6.3.6 Marking

The sampling procedure and the criteria for conforming shall be as given in Annex D of IS 4985.2000.

1. Each pipe shall be clearly and indelibly marked in ink/paint or hot embossed on white base at intervals of not more than 3 meters, in colour as indicated below. The marking shall show the following.

a. Manufacturer's name or trade-mark
b. Outside diameter
c. Class of pipe and pressure rating
d. Batch or lot number, and year of last two digit
e. The letters "JBIC-KWSP".

2. The information according to above Para 1 and Para 3 shall be marked in colour as indicated below for different classes of pipes:

Class of pipe	Colour
Class 1 (0.25 Mpa)	Red
Class 2 (0.4 Mpa)	Blue
Class 3 (0.6 Mpa)	Green
Class 4 (0.8 Mpa)	Brown
Class 5 (1.0 Mpa)	Yellow
Class 6 (1.25 Mpa)	Black

In case of plumbing pipes, the information shall be marked in pink colour. In the case of hot embossing, the pipes shall also be provided near the end with a circumferential colour band as indicated above, so as to identify the class of pipe.

BIS Certification Marking

Each pipe shall be marked with, ISI mark.

4.6.4 Medium density polyethylene (MDPE) pipelines

4.6.4.1 General

Reference Standards for MDPE pipelines include the following standards:

BS 5114 Performance requirements for joints and compression fittings for use with polyethylene pipe.

BS 6572 Blue polyethylene pipes up to nominal size 63 for below-ground use for potable water.

CP 312: Part 1 Plastics pipework (thermoplastic material): General principles and choice of material.

CP 312: Part 3 Plastics pipework (thermoplastic material): Polyethylene pipes for the conveyance of liquid under pressure.

WIS* 4–32–03 Blue polyethylene pressure pipe (nominal sizes 90 – 1000 for underground and protected use).

WIS* 4–32–08 Site fusion jointing of MDPE pipe and fittings.

WIS* 4–32–14 P80 and PE100 electrofusion fittings for nominal sizes up to and including 630.

WIS* 4–32–15 PE80 and PE100 spigot fittings, and drawn bends for nominal sizes up to and including 1000.

(* WRC Water Industry Specifications, previously called Information and Guidance Notes)

4.6.4.2 Pipes, fittings and joints

Medium-density polyethylene pipes and fittings for pressure pipelines shall be in accordance with BS 5114, BS 6572 and with specifications issued by WRC as Water Industry Specifications (WIS) 4–32–03, 4–32–14 and 4–32–15. The manufacturer shall be responsible for all testing and quality assurance. Pipes exceeding 90mm nominal diameter shall not be supplied in coils. Pipes up to nominal size 63 shall further comply with BS 6572.

All MDPE pipe and fittings for thermal fusion jointing to form an individual pipeline or pipeline system shall be supplied by one manufacturer unless the Engineer approves otherwise. Electrofusion couplings are excepted from the requirement but must be of a type approved by British Gas and incorporate pins which pop up to confirm that optimum melt pressure has been achieved.

Mechanical joints shall be of the Viking Johnson 'Quicklock' type and shall be complete with liners.

4.6.4.3 Thermal fusion-jointing equipment

All tooling and equipment used for thermal fusion jointing shall be of types acceptable to British Gas and shall include all equipment necessary to cut, plane and clean, clamp, heat and align pipe and indicate or control temperatures and heating and cooling periods to a standard acceptable to British Gas. Equipment for thermal fusion jointing shall comply with Water Industry Specification (WIS) 4–32–08.

Fusion tools and heating plates shall be electrically heated and thermostatically controlled with any handles or brackets made of material having electrical insulating properties conforming to BS 2559: Part 3 for use with 110V ac or, if made of wood, they shall conform to BS 3823: Part 1. The tool or plate shall be earthed through the generator.

A thermometer shall be fitted and shall have a green zone indicating the correct fusion temperature range

for MDPE marked with the appropriate code. Thermometers shall be suitably protected from mechanical damage, shall be replaceable and shall be accurate to !3°C within the fusion temperature range. If an alternative temperature-indicating system is used, the plate shall have provision for inserting a suitable conventional thermometer.

The wattage of the heater elements shall be such that the required surface temperature range is reached within 15 minutes in still air and at ambient temperatures of 20°C !5°C.

The input leads shall conform to BS 6500 Table 7 or other agreed standards.

The temperature control system (thermostat) shall be flameproof in accordance with BS 4683: Part 2.

Hydraulic rams used to align pipe ends and bring them together shall each have independent pressure gauges. Each gauge shall have a performance certificate indicating any deviations in true to actual readings issued by an independent tester not less than one month prior to its use. The certificates shall be made available to the Engineer, together with data relating the hydraulic pressure of the machine to the total force applied to the pipe.

4.6.5 High density polyethylene pipes

4.6.5.1 General

Reference Standards for HDPE pipelines include the following standards: —

IS 4984 : 1995 Specification for the Standards High Density Polyethylene Pipes

IS 7328: 1992 Specification for the material of manufacturing

IS 2530:1963 Specification for the Melt flow Rating of the pipe material, carbon Black content and Dispersion

IS 10141:1982 Specification for the usage of antioxidants in the manufacturing

IS 4984:1995 Pressure coefficient – for this maximum working pressure, procedure for the measurement of pipe wall thickness

IS 9845-1986 Specification for the composite sample for migration test

IS 10148:1987 Specification limits for the overall migration of constituents

IS 7328: 1992 Test for density of HDPE pipes

IS 7634 (Part II) Guidance on proper methods for laying and jointing of Polyethylene pipe work system.

4.6.5.2 Compliance with standards

Subjects to the further requirements of this specification, the pipes under this contract shall be of approved manufacture and shall comply with the requirements of IS. 4984: 1995. Pipes meeting any other internationally accepted standards ensuring a quality equal to or higher than the standards mentioned above will also be accepted.

4.6.5.3 Colour:

The colour of the pipe shall be blue. For the purpose of identification of the pipes covered in this standard, each pipe shall contain minimum three equi-spaced longitudinal stripes of yellow color and a width 3 mm (min) in blue colour. These stripes shall be coextruded during pipe manufacturing and shall not be more

than 0.2 mm in depth. The material of the stripes shall be of the same type of resin, as used in the base compound for the pipe.

4.6.5.4 Reversion test

When tested according to the procedure given at Annex C, the value of the longitudinal reversion shall not be greater than 3 percent.

4.6.5.5 Overall migration test:

When tested from a composite sample of minimum 3 pipes as per IS 9845- 1986, the overall migration of constituents shall be within the limits stipulated in IS 10148: 1987.

4.6.5.6 Density

When tested from a composite sample of minimum three pipes as per Annex A of IS 7328: 1992, it shall meet the requirement as given in 14.2.

4.6.5.7 Melt flow rate (MFR)

When tested from a composite sample of minimum three pipes as per IS 2530: 1963, at 190^0C with nominal load of 5 kg f, MFR shall be between 0.4 to 1.1 g/10 minutes and also shall not differ by more than 30 % of MFR of the material used in manufacturing pipe (see 14.2)

4.6.5.8 Carbon black content and dispersion:

When tested from a composite sample of minimum three pipes, in accordance with IS 2530: 1963, the carbon black content shall be within 2.5 $\pm$ 0.5 % percent and the dispersion of carbon black shall be satisfactory.

4.6.5.9 Sampling, frequency of tests and criteria for conformity.

Type tests are intended to prove the suitability and performance of new composition a new technique or a new size of a pipe. Such tests therefore need be applied only when a change is made in polymer composition or method of manufacture, or when a new size of pipe is to be introduced. Even if no change is envisaged, type test shall be done at least once in two years on each pressure rating and garde of pipe of the highest size manufactured during the period.

4.6.5.10 Acceptance test.

Acceptance tests are carried out on samples selected from a lot for the purpose of acceptance of the lot. All pipes of the same size, same pressure rating and same grade and also manufactured essentially under similar conditions of manufacture, shall constitute a lot. For ascertaining conformity of the lot to the requirements of this specification, samples shall be selected in accordance with the provisions as mentioned under 9.2.3 and 9.2.4 IS 4984: 1995 and tested for compliance. Scale of sampling is as below.

Scale of sampling for tests for Hydraulic Characteristic, Reversion, Overall Migration, Density, MFR and Carbon black content, Dispersion.

No. of Pipes	Sample size
Upto 150	3
151 to 1200	5
1201 to 35000	8

4.6.5.11 Marking

Each straight length of pipe shall be clearly marked in indelible ink/paint on either end and for coil at both ends or hot embossed on white base every meter throughout the length of pipe/ coil with the following information.

a. manufacturer's name/ Trade- mark
b. Designation of pipe (example PE 63 PN 10 DN 200) and
c. Lot number/ Batch number and year.
d. Letter of "JBIC-KWSP".

4.6.5.12 BIS certification marking.

Each pipe shall be marked with ISI mark.

4.6.5.13 Certificates of tests

The Concessionaire shall forward to the Engineer the following certificates, where relevant:

(a) works tests on pipes and fittings;

(b) material tests;

(c) inspection;

(d) welder-qualification tests;

(e) non-destructive tests on completed welds.

4.6.5.14 Method and programme of pipeline testing and cleaning

The Concessionaire shall submit for the approval of the Engineer details of his proposed methods and programme for pipeline testing, swabbing, disinfection and cleaning (including details of test and cleaning equipment).

4.6.6 Valves

4.6.6.1 General

Reference Standards applicable to various types of valves include the following standards:

IS 6418: 1971 Cast iron and malleable cast iron flanges for general engineering purposes

IS 13159 Part 1Specification: steel pipe flanges and flanged fittings part1 dimensions.

IS 6392: 1971 Steel pipe flanges – specification.

IS 13095 : 1991 Specification : Butterfly valves for general purposes.

IS 14846:2000 Specification for sluice valves for water supplies

IS 210 : 1978 Grey iron castings

IS 305 : 1981 Aluminium bronze ingots and castings

IS 318 : 1981 Leaded tin bronze ingots and castings.

IS 1570 part 2 Schedules for wrought steels part 2 carbon steel (unalloyed steels)

IS 1865 : 1974 Iron casting with spheroidal or modular graphite.

IS 1875 : 1978 Carbon steel billets, blooms slabs and bars for forgings.

IS 2004 : 1978 Carbon steel forgings for general engineering purposes.

IS 2500 Part 1 Sampling inspection tables: part1 Inspection by attributes and by count of defects.

IS 2500 part 2 Sampling inspection tables: part2 Inspection by variables for percent defective.

IS 2856 : 1987 Carbon steel castings for pressure containing parts suitable for high temperature service (fusion welding quality)

IS 14845 C.1air relief valves

IS 3444 : 1987 Corrosion resistant high alloy steel and nickel based castings for general application.

IS 4854 part 3/1974/part 1 Glossary of terms for valves and their parts: part3 Butteryfly valves part 1 sluice valves.

IS 9866 : 1981 Marking system for valves

All valves shall be designed to avoid cavitation and vibration in all positions, to minimize head loss in the open position and to seal the water passage when completely shut. All operating spindles and gears shall be provided with adequate points for lubrication. Unless otherwise specified, all valves shall be closed in a clockwise direction. Lifting lugs shall be provided for valves for sizes 600 mm and above. Head loss curves through the valves for throttled flow conditions shall be provided for all valve sizes. Valves shall be suitable for use with water supplies.

4.6.6.2 Valve coatings

Unless the Engineer has approved an alternative coating system, the internal and external surface of valves shall be prepared and coated as described in IS 14846:2000 Para 9.

4.6.6.3 Flanges

Unless otherwise stated, all valves shall be double flanged and all valve flanges shall be in accordance with IS 1538

Bolts and nuts shall confirm IS 1363 and IS4218 (Part 5). Tech headed bolts may also be used where necessary. All valves shall be supplied complete jointing material stainless steel bolts, nuts, washers, rubber sheet and grease.

4.6.6.4 Work tests

All valves shall be hydrostatically tested at the place of manufacture. The Concessionaire shall supply a certificate stating that the valves supplied have satisfactorily passed the specified tests and comply in all respect with this specification.

All valves shall be subjected test in accordance with I.S. 14846.

4.6.6.5 Packing

All valves shall be securely packed in crates or boxes for protection against damage during transit, and shall be accompanied by the materials necessary to secure all flanges to adjacent pipework. These materials shall also be suitably packed and shall be stored away from sunlight at all times.

4.6.6.6 Sluice valves

Sluice valves shall be of waterworks Standard to IS 14846 with inside non-rising spindles. Sluice valves shall be of the double flanged cast iron wedge gate type unless otherwise specified. They shall have a cast iron body withs renewable gunmetal faces on body and wedge and bolt on cast iron bonnet.

The gland or stem seal housing shall be cast with an arrow on the upper side indicating the clockwise direction of closure of the valves.

Each sluice a valve shall be provided with a cast-iron cap secured by a non-corrodible set screw. No hand wheels are required. Gearing shall be supplied for valve 350 mm dia. And above to ensure that the valve can be operated by one man against the differential head for which it is designated.

Valve stems shall be of stainless steel, machined all over and with a machine cut robust trapezoidal or square form thread, operating a gunmetal nut.

Steam seals shall be of the stuffing box and gland from arranged for easy replacement of packing and shall be accessible for maintenance without removal of the valve from service.

All nuts and studs subject to vibration shall be fitted with spring washers or locking tabs.

The Concessionaire shall provide work to avoid unair belt, both during closing and opening.

4.6.6.7 Butterfly valves

Butterfly valves shall comply with IS 13095 and be of double flanged or water pattern with metal or resilient seating and grey cast iron body.

Valve shall be drop tight at closure and be designated for drop tight shut-off of flow. The applicable tests in IS 13095 shall be applied at works to each butterfly valve.

The body end parts shall be circular and the diameter not less than that of the nominal bore of taper pieces.

The disc shall be in gray or ductile cast iron with resilient seating ring in moulded rubber or other material to the approval of the Engineer located in a landing on the disc and secured by a gunmetal retaining ring fixed with screws made from homogeneous corrosion-resistant material.

Shaft-Stainless Steel to IS 6603.

Sealing Ring: Resilient or suitably approved equivalent.

Retaining Ring & Seat: Stainless Steel IS 6603.

The Concessionaire will ensure that the Butterfly valve gearing provides sufficient closure time of the valve, to minimize the development of water hammer pressure. As a minimum provision, the gearing shall provide the time of closure to ensure at least two pressure waves reflections are accommodated within the time of closure. The above provision shall not absolve the Concessionaire in ensuing and providing valves having suitable time to ensure minimization of water hammer pressure.

The valves shall be made by reputed manufacturer and the Concessionaire shall provide documentary proof of the satisfactory performance of the valves not less than 10 years in continuous service.

4.6.6.8 Proof of design test

For acceptance of the make of the Butterfly valves by the Engineer, the Concessionaire shall furnish a certified statement (by recognized institution or laboratory) that proof of design test was carried out as

described in IS 13095 and all requirements were successfully met.

4.6.6.9 Air valves

Air valves shall be of single or the double orifice pattern as specified with gray or ductile cast iron bodies. The inlet flanges shall be faced and drilled in accordance with IS 14845 to the appropriate diameter and the pressure rating of the pipeline concerned.

The valves shall be capable of releasing air from the pipeline without restriction of rate of filling or flow due to back pressure and also to allow admission of air during pipeline emptying at a rate sufficient to prevent excessive depression of pressure in the pipe.

Valves shall be designed to prevent the operating element being in contact with the pipeline liquid by approved means such as the provision of an auxiliary float chamber sufficiently large to isolate the orifice valves and seats throughout the rated operational range.

Air valves shall be fitted with separate isolating sluice valve which shall be drop tight on closure and shall comply with the specification for sluice valves elsewhere herein and gearing shall be provided necessary to facilitate operation.

Air valves shall be of a design which inhibits the entry of insects into the pipeline.

All air relief valves and associated isolating valves shall be works tested and capable of withstanding the test pressures specified above for valves generally.

All materials used in the manufacture of the valves shall conform to IS 14845

Triple clusture air valves shall be of the combined small and large orifice valve pattern. The assembly shall be provided with a 12 mm. tapping for draining purposes and the tapping shall be closed with a brass screw plug.

The design of the valve shall be such that there is no possibility of the ball of the large orifice being suddenly caught up in the escaping air stream during the filling of water main at high rates thereby closing the valve prematurely. The diameters of the balls in each unit of the air valve shall be suitable for operating under the specified rated pressure. The minimum diameter of ball within the small orifice chamber shall be 125 mm for air valves rated at PN-10.

For each triple cluster air valve location on large-diameter pipeline, the pipeline diameter and the physical features as shown on the drawings governing the maximum possible rate of air entry shall be taken into account by the Concessionaire when offering the air valve. The size of the air valve provided for each location shall be such that air valve provided for each location shall be such that air can be admitted at the rate necessary to prevent a vacuum developing when any washout is opened or when a burst occurs at a critical point. The Concessionaire shall provide attested experimental data to confirm the adequacy of the air valves offered. For guidance; the capacity of inflow & outflow of air though Air valve may be about 240 and 470 m3/min. respectively.

4.6.6.10 Pressure-reducing valves

Pressure-reducing valves shall automatically reduce valve inlet pressures, of magnitude of, upto maximum working pressure, to the specified constant pressure at the valve outlet. Valves shall open immediately outlet pressure falls below the specified constant pressure and close drop tight when the outlet pressure rises to the specified constant pressure. Operations shall be controlled by means of water

pressures at tapping located within the valve inlet and out let.

4.6.6.11 Delivery

The materials subject of this Section shall be delivered to the Temporary storage buildings described in Part I. Crates and other containers shall be opened as required by the Engineer as required at the store (and/or elsewhere) at an earlier stage of delivery) to permit inspection of the contents. They shall then be resealed and stacked within the store as the Engineer directs. The Concessionaire shall place additional marks on the containers as the Engineer may direct, so that the contents of each can subsequently be ascertained without further disturbance of the stack.

4.6.6.12 C5.6.12 Tee-keys spindles

The Concessionaire shall supply tee-keys of square form head.
Tee-keys shall be of mild steel and shall have uprights between 1000 and 1200 mm long and cross pieces between 600 and 800 mm long. Spindles shall be of galvanized mild steel, and fixed in secure galvanized steel trunnions secured to chamber walls by adequate galvanized hexagon raw bolts.
Extension spindles shall be provided of sufficient length to enable washout tees on large-diameter pipelines to be operated by a person standing on the roof of the chamber.

4.6.7 Pipeline installation, testing and disinfection

4.6.7.1 Pipe laying

The Concessionaire shall furnish all labour, materials, equipment and incidentals required to install test and disinfect pipelines which shall not be allowed to float under water at any circumstances.

4.6.7.2 General requirements

All pipes shall be laid to lines and grades shown on the Drawings or in conformance with the manufacture's recommendations.

Pipe end covers and other transits protections fixed by the pipe shall be retain in place except for taking over inspections until the pipes are finally inspected shortly before they are laid.

All pipes, fittings and accessories shall be examined, and no piece which is found to be defective shall be installed.

When pipes and fittings etc are strung adjacent to the pipe trench prior to laying they shall be supported clear of the ground on suitable approved support to prevent damage to their external coating.

Excavation bedding backfill shall be done as per specification in Section B 1.4 "Trench Excavation" and backfilling in this section, all to the satisfaction of the Engineer.

The open ends of the installed pipes shall be plugged with a watertight plug, or other approved means, after the Concessionaire has finished the installation on each day/night, or when there is no pipe laying in progress. The plug shall be taken off whenever the Concessionaire is ready for joining pipes. The Engineer reserves the right to order the Concessionaire to remove any pipe length, which has not been plugged as required to clean the inside of the pipe from damage, and prevent dirt, debris and water from entering the pipe. The Concessionaire shall prevent trench water, mud, sand or sewage from entering the pipe during installation.

The type of joint required for each material shall be in accordance with Specification.

All rubber joint rings and gaskets must be stored in a cool damp location in black polythene sacks and

shall not distributed to the trench side until immediately prior to assembly thereof. Rubber gaskets shall be well lubricated prior to fitting.

Care shall be taken during jointing the pipes. All pipe fittings shall be checked for defects and cleaned before joining.

Any field cutting of the pipe shall be done only with the approval of the Engineer. The Concessionaire shall submit to the Engineer for prior approval details of his cutting method, along with types and sizes of pipes to be cut. Any damage to the coating and/ or lining shall be immediately repaired. Where cut pipe has been installed without the above prior approval of the Engineer, and the work is found not to conform to the specifications, the Engineer has the right to order the Concessionaire to remove that pipe length for rectification. All expenses involved shall be borne by the Concessionaire.

Each pipe and fittings shall be laid true to alignment, curve and gradient in accordance with the drawing or as directed by the Engineer. The minimum cover and the minimum gradient shall be as per drawing and specification.

The pipe shall be laid to even gradients and sight rails shall be provide for these purposes at intervals not exceeding 50 metres and at changes of direction and grade.

Pipes and fittings supposed to view at culvert or bridge crossing and in manholes or chambers shall be painted in accordance with specification.

The Concessionaire shall take all preventive measures such that pipes do not float under any circumstances during construction and testing.

4.6.7.3 Installation of pipe and fittings.

I Installation of Ductile Iron (DI) Pipe and Fittings.

All pipes and fittings to be used in this work shall be in accordance with specification.

All pipes shall be carefully inspected for defects before installation. No pipes or fitting which shows defects excluded by the specifications shall be used. Any injury to protective coating of the pipe or fittings shall carefully be repaired before installation.

The Concessionaire shall, after excavation the trench and preparing the bed for the pipes, furnish all necessary facilities for properly lowering and placing the section of the pipe in trench without damage and shall properly install the pipe. The section of the pipe shall be fitted together correctly and shall be laid true line and grade in accordance with the bench mark established by the Concessionaire. The full length of the barrel of the pipe except the socket (bell) or flange which shall not bear on the sub grade.

As far as possible, the pipe shall be lowered into trench using cranes. No pipe shall be rolled into place for lowering into trench except over suitable timber planking free roughness likely to damage any coatings. If the prepared bed is damaged for any reason, the pipe shall be raised and the bed made good before pipe laying is continued.

Whenever the work ceases for any reason, the unfinished end of the pipeline shall be securely closed with a tight fitting plug or cover. The interior of each pipe after being laid shall be thoroughly cleaned.

Any pipe which is not in true alignment both vertical and horizontal, or shows any undue settlement after laying shall be taken up and re- laid correctly by the Concessionaire at his own expenses when so ordered

by the Engineer.

When subsoil water is encountered, it shall be kept below the sockets when joining by pumping or other means. In no case shall pipes and / or fittings be jointed before being lowered into position.

If any damage should occur to any pipes through failure of the Concessionaire to comply with these conditions, the damage shall be made good at the Concessionaire's expenses.

When the pipes are specified to be installed with the polythene sleeves or tape wrap, the Concessionaire shall take necessary care to do it strictly in accordance with the specifications of the manufactures, using the recommended material, tools and equipment and methods.

If in the opinion of the Engineer, the sleeves or wrap fails to provide the protection to the pipe as intended due to improper material, tools or methods used by the Concessionaire, he shall replace the sleeves or tape wrap in the affected area as directed by the Engineer, at his own cost.

i Concrete Protection of pipe

When indicated on the drawings or ordered by the Engineer, pipe shall be encased in concrete in accordance with the details shown on the drawings. Such concrete shall not be placed until the joints at each end of the pipe have been completed. Each pipe to be encased shall be supported on at least two purposes made precast concrete blocks of same grade of encasement concrete which shall be left in place and full width and depth of concrete encasement shall be placed and carefully tamped beneath the pipe followed at once by the addition of the encasing concrete.

ii Push in Joints and Restrained (Self Anchored) Joints

Installation shall be in accordance with the manufacturer's recommendations. Sockets and spigots shall be thoroughly cleaned prior to making the joint. Only lubricant recommended by the manufacturer shall be used and it shall be non- toxic. The completed joint shall have a uniform contract by the gasket between the outer surface of the spigot and the rubber ring seat of the socket.

iii Flanged Joints

Joints shall be made up square with even pressure upon the gasket and shall be properly water tight Gasket shall fit the inside dimension of the pipe accurately so that no surface material projects out into the flow area. The completed joint shall be perfectly aligned. Flanged joints shall be coated including all bolts and nuts with Denso paste and primmer, Denso mastic, Denso Mastic tape and PVC or polythene outer wrapping.

iv Slip-on Coupling and Flange Adapters

Coupling and flange adapters which are as specified in Section 9.1.3 shall be used where shown on the drawings approved by the Engineer. Installation shall be accordance with the manufacturer's recommendations. Gasket seats and gaskets shall thoroughly cleaned before assembly. The completed joint shall have uniform contract by the gasket between the outer surface of the spigot and the gasket seat at the socket. Coupling and flange adapters shall be coated including all bolts and nuts with Denso past and primer, Denso tape and PVC or Polythene outer wrapping.

v Deflection of Pipelines

Minor changes in direction of pipeline both vertically and horizontally shall be made through deflection at the joints. Such deflection shall not exceed the values given below.

Nominal Diameter (mm)	Maximum Allowable Push- on Joint	Deflection (Degree) Mechanical Joint
80 to 200	5.0	5.0
250 to 350	4.0	4.0
400 to 600	3.0	2.5
700 to 900	2.5	2.0
1000 to 1200	2.0	1.5

Joints with deflection shall be installed in accordance with the manufacturer's instruction

vi Cutting of Pipes

Pipe shall be cut using power driven abrasive wheel cutting machine. Acetylene torch and chisel methods will not be permitted in any circumstances. Cut spigot ends shall beveled to the same dimensions as the normal spigot ended pipe. The edges of the cutter shall be given two coats of approved paint and the internal coating shall be repaired if damaged. The Concessionaire shall ensure that the diameter at the point of cutting will match the pipe to which it is to be jointed.

vii Welding

No site welding work on ductile iron pipe an fittings shall be undertaken without the approval of the Engineer. Where approved, welding work shall be undertaken in accordance with the manufacturer's recommendation.

viii Protection of Joints

All buried flange joints, and any un-coated mechanical coupling shall be protected by wrapping with "Denso Paste" , "Densyl Mastic" ,"Densyl Tape" and "PVC Outerwrap" or similar approved materials.

The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly coated with "Denso Paste" over the whole of the joint. A liberal amount of paste should be left around all bolt heads, narrow cavities etc.

"Densyl Mastic" shall then be applied to coverall bolt heads and nuts to from a triangular fillet against flanges and to fill all gaps and abrupt changes in contour to provide an even contour for wrapping.

"Densyl Tape" shall than be applied circumferentially, care being taken to smooth and eliminate any air pockets and to from the tape well into all angles and changes in contour. The tape should be applied with an overlap of at least 25 mm and should extend at least 50 mm on either side of the joint.

Finally, an outer wrapping of "PVC Outer wrap" shall be applied with minimum lap of 25 mm to completely cover the "Densyl Tape"

II Installation of Steel Pipe (SP) and Fittings

All pipes and fittings to be used in this work shall be in accordance with respective IS specification.

All pipes and fittings shall be handled and installed in accordance with the applicable section of the requirements described herein.

At crossings over canals and ditches, the exposed steel pipes and fittings shall be painted with two costs of synthetic asbestos red lead primer and one coat of Aluminum paint. The underground steel pipe shall

be tied around with synthetic asbestos cloth. Steel sleeve pipe shall be painted with two coats of coal tar epoxy.

The end of the pipe shall have wooden stiffness installed inside of the pipe at quarters points and at both end of the pipe. This blocking shall remain inside the pipe until the pipe has been installed.

When field cutting or mitering of the pipe is required the cutting shall be done by the acceptable cutting machine, leaving a smooth cut a right angle to the axis of the pipe or deflection angle. Cut end of the pipe shall be beveled with a special tool made for the purpose, and the beveled end shall be exactly the same as the plain as manufactured at the factory.

Steel pipe with plain ends shall be joined together with a flexible coupling as specified or where shown on the drawings. The Concessionaire shall make excavation of sufficient width and depth to provide the suitable room for jointing the pipes the pipes and fittings. The Bedding at the joint shall be installed and compacted after the jointing has been completed. Where fittings such as bends, tees and blanks are used, all fittings shall be jointed with single butt welded joints unless otherwise shown on the drawings.

Any damages to the exterior coatings and interior coating and interior lining shall be repaired in accordance with the manufacturer's recommendations. If, in the opinion of the Engineer, the damage is not properly repaired by the field methods, the Engineer reserve the right to order the Concessionaire to use the method of repairing that is the same as the manufacturer's procedure. The expense of repairs shall be borne by the Concessionaire.

Welded joints shall be butt weld and in full conformance with specification IS 3589. Welders in charges shall have the qualification stipulated in or approved equal.

The Concessionaire shall submit the qualification of the proposed welders for the steel pipe jointing for the approval of the Engineer. The Engineer may request the Concessionaire to conduct the testing the examination of the capability of the welders. The Concessionaire shall when requested by the Engineer make the necessary arrangements for such testing for joint welding at his own cost.

After all field welded joints have nee made, and inspected and approved by the Engineer the joints shall receive the protective coating and lining as specified below.

i Epoxy Painting (Above ground Exposed Pipe)

All field welded joints in the above ground exposed pipeline shall be field coated with at least two (2) coats of epoxy resin paint. The first and second coats shall be of minimum coating thickness not less than 40 and 30 microns, respectively. The colour of epoxy paint shall be determined by the Engineer from the sample submitted by the Concessionaire. The method of filed painting shall confirm to the paint manufacturer's instruction and recommendations.

Unless otherwise permitted by the Engineer, shop coating and filed painting materials shall be from the same manufacturers

ii Cement Mortar Lining

All field welded joints shall receive field applied cement mortar lining in accordance with IS 3589. The lining system shall be equivalent to the shop applied lining and shall be applied across the inside of the joints.

Bolts and nuts for mechanical joints, flanged joints and blank flanges shall be given a coat of bituminous paint after the jointing has been completed.

III Installation of Unplasticized Polyvinyl Chloride (uPVC) Pipe and Fittings.

Careful consideration must be given to the handling and storage of polyvinyl chloride pipe and fittings. The pipe must be stored out of any direct sunlight. Extreme care must be made to prevent any scarring or nicking of the pipe from bearing on sharp objects. Any pipe which has any cut or bruise deeper than 10% of the wall thickness will be rejected and shall not be used in the work. The section of pipe with such a cut shall be reject in its entirety. The pipe shall be stored in such a manner that no direct sunlight is on the pipe but ventilation is provided. Covering the pipe with a tarpaulin shall not be allowed Stacking shall not exceed 600mm in height.

In normal ground, pipe shall be bedded as specified is drawing. The same material shall be placed alongside the pipe and compacted in 200 mm layers upto the crown of the pipe. Same material shall be placed over the pipe and compacted tin two layers, upto a depth of 300 mm

In other types of ground, additional bedding types shall be used, as shown in relevant typical drawings.

Where uPVC pipes passed under or at the side of culverts they shall be protected by Sleeve pipes as shown on the drawings.

The joints shall be of the push-in type. The socket and spigot of the pipe shall be carefully cleaned before the rubber ring is set in place. The spigot shall then be covered with an approved lubricant and the pipe pushed into the socket. Pushing the pipe into the socket shall be done by barring against the opposite end of the pipe being installed. A wooden block or other suitable device shall be used to prevent any damage to the socket against which the bar is being pressed. No blocking will be allowed under the pipe and it shall bear evenly along its entire length on the bedding material.

Cutting of the pipe shall be kept to a minimum. When cuts are necessary they shall be perpendicular to the axis of the pipe and smooth. Cuts shall be made with tools in conformance with the pipe manufacturer's recommendations. Cut ends shall then be tapered and believed with a special tool made for that purpose and the believed end shall be exactly the same as the spigot end of the pipe as manufactured at the factory.

Solvent weld joints for pipes of diameters upto 90 mm shall be made in strict accordance with the manufacturer's recommendations and utilize only solvents furnished by the manufacturer. In addition it will be necessary to snake the pipe so that on offset from true horizontal alignment of 30 centimeters in 30 meters of laying length will be provided. Care shall be taken to insure that the temperatures of both sections of pipe being jointed are the same.

For the uPVC fittings when forming the thrust block and anchor blocks a polythene film or equally suitable material membrane to the satisfaction of the Engineer of minimum thickness 2 mm shall be provided to separate the fitting from the concrete of the trust or anchor block.

The warning tape shall be of polythene, and should have performance details applicable to the 100 micron material of "Boddingtons underground warning tapes", or equivalent.

- Minimum ultimate tensile strength at break (longitudinal and transverse) shall be 10MN/m2
- Minimum Elongation shall be 300% (Longitudinal) and 350% (Transverse)
- Shall be resistant to chemical attack from the ground conditions with pH ranging from 3.0 to 9.0

The width of the tape shall be 100mm. tape shall be blue colour, with the words printed KWSP on upper side of the tape in block letters, printed in two rows, at an intervals of 1 m.

IV Installation of Galvanized Steel (GS) Pipe and Fittings

Only pipes, fittings and accessories which are in accordance with the requirement is IS specification shall be used in this work. Installation of pipes, fittings and accessories shall be in conformance with the manufacturer's recommendations, or as directed by the Engineer. Gibault or flange joints may be used if necessary.

All threads for screw joints shall be clean, machine cut, and all pipe shall be reamed before erection. Each length of pipes as erected shall be up-ended and rapped to dislodge dirt and scale.

Screwed joints shall be made up with good quality thread compound and applied to the male thread only. After having been set up, a joint must not be backed off unless the joint is completely broken, the threads cleaned, and new compound applied.

No close right- and left-hand nipples shall be used. All nipples shall be of such that the correct size of pipe wrench can be used on them when in place.

At crossing over canals or ditches, the pipe shall be laid in accordance with the details and/or construction method specified on the drawings or as directed by the Engineer.

Pipe laid under ditches, shall be in accordance with the details shown on the drawings or as directed by the Engineer. Pipe bedding shall be compacted for the entire length of the pipe good alignment shall be preserved and fittings may be used where necessary.

V Installation of PE pipes and fittings

Flanged fittings shall not be used unless directed by the engineer. Joints between polyethylene pipe and metal flanges, such as at valves, shall be by means of metal–PE flange adaptors, specifically designed for this purpose.

Thermo fusion welding: Butt fusion welding. Shall be done using approved proprietary equipment and shall on no account be made by hand. Joints shall be made in accordance with manufacturer's instructions, but shall in any case include the following steps:

1) Surface Preparation: The mating surfaces of the components to be jointed shall be square and free from imperfections. Pipes for cutting shall be cut using appropriate pipe-cutters designed for the purpose. On no account shall pipes be cut by hand using improvised methods, e.g. knife, hacksaw etc.

2) Heating the surfaces: The surface of the heated plate shall be clean and maintained at 210 °C, or as otherwise stipulated by the pipe manufacturer. The mating surfaces shall be pressed constantly against the plate until a small bead of molten material is formed. Thereafter the pressure shall be reduced to ensure that the bead does not continue to grow whilst heating is continued.

3)Welding: The hot plate shall be removed and the heated faces brought together under pressure. Pressure shall be maintained until the joint area has cooled sufficiently. The ridge produced inside and outside the pipe, shall have a height not exceeding a quarter of the wall thickness.

Bending:

Pipe shall not be heated and stressed to form curves or bends. Gradual curves may be introduced into the pipe at ambient temperatures to form direction changes. The inside radius of the bend shall be not less than 20 times the outside diameter of the pipe.

Storage:

Pipes shall be stored on flat, clean surfaces free of sharp objects or any other item that may mark or damage the pipe in any way. Pipes shall not be stored on or against hot surfaces. Blue and Black polyethylene pipe shall be stored under cover and out of direct sunlight.

Coils may be stored either on edge or stacked flat one on top of the other.

Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

Installation of buried pipes

When laying pipes in hot weather, the trench shall be partially backfilled before making the final connections and locating anchor blocks.

Moling

Only coiled pipe shall be installed by moling. Moling methods may include pulling pipe through holes pre-drilled by mole-bore, and mole-ploughing using a proprietary ploughing machine.

The Concessionaire shall ascertain that ground conditions are suitable for moling before commencing any such work. The Concessionaire shall ensure that he has complete knowledge of any services that may lie along, or in the immediate vicinity of the pipeline route, and has taken appropriate mitigation in accordance with the Specification, before he commences.

The diameter of the mole should be 1½ to 2 times the outside diameter of the pipe being laid.

The following procedures shall apply when installing pipe:

1) Any trenches/pits required for launching and receiving moles, pulling pipe, and making joints, shall be made in advance of the works and clearly identified. The pits should be planned at intervals slightly shorter than the length of the coils to be used. Starting and intermediate pits shall be at least 1.5 m long and 0.3 m wide and to the depth it is intended to plough.

2) Pipes shall be uncoiled and laid on the ground in the direction of pulling (or in a wide circle) near the hole at which they will be needed. The ends of the pipe shall be covered or bunged in order to keep soil from entering the bore.

3) Pulled pipes shall be laid individually between pits and pulled by tractor or winch through to the next pit. Only continuous lengths shall be pulled, pulling of coupled pipes shall not be permitted. In hard soils the friction may be reduced by pouring a little water into the hole made by the plough.

4) The Concessionaire shall make adequate allowance for expansion of the pipe due to pulling or laying by plough. Pipes shall be left overnight following laying and before making joints, to allow for contraction of the pipe.

Above ground installations

Pipe fitted above ground shall be black pipe supplied in straight lengths, unless otherwise agreed by the Engineer. Where pipe is cut from a coil, fixing shall be arranged so that the curvature of the pipe is corrected by contact with the surface to which it is being fixed. Pipe shall not be straightened by applying tension.

Pipe clips shall be plastic and shall be correctly aligned to provide a flat smooth surface for contact with

the pipe. No sharp edges shall be present on supports. Valves and other such items shall be properly supported.

Pipes shall not be placed adjacent to hot surfaces.

Support spacings

Pipe shall be continously supported or on fixings such as pipe clips, brackets, etc., which shall be used at approximately the following spacings. Values are for use in temperatures up to 20 °C. Spacings shall be reduced by 25% between 20-30°C. Pipes shall be continuously supported where temperatures are above 40°C.

Nominal Size	Spacing (m)	Nominal size	Spacing(m)
16	0.45	50	0.7
20	0.6	63	0.85
25	0.6	90	0.85
32	0.6	110	0.9
40	0.7	140	1.1
		160	1.3

Support distances may be doubled for vertical pipes.

Expansion and contraction

Adequate means shall be provided to account for expansion and contraction. This shall be by means of bends/changes of direction at appropriate intervals or purpose designed bellows, sliding gland expansion joints or expansion loops.

4.6.7.4 Thrust and anchor blocks

a. Concrete thrust and anchor blocks shall be formed at bends, tees and valves in accordance with the typical sections shown on the drawings or otherwise as directed by the Engineer. The additional excavation shall be made after the bends etc. have been jointed and the concrete shall then be placed with all possible speed. The back of supports and blocks shall abut on to solid ground, all loose material being removed before concreting.
b. The concrete used for thrust and anchor blocks shall be Grade 15, After placing the concrete shall be kept in view for not less than six hours. No pressure shall be applied in any section of main until the concrete has had at least three day's curing.
c. At uPVC fittings a polythene film or equally suitable material membrane to the satisfaction of the Engineer shall be provided to separate the fittings from the concrete of thrust of anchor blocks.

4.6.7.5 Exposed piping

The Concessionaire shall furnish and install sleeve or wall casting for all pipes passing through masonry and concrete floors or walls and concrete inserts for hangers and supports as soon as forms are erected and before concrete is poured. Before setting these items, the Concessionaire shall check all and figures which have a direct bearing pipe location and he shall be responsible for the proper location of his pipes during the construction of the structures.

Piping shall be installed to the required lines and grades and as closely as possible to walls, ceilings, columns and other structural parts so as to occupy the minimum of space, and all offsets and fittings required to accomplish this must be furnished. All dimensioned pipes and fittings shall be installed that no stress or strain is created in the lines and associated equipment due to forcing parts into position.

Changes in direction shall be made using proper fittings. Piping shall run parallel and at right angles to walls, unless noted otherwise.

Temporary bracing and supports shall be provided to adequately support the pipe during its installation and care shall be taken placing piping to prevent damage to the pipelining or pipe coating or to adjacent structures or equipment. All supporting piers and blocking shall be in place before temporary supports and bracing are removed.

Flange piping shall have a sufficient number of couplers and adapters to allow convenient removal of piping.

The Concessionaire shall furnish and place all inserts for the support of piping installed under this section in masonry and in concrete forms before concrete is placed, unless otherwise permitted.

System shall be arranged with low points and drains to arranged with unions or union connections at low points to permit draining. Fill connections shall also be provided on closed systems where required.

Adequate air vents shall be provided at high points in all liquid carrying pipes. All exposed piping shall be rigidly supported by pipe hangers and supports specified hereinafter.

All pipes shall be sound and clean before installation.

In case interference develops between piping and appurtenances, the Engineer will decide which work is too relocated regardless of which was first installed.

Upon completion of installation and testing, the Concessionaire shall paint all exposed piping.

Where the pipe passes through wall sleeves, the sleeves shall be caulked with sealing compounds recommended by the pipe manufacturer and approved by the Engineer. Sealing compounds shall be applied in accordance with the manufacturer’s instructions.

4.6.8 Installation of valves, fire hydrates & markers

4.6.8.1 General

Scope of work

The Concessionaire shall supply all labour, equipment and material required to install valves, fire hydrants and market posts, and construct valve chamber and surface boxes, as shown on the drawings and as specified herein. This work includes surface breaking excavation and backfill; sheeting and bracing, on site forming; supply and installation of pipes, fittings, valves, fire hydrants and appurtenances; supply and installation of miscellaneous metal work, surface restoration and other work needed to complete the valve boxes.

Most of the components of work for above works are specified in other parts of this Specification. This section consolidates a description of the work required for above works in particular. The Concessionaire

shall consult other parts for further details.

Submittals

The Concessionaire shall prepare and submit a shop drawing for each installation. The shop drawings shall be based on the schematic arrangement shown on the drawings and include the dimensions of piping, appurtenance and other equipment to be installed and shall extend to the limits of the installation shown on the drawings or to the limit of special pipe construction. All supports, clearances and materials to be installed shall be shown.

4.6.8.2 Materials

Cement aggregate, water, admixture, reinforcing steel, concrete, form work, shall be in accordance with provision of "Concrete", and the valves, fire hydrants, man holes, surface boxes and appurtenances shall be in accordance with the specifications.

4.6.8.3 Location of installation

1) Fire Hydrants

The location of the fire hydrants shall be either under the pedestrian walkway or under the shoulder of the road, but shall not be under the carriageway. The location shall be approved by the Engineer before installation.

2) Valves

The location of the valves shall be a sufficient distance away from the road junctions that the installation is not adversely affected by future road widening or surfacing by the road maintenance authorities. The Concessionaire shall obtain the approval of the Engineer before installation.

4.6.8.4 Execution

1) Underground Utilities Interference

When underground utilities are shown on the drawings or anticipated to exist near the proposed location of the installation, the Concessionaire shall excavate test pits to make sure that the existing underground utilities will not interfere with the construction of the structure. On the other hand, if underground utilities are found to be actually existing, proper precautions shall be instituted so as not to disrupt service to the general public.

2) Manhole Frame and Cover

Manhole frame shall be set with the top conforming to the grade of the pavement or finished ground surface, or as indicated on the drawings, or as directed by the Engineer. Frames shall be set in full bed of mortar.

3) Valve Box

Valve Boxes shall be constructed with the top of the cover lower 0.2m from the grade of the payment or the manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface, or as indicated on the drawings, or as directed by the Engineer. The manhole frame and cover shall be raised with its top conforming to the grade of the pavement or finished ground surface.

4.6.8.5 Installation of marker posts

Marker posts shall be installed at the locations of all valves and meters of the distribution pipe lines and transmission mains and at the location of fire hydrants. The type location and diameter of the main shall indicate as specified in the relevant drawing, for the specified size of valves and pipe lines. Concessionaire

shall obtain the approval of the Engineer regarding the location of marker posts, and also obtain the permission from the relevant authorities for the installation of the marker posts.

4.6.9 Testing and disinfection

4.6.9.1 General

1) Scope of Work

The Concessionaire shall furnish all labour equipment, material and metering device required for the pressure and leakage testing and the disinfection of the finished pipelines. The finished pipeline includes the pipes, fittings, valves, fire hydrants and all other appurtenances that are constructed under this Contract. The Concessionaire shall provide the facilities necessary to convey the water from its sources, as designated by the Engineer, to the place where it is required, and shall install the metering device.

All testing and disinfecting operations shall be done in the presence of the Engineer.

Late delivery of valves will not be allowed to delay testing and commissioning of a pipeline. In such cases the Concessionaire shall supply and install spool or make up pieces so that testing may proceed. The Concessionaire shall install valves later in a manner acceptable to the Engineer.

2) Submittals

The Concessionaire shall submit, as part of his shop drawings, a sketch for each section of pipe to be tested. The sketch shall show the section schematically in profile and shall contain a sequence of operation to be followed during the test such as observations and closing of air-valves, blow-off and other appurtenances; shall show point of filling, point of pressure observation and test pressure.

4.6.9.2 Field hydrostatic pressure test

Hydrostatic pressure test procedure for the pipeline shall not be less than 1.5 times of the maximum working pressure or site test pressure as specified in the Particular Specification.

For all pipe sizes, the working pressure shall be of water column based on the elevation of the lowest point in the pipeline under test, and corrected to the elevation of the test gauge.

All tests shall be conducted on the pipelines in the sections after the trench is backfilled, but before pavement restoration. Joints shall be exposed during the test wherever possible.

Before a length of pipeline tested, each pipeline securely anchored, all thrust and anchor block shall have been constructed.

Maximum length of pressure testing shall be 1 km.

All pipeline shall be thoroughly flushed out with water prior to testing.

The pipeline shall be prepared for testing by closing all valves and hydrants; placing substantial stops and bulkheads at openings, opening air valve assemblies and fitting air release taps at all other high points along the pipeline. Theses taps shall later be removed after completion of the testing and disinfection and, unless otherwise specified, replaced with permanent plugs.

The pipeline shall be slowly filled with water, allowing all air pockets to be released, until the pipe is completely filled and under working pressure at which condition it should be allowed to stand for 24 hours. Any apparent defects in the pipeline at this stage at this stage shall be rectified by the Concessionaire. To demonstrate that air has been removed the Concessionaire add a measured amount of water at filling point and measure outflow at remote points of pipe being tested. If remote points of pipeline

do not contain convenient points to measure outflow the Concessionaire shall install taps.

The hydrostatic pressure shall be raised to the pressure. The duration of the pressure test shall be for a period of two (2) HOURS. Any defective pipe, fittings, joint, valve or hydrant shall be removed and replaced and the test shall be repeated until satisfactory to the Engineer.

4.6.9.3 Field leakage test

The leakage test shall be conducted after the pressure test has been satisfactorily completed. The duration of each leakage test shall be two (2) hours, and during the test the pipeline shall be subjected to the same test pressure stated in the proceeding paragraph. The pipeline leakage shall be taken as the amount of water, as measured by the metering device.

Needed to be injected into the maintain the test pressure for the two (2) hours leakage test period.

The allowable pipeline leakage shall be less than 2.3 litres per 24 hours per mm-pipe diameter per km-length as presented by the formula below.

$$\frac{Q}{D \times L \times H} \times 24 < 2.3$$

Where:

Q : Amount of Leakage in litres

D : Diameter of pipe in millimeters

L : Length of pipeline in kilometers

H : Duration of leakage test in hours

Should any test of pipe laid disclose a leakage greater than the specified above, the Concessionaire shall locate and repair or replace the defective materials or the satisfaction of the Engineer. The test shall be repeated until any leakage falls within the permitted allowance.

4.6.9.4 Disinfection

1) Swabbing

After the pipelines have been completed and pressure tested satisfactorily in accordance with the relevant Clause then the Concessionaire shall on the instructions of the Engineer prove any length of pipeline to be free from obstruction.

Proving shall be carried out by means of passing through the pipelines a polyurethane foam swab of approved grade in accordance with the following procedure.

Pipelines shall be proved in sections between entry and exit points. The location of the permanent swabbing points is indicated on the Drawings. Temporary swabbing points shall be provided in the distribution system by insertion of tees and valves which shall be removed after proving and replaced by short lengths of straight pipe.

At the start of the isolating valves on either side of the entry point the swab will be free to travel along the pipeline towards the downstream exit point.

The theoretical loss of head between the entry point and either end of the section will previously have been determined by the Engineer for a flow of water which will cause the swab to travel through the section at a suitable predetermined velocity. This flow and the corresponding required velocity of the swab will be controlled by throttling of valves at the exit point or at hydrants or washout.

Washout or hydrants downstream of swabs shall be controlled so that any rubbish, slit, debris or other extraneous matter may be discharged during the passage of the swab along the pipeline.

Proving of any section shall be repeated as required by the Engineer in the event of the initial or any subsequent operation not being to his satisfaction.

The Concessionaire shall provide all transport and labour required to prove a pipeline free from obstruction.

Diameters 300 mm and greater:

Visible dirt and debris should have been removed either manually or by the use of cleaning pigs before testing.

After the pipelines have been completed and pressure tested satisfactorily as herein specified the Concessionaire shall flush out and cleanse the pipelines

Pipeline shall be cleaned in sections and this shall be carried out by passing polyurethane foam swabs through the pipeline. The swabs shall be to the approval of the Engineer. Water for passing swabs will be made available by the Employer.

Diameter less than 300mm:

Pipelines shall be cleansed in sections by flushing with portable water, provide by the Employer, for a period of time shall be decided by the Engineer's representative.

Cleansing of any section shall be repeated as required by the Engineer's representative in the event of the initial or subsequent operation not being to his satisfaction.

The Concessionaire shall supply all necessary equipment for the cleansing and sterilizing operations, including sufficient swab and swab detectors.

Swabs shall be passed through pipelines at speed of between 0.2 and 0.4 meters per second to obtain the best cleaning result with the minimum number of passes. Should it be appear from the debris collected by the swab that damage to the lining has occurred, the Concessionaire shall be wholly responsible for repairing the lining the satisfaction of the Engineer's Representative.

The cost of the initial sampling analyses and preparing reports on the bacteriological quality of water be borne by the Employer but, in the case of the initial reports be unsatisfactory the cost of any subsequent sampling analyses and preparing reports shall be borne by the Concessionaire.

2) Disinfection

Before being placed into service, or before certification of completion by the Engineer whichever occurs earlier all new pipelines which will convey the filtered water shall be disinfected with chlorine, and a satisfactory bacteriological analysis of the water shall be submitted to the Engineer.

The amount and concentration of chlorine solution applied shall be such as to provide a dosage of not less than 50 mg per litre, introduced into the lines as directed by the Engineer. After a contact period of 24 hours, the chlorine residual at the end of pipeline shall not be less than 25 mg per litre. The system shall

then be flushed with clean water until the residual chlorine is not greater than 0.75 mg per litre but not less than 0.25 mg per litre.

The point of application of the chlorination agent is normally at the beginning of the pipeline through a corporation stop insertion on the top of the laid pipe, and the point of withdrawal (normally by blow-off) is at the opposite end of the line.

Should the initial treatment fail to result in the conditions stipulated above, the chlorination procedure shall be repeated until satisfactory results are obtained.

The Concessionaire shall dispose of the water used in the pipeline testing and disinfecting operations without causing damage to adjacent property.

4.7 Building Work

4.7.1 Finishes in general

If in the opinion of the Engineer, the Concessionaire consistently fails to achieve the required standard of finish for any of the works detailed in this section, the Engineer may order the Concessionaire to employ a specialist firm of sub-Concessionaires approved by the Engineer to carry out all or part of this work at no extra cost to the Employer.

4.7.2 Cement/lime mortar

Mortar for brickwork, brickwork and stonework shall be prepared in accordance with I.S. 2250. Cement mortar shall consist of Portland cement and sand, in proportions specified elsewhere. Lime mortar for laying of tiles shall consist of one part of cement, 2 parts of lime and 6 parts of sand.

Mortar shall be mixed on clean, hard, dry platforms protected from sun and rain. The constituents shall be measured using properly made gauge boxes and shall be thoroughly mixed dry before water is added. Any mortar not used 30 minutes after the water is added shall be discarded.

For lime mortar, lime from burnt stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to Site. Lime which is damaged due to rain, soaking, moisture or air slaking shall not be used. Portland cement for mortar shall comply with I.S. 269.

Sand for mortar shall comply with I.S. 2116 and shall be of the following grading:

I.S. Sieve	**Percentage passing by weight**
4.75 mm	98 - 100
2.36 mm	80 - 100
1.18 mm	60 - 80
600 microns	40 - 65
300 microns	10 - 40
150 microns	0 - 10

Sand for mortar shall be from an approved source and shall consist of hard, coarse siliceous grains free

from deleterious matter. It shall be stored separately from other sand or fine aggregate and shall be kept covered. The Concessionaire shall submit samples of sand for mortar for the Engineer's approval if ordered.Water for mortar shall comply with the specification for water for concrete.

4.7.3 Bricks

Bricks for common brickwork shall be whole, sound, well burnt clay bricks free from cracks and shall comply with the requirements of I.S. 1077. Samples of bricks to be supplied shall be submitted to the Engineer for his approval. Clay engineering bricks shall comply with the requirements of I.S. 2180.

Bricks shall not be tipped on the Site but shall be carefully stacked by hand in separate stacks. Broken or damaged bricks shall not be used in brickwork.

Crushing Strength = 50 kg/cm2

Water Absorption = not >25% for partition walls

Size = Tolerance Allowed = 3.3% positively

4.7.3.1 Brickwork

Brickwork shall be built in accordance with the requirements of I.S. 2212. Every brick shall be wetted and laid on a full and close joint of mortar on its bed, side and end in one operation, joints being, fully flushed up as the work proceeds. No previous course shall be wetted if it has dried and the walls shall be brought up evenly with no portion racked up (and not toothed) more than one metre higher than another. All brickwork shall be properly bonded together. Joints shall not exceed 10 mm in thickness and shall be raked out to a depth of 7.5 mm as a key for rendering or plastering. All courses shall be truly horizontal and all perpends shall be strictly plumb and square.

In the cavity walls the two leaves of brickwork shall be bonded with galvanised wall ties 150 mm to 250 mm long as required. The ties shall be built into the horizontal joints as the work proceeds and the space between successive ties shall not exceed 750 mm horizontally nor 250 mm vertically. Ties shall be staggered and shall be laid sloping down towards the outer leaf of the cavity. Cavities shall be kept free from mortar droppings by the use of suspended battens and temporary openings at the bottom of the wall. Every fourth vertical joint in the external face in the course immediately above the horizontal damp proof courses shall be raked out and left open to form a weephole. Completed brickwork shall be kept wet for a minimum period of 14 days.

4.7.4 Concrete blocks

Concrete blocks whether made on or off Site shall be manufactured to the shapes, sizes and finishes as specified or directed by the Engineer and shall comply with the requirements of IS: 2185. The Concessionaire shall submit full details of his proposed manufacturing arrangements to the Engineer for his approval before making any blocks for use in the Works and shall submit such samples as may be needed to demonstrate the quality of the finished product. Production of blocks shall be of equal standard to the approved sample blocks.

Concrete for blocks shall be made such that the combined aggregate shall have a fineness modulus lying between 3.6 and 4 and shall conform with the following grading

I.S. Sieve	Percentage passing By weight

12.5 mm	100
10 mm	> 85
4.75 mm	> 60
300 microns	> 10

Concrete for blocks shall be minimum Class M-20. Hand mixing shall not be permitted. When ordered by the Engineer, sample block from any batch shall be tested as specified in I.S. 2185.

Finished blocks shall be neatly stacked for storage on firm dry support and shall be covered to protect them from dirt, sun and rain. Damaged blocks shall not be used in the Works.

4.7.4.1 Blockwork

Concrete blockwork shall be laid generally as specified for brickwork above except where specified otherwise or as directed by the Engineer. The construction of hollow block masonry shall be generally in accordance with I.S. 2572. Blockwork for partition walls shall be laid in stretcher bond. Fair face blockwork which is not to be plastered shall be neatly pointed as specified.

4.7.5 Pointing

Unless other type of pointings is specified in the item or the special provisions, pointing shall be of the grooved type. The joints in the masonry shall be raked out to a depth not less than the width of the joint when the mortar is green. The joints are to be brushed clean of dust and loose particles with stiff brush. The area shall be washed and the joints thoroughly wetted before pointing is commenced. The raked-out joints shall be filled with mortar of the specified mix and required consistency and well pressed and rubbed smooth.

A semicircular depression 3mm dia shall be made in the joint by pressing a clean string with trowel keeping the string exactly horizontal and on the centre line of the joint.

The vertical joints shall be similarly marked. These depressed lines will then be immediately rubbed till they become uniformly 6mm deep, 6mm wide and assume fairly blackish colour.

Where joints are not horizontal and vertical as the case of uncoursed rubble masonry, the pointing shall be made along the centre line of actual joints and the junctions of pointing made neatly.

The pointing mortar shall not be spread over the adjoining stones. Mortar pointing shall be restricted to the width of the joints, and all superfluous mortar shall be removed with a trowel.

4.7.5.1 Watering

The pointed face shall be kept continuously wet for 14 days after initial set. Should the mortar perish or deteriorate through neglect of watering or any other default and if the work is not done neatly as specified above, the pointing shall be removed and redone, at the expense of the Concessionaire.

4.7.6 Uncoursed stone masonry

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice its height. Every stone whether large or small, shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints

at least every 80 mm and long vertical joints of joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where batter has to be given it shall be uniform. The stones at all comers and junctions of walls shall be of large sizes and hammer dressed to the correct angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose) until it has set. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall be allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously. The stones shall overlap and cross each other as much as possible. No course shall be laid unless the previous course is perfectly set.

At least one header or through stone per square metre of wall face shall be built into the work. The headers or through stones shall be at least 0.05 m2 in area at face and shall have at least 0.025 m2 area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form a tie from front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a header.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Engineer to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre-cast plain concrete headers in M-20 mix may be permitted at the discretion of the Engineer. No extra payment will be made for the provision of substitute headers in concrete

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall be laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.
Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one per square metre as specified or directed. They shall be pointed with 1:2 cement sand mortar after raking the joints to a minimum depth of 25 mm.

Completed masonry shall be kept wet for a minimum period of 14 days. In wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

4.7.6.1 Pointing of uncoursed masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Engineer. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

4.7.7 Stone pitching

Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be at east equal to the specified

thickness of the pitching.

After excavation and trimming, slopes to be pitched shall be spread with a 75 mm thick layer of crusher run rock or graded coarse aggregate ranging from 75 mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50 mm dia weep-holes shall be provided at intervals not exceeding two metres in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

4.7.8 Rubble packing

Rubble used for packing under floors, foundations, etc. shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Engineer.

Rubble shall be laid closely in position on the sub-grade. All interstices between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of interstices. Such filling shall be carried out simultaneously with the packing in position of rubble stones and shall not lag behind. Small interstices shall be filled with hard clean sand and well-watered and rammed.

4.7.9 Flooring

4.7.9.1 Floor screeds

Where required or specified, dense concrete floor screeds shall be placed over the structural concrete floor. Before the structural concrete is fully hardened, the surface shall be roughened by wire brushing in order to expose the aggregate. Immediately before laying the screed, the concrete shall be cleaned with stiff brushes and then thoroughly dampened. Before the screed is laid and after the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface.

Where directed by the Engineer an approved water proofing admixture shall be added to screed concrete in accordance with the manufacturer's recommendations.

Heavy duty screeds shall be in M20 concrete. The coarse aggregate shall be well graded to a maximum size of 12 mm. Light duty screeds shall consist of 1 part Portland cement by weight to 4 parts sand. Water content shall be kept to the minimum consistent with providing adequate compaction. Unless otherwise specified, screeding shall be finished to a U2 quality.

Screeds shall be laid to the falls shown in the specification drawings subject to a minimum fall of 1 in 120. The minimum thickness of screed shall be 60 mm for heavy duty and 40 mm for light duty. Screeds shall be cured in accordance with the Specification for concrete.

4.7.9.2 Indian patent stone flooring

The Indian Patent Stone Flooring shall be 50 mm in thickness and shall consist of cement concrete mixed in the proportion of 1:2:3 (with 12.5 mm chips only) with an admixture of approved water-proofing compound. The water cement ratio of approximately 0.5 should be used.

Neat cement slurry shall be applied to the surface and the flooring laid, in bays of suitable sizes but not exceeding 6 sq.m. each, to the required slope in a chess board panel fashion and neatly finished smooth in red colour where directed with lines drawn as directed. The concrete shall be cast against teakwood stop-off boards, which shall be removed only after the concrete is set.

No dry cement shall be allowed to be used for finishing the surface. Mechanical mixing may be resorted to. The surface shall be kept well-watered after it is dry, for period of 8 days.

Construction joints shall be formed in between the sequential panels cast, with straight edges, 20 mm deep and 12 mm wide in groove form. These joints on completion of work, shall be cleaned and washed free of dust with the help of brush and shall be treated with hot bitumen poured in the gap, over which fine sand shall be spread to arrest the flow of bitumen.

4.7.9.3 Shahabad/Tandur/Kota/Kadappa stone flooring

Stones, shall be of approved quality, hard, sound, durable and of uniform thickness. Edges shall be chisel dressed and the top surface shall be machine polished with joints running true and parallel from, side to side. Stones shall be laid on a bed of lime mortar of proportion 1:2 or cement mortar of proportion 1:4. Thickness of mortar bedding shall not be less than 12 mm and not more than 25 mm. Before laying, the stone slabs shall be thoroughly wetted with clean water. Thick cement slurry shall be spread over the mortar bed over as much area as cou1d be covered with the stone slabs within half an hour. The slabs shall then be laid and gently tapped with mallet till they are firmly and properly bedded. There shall be no hollows left. The joints shall not be more than 2 mm wide and shall be struck smooth. The floor shall be kept covered with damp sand or water for a week. Slabs shall be of standard sizes and shapes and shall meet all the required properties and test requirements as stipulated in I.S. 1124.

Stones in skirting shall be laid against a bedding of cement mortar l:4 20 mm thick to the full height of skirting, to a true plane, level and plumb. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal grooves at the top of skirting shall be provided if required. The skirting surfaces shall be repolished with hand to the satisfaction of the Engineer. The skirting shall be cure for 7 days. Top of exposed skirting shall be machine cut and polished. Tile used at projecting corners shall be suitably levelled to present a neat corner.

4.7.9.4 Marble mosaic flooring

The type, quality, size, thickness, colour etc. of the tiles for flooring and skirting work shall be of best quality from samples approved by the Engineer.

Before the tiling work is commenced, the sub-surface shall be thoroughly cleaned and washed of all loose materials, dirt, and scum or laitance and then well wetted without forming water pools on the surface.

The tiles shall be laid on lime concrete mortar bedding of 30 mm thick. The proportion of mortar shall be one part of cement, 2 parts of lime and 6 parts of sand. The mortar shall be evenly spread on the sub-floor. Over this mortar bed, 5 kg. of cement per sq.m. of floor area shall be spread. The tiles shall be fixed on this bed one after another, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be perfectly straight and uniform in thickness. The tiles shall be laid perfectly in level unless otherwise specified or required or desired by the Engineer. After laying the tiles the joints shall be finished with white cement or cement of approved colour.

For lime mortar, lime from burnt stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to site. Lime which is damaged due to rain, soaking, moisture or air slaking will be rejected.

Floor tiles laid adjoining the wall shall project 12 mm under the plaster, skirting or dado as may be required by the Engineer. Half tiles and pieces shall be avoided, as far as possible. After laying, the flooring shall be allowed to cure undisturbed or seven days. Design traffic shall not be allowed on the floor for at least

14 days after laying the tiles.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound if it does such tiles along with any other cracked or broken tiles shall be removed and replaced with a new tile to proper line and level. The same procedure shall be followed again after the tiles are finally polished. For the purpose of, ensuring that such replaced tiles match with those earlier laid, it is necessary that the Concessionaire order enough extra tiles from the factory to meet this contingency. The tiles shall finally be cleaned and polished by using dilute oxalic acid or any other method recommended by the manufacturer and approved by the Engineer.

4.7.9.5 Glazed tile flooring and dado

Glazed tiles including ang1es, corners, borders and specials shall be of an approved make and quality, Johnson or equivalent.

Before laying the tiles shall be soaked in water for at least 2 hours and shall be set in lime concrete mortar of one part of cement, two parts of lime and six parts of sand or cement mortar 1:4 for floors and cement mortar 1:4 for dado to walls. Tiles which are fixed in the floor adjoining the wall shall be so arranged that the surface of the round edge tiles shall correspond to the skirting or dado. Neat cement grout of honey like consistency shall be spread over the bedding mortar just to cover so much area as can be tiled within half an hour. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight lines. The joints between the tiles shall not exceed 1.5 mm in width.

4.7.9.6 Acid and/Oor alkali resistant tile flooring and dado

The acid and / or alkali resistant tiles shall have true and straight edges, shall be non-absorbing, without stains, non-fading, shall conform to IS: 4457 and approved manufacturers.

The Concessionaire shall submit for the Engineer's approval the characteristics of the tiles and shall enclose the manufacturer's litreature for the same confirming their serviceability for both acids and alkalis. The Concessionaire shall submit samples of tiles for approval to the Engineer and the bulk supply will only be accepted if it conforms in all respects to the approved samples kept with the Engineer.

The surface over which tiles are to be laid shall be plain and plumb and without uneven depressions. It shall be chemically etched with 15% commercial hydrochloric acid and then washed with alkaline solution. Subsequently, the surface shall be washed with sufficient water until it is fully neutralised.

After the under bed is thoroughly dried, it shall be cleaned thoroughly with wire brushes to remove all loose particles and brushed properly to obtain a completely dust free surface. A heavy grade bituminous corrosion resisting protective coating shall be applied on to this dust free surface either by brushing or by other means in accordance with manufacturer's specifications so as to provide an isolating layer between the Portland cement concrete and the acid-alkali resistant treatment as well as to provide a proper bonding between the same.

This bituminous material shall be resistant to the splashes and fumes of both inorganic acids and alkalis and should form an elastic film not subject to flaking. Prodorlac SPL as marketed by Coromandal Prodorite Pvt. Ltd. or equivalent may be used for this bituminous lining and the number of coats provided as per manufacturer's recommendation. If a multiple coat is used, sufficient drying period shall be allowed between

completion of one coat and application of the next as recommended by the manufacturer, and depending on the prevalent temperature. On top of the bituminous undercoat specified above, a special mastic of 12 mm minimum thickness or as recommended by the manufacturer shall be applied to provide an impervious underlay membrane to the tiling. This special mastic shall consist of a primer and a mortar. Both these shall be thermoplastic compounds of selected fillers and blended bitumens which are solid at ordinary temperatures.

The primer shall be broken up into small pieces and put into cauldron and heated. The material shall be kept in motion during heating. When the primer is hot enough to flow it shall be poured over the undercoat surface and promptly spread to uniform thickness.

Care shall be taken to avoid moisture entrapment on the surface and to eliminate bubbles. Two layers of primer are normally suitable, but manufacturer's recommendation in this regard shall prevail.

The mortar is to be heated as required to make a stiff paste similarly breaking up into fairly small pieces and melted in the cauldron. When it reaches a butter like consistency, it is to be applied on to the primer applied surface in single or multiple layers as to form a total thickness of the special mastic membrane of at least 12 mm or as required by the manufacturer's specification. The mortar shall be applied hot either by trowelling or by means of a standard wooden float and thoroughly worked in until it forms an even coating. The covering shall be done piece by piece and care taken to keep the correct temperature, so that a perfect weld is made. The special mastic material may be the product of Coromandel Prodorite Pvt. Ltd. or equivalent. Over this underlay the acid/alkali resistant tiles shall be bedded in special cement mortar and jointed in acid/alkali resistant resin based cement mortar . The bedding mortar shall have a bed thickness not less than 6 mm. The material shall be self-hardening, chemically setting silicate type and chemical resistant comprising an intimate mixture of a solid filler, a setting agent usually contained in the filler and a liquid binder.

The material may be supplied in two components, powder and solution. When the filler powder and the liquid binder are mixed at ordinary temperature, a trowelable mortar shall be formed which should subsequently harden by the chemical reaction between the setting agent and the silicate binder forming an insoluble silica gel. The liquid binder may be a neutral solution of sodium silicate and/or potassium silicate and the fillers may be silica, quartz or other material insoluble in common mineral acids.

The jointing of the tiles shall be done with a self-hardening cement mortar specially designed to resist both acidic and alkaline as well as mixed acidic and alkaline conditions. For this purpose a resin-type chemical resistant mortar conforming to IS:4832 Part II shall be used comprising an intimate mixture of liquid resinous material and a powder composed of properly selected filler material and usually containing the setting agent. The material may be supplied in two components which when mixed at ordinary temperature shall form a trowelable mortar that subsequently hardens. The liquid resin may be either one of or a combination of the types like phenolic resin, furane resin, epoxy resin and polyester resin. The filler materials, which are usually of a carbonaceous or siliceous nature shall be selected to have resistance particularly to Hydrochloric acid and caustic soda. The catalyst material may be incorporated in the fillers in such a manner that it becomes effective when mixed with resin .For phenolic and furane resin mortars the resin and the filler may be supplied in two packs. The resin shall have a viscosity that will permit it to be readily mixed with the powder by manual methods. The filler materials shall have properly graded particles that will permit the preparation of a minimum joint thickness of 1.5 mm.

The mortar is to be prepared and applied strictly in accordance with the manufacturer's instructions. If the material is supplied in two separate parts, an inert powder and a resin based syrup, they must be mixed in the proportions given by the manufacturer's data table.

The jointing shall be done for the full depth of the tile and the joint width shall be 3 mm. The joints shall be finished smooth and flush printed.

Mixing shall be carried out very thoroughly and carefully in a clean enamelled dish or bowl. Any lumps in the powder shall be broken down by careful mixing. Mixing shall be carried out by adding powder to the syrup. The mixing shall be so arranged that the mixed mortar is used up quickly and does not remain in bulk longer than the time specified by the manufacturer. At a temperature of 200°C or above, the mixing pan and contents shall be kept cool by immersion in water. All necessary measures should be taken so that the bulk masses of this resin based mortar, which generates heat in setting, are not allowed to remain under fairly warm conditions which may lead to a flash set. To avoid this, it is essential that the mixed mortar is spread in a thin layer on a flat tray and not left in a mass. After jointing the tiles, the flooring should not be placed under service in normal conditions before eight days or as recommended by the manufacturer and depending on atmospheric temperature. During setting and hardening, no water, steam or acid should come in contact with this jointing mortar.

If the flooring has to be sloped the same shall be provided in the concrete slab or an additional graded underbed shall be provided if required, with cement sand mortar (1:3) by volume as specified or as directed by the Engineer.

The Concessionaire shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer IS specifications, and shall lay underlayer, special mastic, setting mortar etc. and set the tiles properly in full conformation with the manufacturer's instructions. The entire work shall be done in workmanlike manner to the complete satisfaction of the Engineer.

4.7.9.7 Heavy duty abrasion resistant flooring

The type, quality, size, thickness, colour, etc. of the tile for flooring and skirting work shall be of the best quality approved by the Engineer. For this purpose, the Concessionaire shall provide the Engineer with necessary samples for his selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases. The tiles shall be laid on lime concrete mortar bedding of about 30 mm thick to give an overall thickness of 50 mm.

4.7.9.8 Integral cement finish on concrete floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface.

4.7.10 Surface coatings

4.7.10.1 Brick bat cobachina mosaic type water proofing

The proportion of brick bat shall be 2 parts of brick bat to one part of lime mortar (one part of lime to 2 parts of sand). The brick bats shall be hard, well burnt and of size varying from 12 mm to 25 mm. Lime shall be of best quality of hydraulic lime double ground. While preparing brick bat concrete, jaggery in portion indicated by the Engineer shall be added. The brick bat coba shall then be laid to slopes, providing necessary wattas, and beated at least for 48 hours after laying. Over the brick bat coba a bedding of 1:2 lime mortar 20 mm to 25 mm thick, shall be provided. A layer of neat cement grout, about 10 mm thick shall then be laid. Immediately on application of cement grout, assorted pieces of coloured china,

previously soaked in water shall be set closely on the fresh surface and properly tamped to the required grade, The cement grout freshly laid shall work its v lay to the top surface. The surface after completionof work shall be finally cleaned with saw dust, and waste and if so directed by the Engineer with dilute acid. China mosaic shal1 be cured for at least 10 days. If so directed by the Engineer, a border of colour or white mosaic shall be provided.

Brick bat coba and china mosaic shall be taken up the parapet walls to a height of 125 mm to 150 mm. Necessary wattas shall be provided towards drain pipes as shown on drawings or as directed by the Engineer.

On prior approval from the Engineer, cement based proprietary type of waterproofing may be allowed to be done by a Specialist Concessionaire.

The Concessionaire shall give a guarantee of waterproofing for a minimum period of 10 years against bad or faulty material faulty material and construction and shall rectify the work at his own cost during the guarantee period.

4.7.10.2 Neeru plaster

Cement and sand shall conform to IS: 269 and IS: 383 respectively.

Neat lime shall be made of the best description of lime, slaked with fresh water and sifted. The lime shall be reduced to fine powder by grinding it on a stone or in a hand mill as directed by the Engineer. The neat lime thus prepared shall be kept moist until used and the quantity to be prepared at one time shall be such that it can be consumed within eight days.

All stone or brick masonry surface shall be thoroughly wetted for at least 6 hours and the joints raked out to a depth of at least 12 mm and walls washed before any plastering is done. The surface shall then be rendered with 1:4 cement sand plaster with specified roughness. The surface shall then be floated or set with a thin coat, 3 mm thick, of cement and polished well with a trowel or flat board. The cement mortar shall be used within 30 minutes after it leaves the mixing board or mill. Before any plaster work is started patches of plaster 150 mm x 150 mm shall be put on at every 3 metres as gauges so as to ensure an even thickness throughout the work. Cement plaster shall be done in even squares or strips. Care shall be taken to keep the whole surface thoroughly wetted for at least a week. The finishing surface shall be as specified and directed. Neat lime finish shall be applied to the prepared and partially set but somewhat plastic surface with steel trowel to a thickness slightly exceeding 1.5 mm, (1/16”) and rubbed down to 1.5 mm (1/16”) thickness and polished to a perfectly smooth and even finish working from top to bottom. The total thickness of the plaster shall be at least 12 mm.

The junction between beams and brickwork shall be plastered after fixing the expanded metal wire mesh of 300 mm width. 10 mm deep and 15 mm wide groves shall be provided between concrete & brick surfaces.

4.7.10.3 Sand faced cement plaster

Cement and sand shall conform to IS: 269 and IS: 383 respectively. The sand faced cement plaster, where specified, shall be applied in two coats. All stone or brick masonry surface to be plastered shall be thoroughly wetted for at least 6 hours and the joints raked to a depth of at least 12 mm and walls washed before any plastering is done.

The first coat of cement plaster in 1:3 cement sand mortar shall be applied uniformly all over the surface to be plastered to a thickness of 14 mm with a trowel and in exact plumb. This coat shall be allowed to

set for not less than half an hour. Indentation shall then be made in the form of waves by raking a wire broom over the surface to form' a key for the second coat. Water proofing compound such as CICO, Impermo etc. shall be added in the 1st coat of cement plaster at the rate of 1.50 kg. per bag of cement or at the rate specified by the manufacturer for its effective results. The plastered surface shall be allowed to cure for at least four days.

The second coat shall be applied in 1:3 cement sand mortar using clean sand screened through a mesh of not less than 1.5 mm and not more than 3.00 mm size to a uniform thickness of 6 mm by trowel and flat board in exact plumb. The surface shall then be tapped with a cork, piece to give a desirable uniform granular appearance. Care shall be taken for keeping the whole surface thoroughly wetted for at least one week.

4.7.10.4 Epoxy linings

The Concessionaire shall employ specialist firms, approved by the Engineer, for the supply and laying of epoxy linings.

4.7.10.5 Acoustic tiles

Acoustic tiles shall be of a design and manufacture approved by the Engineer and shall be bonded to ceilings in accordance with the manufacturer's details. They shall have glass wool backing resin bonded to grade RB2 and be fixed on timber or aluminium scantlings.

4.7.11 Inserts, bolts, etc.

Fabricated pipe, moulded, cast or fabricated frame inserts, bolts, plates, etc. shall be provided in masonry and concrete works as required. It is imperative that all inserts, bolts, fixtures and fittings shall be provided in their position very accurately. Such inserts and bolts shall be fixed by use of templates. If as a consequence of negligence on the part of the Concessionaire, the inserts, bolts, fixtures, fittings, etc. are out of alignment, the Concessionaire shall make arrangements to have the inserts and bolts removed and refixed in their proper position as directed by the Engineer.

4.7.12 Woodwork in doors, windows, partitions, louvers, railings, etc.

Wood used for all work shall be of approved quality of teak wood and properly seasoned by at least 6 months air drying, suitable for joiner's work, should be of natural growth, uniform in texture, straight grained, free from sapwood, dead knots, open shakes, boreholes, rot, decay and all other defects and blemishes.

The thicknesses specified for joiner's wrought timbers are, unless otherwise specified, prior to planning and 3 mm will be allowed from the thickness stated for each wrought face.

All joining shall be wrought on all faces and finished off by hand with sand paper, with slightly rounded arises.

The joints shall be pinned with hard wood pins and put together with white lead. Jointing shall be by means of mortice and tennon or dovetailed joints, as approved by the Engineer.

Any joiner's work which shall split, fracture, shrink, or show flaws or other defects due to unsoundness, inadequate seasoning or bad workmanship, shall be removed and replaced with sound material at the Concessionaire's expense.

Doors, windows and ventilator frames shall be rebated. All dimensions shall be as approved. The top

framing member of doors and top and bottom framing of windows and ventilators shall project about 150 mm in brickwork. The verticals of door frames shall project about 50 mm below finished floor. Surface coming in contact with brick work shall be painted with bitumen as directed by the Engineer. Each of the door and window frames shall be provided with 3 Nos. M.S. 225 mm x 25 mm x 6 mm flat split hold-fasts on each side. These hold-fasts shall be embedded in masonry or concrete work. The work shall conform to I.S. 4021.

Panelled doors shall comprise a 250 mm wide bottom rail, 150 mm wide middle rail and all other rails middle, top and vertical 100 mm wide. All rails shall be 40 mm thick. Panels shall be 20 mm thick. The panelled doors shall have minimum of 3 panels.

The workmanship of all door shutters shall conform to the requirements of I.S. 1003 (Parts I & 11) and I.S. 2202 (Part I). If required, flush door panels shall be tested as per I.S. 4020. Flush doors Shall be of 35 mm thick solid Core.

All doors shall have 15 mm thick, 40 mm wide teak wood architraves on both sides. Railing and architraves shall conform to the shape as approved and fixed by means of screws (counter-sunk or otherwise) or bolts.

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the Engineer.

The whole of the woodwork shall first be treated with two coats of anti-termite wood preservative chemicals of an approved make. All the wood shall thereafter be applied with primary coat of paint. The application of primer shall not be done within 24 hours of the application of the second coat of anti-termite treatment.

The doors shall have following fixtures,

(a) Single leaf doors

(i) Heavy duty railway type butt hinges of oxidised brass, 150 mm long -3 Nos.

(ii) Godrej 6 lever mortice lock with lever handles on both sides -1 No. (Chromium plated brass)

(iii) Tower bolt 300 mm long -1 No. (chromium plated brass)

(iv) Door stop -1 No. (CP brass with rubber stopper)

(v) Door closer -1 No. (Heavy duty hydraulic type)

(b) Double leaf doors

All material shall be same as for single leaf doors.

(i) Heavy duty railway type hinges 150 mm long - 6 Nos.

(ii) Aldrop - 1 No. (300 long)

(iii) Tower bolts 300 mm long - 2 Nos.

(iv) Pull handles - 4 Nos. (CP brass 150 long)

(v) Door stops - 2 Nos.

(vi) Door closer - 1 No.

Where the single leaf doors are 1200 mm wide the number of hinges used shall be four. Similarly, if the height of the door exceeds 2200 mm, the number of hinges shall be suitably increased. The doors shall be provided with parliamentary type hinges, wherever required. Door closures shall be of heavy-duty hydraulic type.

4.7.13 Glazing for doors, windows and ventilators

(a) Glass in general

Glass shall conform to the requirements of relevant IS codes and shall be free from bubble, smoke wanes, air holes, scratches and other defects and shall be cut to fit the rebates with due allowance for expansion. Glass which does not have uniform refractive index or which is wavy shall not be used.

(b) Sheet glass

Sheet glass shall be flat, transparent and clear as judged by the unaided eye. It shall be free from cracks. Sheet glass shall be of B quality or ordinary quality and the thickness shall be as specified. Sheet glass used for glazing in building shall conform to I.S. 1761.

(c) Wired glass

All wired glass shall be 6 mm thick, polished Georgian or equivalent, with both faces ground and polished. The glass shall conform to I.S. 5437.

(d) Glazing

Putty for glazing to wood shall be prepared in accordance with I.S. l635. Glazing work in buildings shall conform to IS:3548.

Compound for glazing to metal is to be an approved special compound manufactured for the purpose.

4.7.14 Metal doors and windows

(a) Aluminium doors, windows and screens

All extruded sections used in work of aluminium doors, windows etc. shall be minimum 3 mm thick of Jindal or Hindal make or equivalent. All sections shall be aluminium anodised in matt or polished finish as directed. Aluminium doors, windows etc. of only approved manufacturers shall be used. The aluminium doors and windows shall conform to I.S. 1948. Fixing of all aluminium doors and windows shall be carried out through the Agency of Manufacturers as per their specifications. Aluminium doors and windows shall be completely water tight.

The aluminium windows shall have either side projected or top projected shutters as specified to facilitate the cleaning of glasses. In case of side hung windows friction hinges shall be used, with stainless steel pins. Centre hung ventilators shall be hung on two pairs of cup-pivots of aluminium alloy or brass or bronze pivots chromium or cadmium plated. Glass panes shall be free from flaws, speck or bubbles and shall be with properly squared corners and straight edges.

Following fixtures and fittings shall be provided:

(i) For Doors

Two floor springs of suitable make such as Everite, Prabhat, etc. or equivalent having double action spring.

Each door leaf shall be fitted with two Nos. of suitable size of aluminium anodised handles from extruded tube of 100 mm x 50 mm minimum.

One leaf out of two shall be fitted with tower bolt at top or bottom of 230 mm size of chromium plated brass.

6 lever brass lock concealed in section tube and openable from both sides with two keys.

1 door closer of heavy duty hydraulic type for each door leaf.

(ii) For Windows

One opener, one handle and 15 cm. long tower bolt of brass, chromium plated.

(b) Steel windows, ventilators and doors

Steel windows, ventilators and doors, including folding doors, shall be supplied complete with frames and fitted with standard fixtures such as hinges, locks, bolts, stoppers, handles as necessary.

Steel used in fabrication of windows and doors shall have a minimum thickness of 3 mm. There shall be no distortion in the frames.

The whole frame with the exception of lugs and external faces of channels shall be painted after manufacture as per specifications.

(c) Vehicular doors

Vehicular doors shall be of mild steel construction not less than 1.25 mm thick and shall be of the roller shutter or concertina type as specified. The doors shall be supplied by a reputable manufacturer to the approval of the Engineer and shall include a wicket door where specified. Doors shall be delivered to site painted with one coat of approved primer. After installation any damage to the paintwork shall be touched up and final painting will be carried out when approved by the Engineer. Doors shall be smooth operating, capable of opening and closing by one man and shall be fully weatherproof when closed. They shall be supplied complete with secure locks including locks to the wicket doors where appropriate.

Slats for the rolling shutters shall be in one piece and be made of heavy gauge steel sheets minimum 1.25 sq.in thickness. A cylindrical hood shall be provided on the top to enclose the shutter when it is open.

4.7.15 Gravel in under drains

The gravel / metal shall be sound, durable, tough, clean, chemically stable of 20 mm single sized which will not become powdery under loads and in contact with water. The gravel shall be free from soft, thin, elongated, or laminated pieces and vegetable or other delicious substances. The gravel shall be spread and thoroughly compacted in layers of 150 mm taking care that it does not get crushed.

4.7.16 White wash

Walls shall be thoroughly cleaned of all dirt and loose particles etc. before white wash is applied. Inequalities and holes shall be filled up with gypsum which should be allowed to set hard. White wash shall be of ordinary fat lime and of good quality. It shall be slaked with an excess of water to the consistency of a cream and allowed to remain under water for 2 days. It shall then be strained through a

cloth and 2 Kg of clean gum added for every cubic metre of lime ready for white washing.

Each coat is to be applied with a brush spray. It shall be laid with a stroke of the brush from the top downwards, another from bottom upwards over the first stroke and similarly, one stoke from the right and another from the left over the first brush before it dries. Three such coats shall be applied.

4.7.17 Breaking of concrete, brickwork, blockwork and stone masonry

The waste material from breaking shall be at once removed from the location and dumped at a suitable location or transported and disposed off as directed by the Engineer. The Concessionaire shall observe all precaution by way of necessary propping, strutting, etc. to the satisfaction of the Engineer, to ensure that the adjacent framework is not damaged.

Any damage to any adjacent framework, brickwork or blockwork resulting from any negligence or the Concessionaire thereof shall be made good at the Concessionaire's cost, to the satisfaction of the Engineer.

4.7.18 Locks

All the doors and gates shall be provided with locks of approved quality available locally and in accordance with I.S. 2209 or I.S. 275 as appropriate. The locks shall be provided with keys in duplicate.

4.7.19 Building services wiring

Unless otherwise specified, internal services wiring shall be carried out in heavy-duty uPVC conduit and trunking incorporating 1.1kV grade, single-core PVC-insulated cable. Wiring installation shall comply with the provisions of IS 732:1989 and SP 30:1985-National Electrical Code.

Wiring shall be carried out on the looping-in system. No joints other than at looping-in points will be allowed.

Cable sizes shall be not less than 1.5mm² for lighting circuits and 2.5mm² for socket outlets, heating and small power circuits.

Conduit systems shall be surface or buried within building plaster/screed finishes as specified.

External services shall be cabled in multi-core PVC-insulated armoured cable, surface-run on building structures and steelwork or direct-buried as appropriate.

4.7.20 Building services — lighting

4.7.20.1 General requirements

The building internal lighting design shall take into account:

- the operating environment;
- the type and style of architectural finish;
- the activities to be performed in the areas;
- access for equipment maintenance;
- operating life.

The minimum service illumination levels shall comply with the minimum recommendations of IS 3646: Part 1:1992 and IS 3646: Part 2:1966 for the appropriate building area and operational function, or as otherwise specified. Illumination levels shall apply to floor levels. CIBSE code shall be applicable to the areas, which are not covered in respective BIS.

In no case shall the illumination be below that necessary to perform work or other essential activity in any particular location.

In areas housing rotating machinery, lighting shall be arranged on multiple-phase circuits to prevent stroboscopic effects.

Where adjacent luminaries are connected to different phases of the supply, a label shall be fitted internally, warning of the presence of the phase-to-phase voltage.

4.7.20.2 General-purpose luminaires

Luminaires shall be of the fluorescent, tungsten or gas-discharge type as specified, and shall comply with IS 10322:Part 1:1982.

General-purpose fluorescent luminaires shall be manufactured from zinc-coated sheet steel of minimum thickness 0.7mm with white epoxy polyester powder or equivalent finish. Luminaires shall be fitted with a trough reflector or prismatic diffuser as specified.

Luminaires for installation in clean and dry areas shall have a minimum degree of protection IP20 (without a diffuser) and IP40 (with a diffuser) to IS 12063:1987.

Luminaires for use in a corrosive environment shall have a glass reinforced plastic body with a prismatic acrylic or polycarbonate diffuser. The degree of protection shall be IP65 to IS 12063:1987. Covers shall be sealed to the body with a neoprene gasket and shall be secured using stainless steel fixing catches. The catches shall be hinged to the body.

Bulkhead luminaires shall be of the heavy-duty type and shall have a diecast corrosion-resistant aluminium body and front frame with epoxy polyester powder or equivalent finish, and prismatic cover. Covers fitted to luminaires located outdoors shall be impact-resistant polycarbonate. The cover shall be sealed to the body with a silicon rubber gasket and shall be secured using stainless steel captive screws. Retaining hinges shall be stainless steel.

Bulkhead luminaires for indoor location shall have a minimum degree of protection IP54 and for outdoor location IPW55 to IS 12063:1987.

Floodlighting luminaires shall be of similar construction to the bulkhead luminaires except they shall be fitted with a clear toughened glass panel. Floodlighting luminaires shall be complete with high-purity anodised aluminium reflector and galvanised steel mounting bracket. Reflector characteristics shall be selected to suit the floodlight application.

Fluorescent luminaires shall be of the switch-start type unless otherwise specified.

4.7.20.3 Emergency lighting luminaires

Unless otherwise specified, emergency lighting luminaires shall be of the self-contained type complying with IS 10322: Part 5:Sec 1:1982 and shall incorporate a fluorescent lamp. The rated duration of emergency lighting luminaires shall be 3 hours.

Exit-type emergency luminaires shall be of the maintained type.

4.7.20.4 Luminaires For hazardous areas

Luminaires for location in Zone 1 and Zone 2 hazardous areas shall comply with IS 13408:1992. The Apparatus Group and Temperature Class shall be as specified.

4.7.20.5 Lamps

Tungsten filament lamps shall comply with IS 418:1978 and shall have a minimum rated average life of 1000 hours. Tungsten lamps shall have a reinforced internal construction to provide increased resistance to filament breakage caused by jolts and vibration. Lamps for special applications shall be as specified.

Tungsten lamps rated up to and including 150W shall be fitted with a bayonet-type lamp cap. For lamp wattage above 150W, the lamp cap shall be of the Edison-screw type. Lamp caps shall comply with BS EN 60061-1:1997 in concurrence with IS 10276: Part 1:1982/IS 9206:1979.

Energy-saving fluorescent lamps used as a direct replacement for tungsten filament lamps shall have integral control gear and a minimum rated average life of 8000 hours.

Fluorescent lamps shall comply with IS 1913: Part 1:1978 and IS 2418: Part 1:1977 and shall have caps of the bi-pin type. Unless otherwise specified, lamps for installation in industrial areas shall have a correlated colour temperature of 3500K (white appearance) and for other areas shall have a correlated colour temperature of 3000K (warm appearance). The minimum rated average lamp life shall be 3000 hours.

Mercury discharge lamps shall comply with IS 9900: Part 1:1981.

4.7.20.6 Ceiling roses

Ceiling roses shall be of insulating material having ignitability characteristic 'P' as specified in ISO 5657:1986. Extension flanges shall be fitted to all surface mounted ceiling roses where the wiring installation is concealed in the building fabric.

Where plug-in connections are specified for luminaires, 2A three-pin outlets and plugs shall be provided which shall be suitable for mounting on to a circular conduit box. When specified, the plug shall be retained in the socket by means of a locking ring.

4.7.20.7 Pendants and chain suspensions

A plain pendant shall comprise a ceiling rose, flexible cord and lampholder. Unless otherwise specified, the flexible cord shall be 0.75mm² and the insulation shall be suitable for a maximum operating temperature of 85°C. Where the lampholder has a metal exterior, the flexible cable shall include a protective conductor which shall be connected to the earth terminal of the lampholder and ceiling rose.

A tube pendant shall comprise a ball and socket cover to fit a circular conduit box and steel conduit not less than 20mm diameter. At the conduit entry to the luminaire a backnut shall be used.

A chain suspension shall comprise a hook cover fixed to a circular conduit box and a chain having a load carrying capacity not less than twice the weight of the luminaire.

4.7.20.8 Supports and fixings

Where fluorescent luminaires 1200mm or more in length are supported directly by the conduit system they shall be fixed to two circular conduit boxes both of which shall form an integral part of the conduit system.

Where the weight of the luminaire is supported by a conduit box or trunking, the fixing of the conduit box or trunking shall be adequate for the purpose.

Luminaires fitted with tungsten filament lamps and having metal backplates shall not be fixed directly to a conduit box in which a thermoplastic material is the principal load-bearing member.

Support of luminaires from cable trunking shall be by means of proprietary clamps or brackets.

Where luminaires are supported from the structure other than by the conduit or trunking system, they shall be fixed by approved purpose-made clamps, bolts, washers and nuts, expanding anchors or proprietary wall plugs and non-ferrous screws as appropriate.

Luminaires mounted on or recessed into suspended ceilings shall be independently supported.

4.7.20.9 Wiring connections

Where luminaires, other than tubular fluorescent, are fixed directly to circular conduit boxes or are supported by pendants or chains, the final circuit wiring shall terminate at a terminal block in the conduit box.

Where fluorescent tube luminaires are fixed directly to circular conduit boxes, the final circuit wiring may be terminated within the luminaire. The wiring shall enter each luminaire at the conduit entry nearest to the terminal block and, where a loop-in wiring system is used, leave by the same entry. Wiring shall not pass through the luminaire.

Where luminaires are mounted on or recessed into a suspended ceiling, connection shall be by flexible cord from a plug-in ceiling rose unless otherwise specified. The plug-in ceiling rose shall be located not more than 500mm from the access in the ceiling and shall be firmly fixed.

Where high-bay discharge luminaires are suspended from the structural ceiling, the connection between the fitting and fixed wiring shall be by plug and socket.

Cables and flexible cords for final connections to luminaires shall be suitable for the operating temperature of the luminaire. Flexible cords for chain suspensions shall have a white sheath.

Cables and cords passing close to ballast within a luminaire shall be suitable for the operating temperature of the ballast.

Where adjacent luminaires are connected to different phases of the supply, a label shall be fitted internally, warning of the presence of the phase-to-phase voltage.

A protective conductor shall connect the earth terminal of each luminaire to an earth terminal incorporated in the adjacent conduit box. Where the final connection is by flexible cord, the protective conductor shall be integral with the cord.

4.7.21 Building and external services — roadway lighting

4.7.21.1 Columns

Roadway lighting columns shall be constructed and installed as per drawing. The base compartment door/cover shall be fitted with a tamper-proof fastening.
Columns shall have bolted base mounting plates for installation on concrete foundation blocks which shall incorporate bottom-entry cable ducts.
Columns shall be complete with baseboard, fuse unit and wiring between the fuse unit and luminaire.
The fuse unit shall have a non-hygroscopic plastic case designed to prevent the ingress of moisture and condensation, integral double-entry cable termination chamber with detachable front cover and enclosed-type fuse complying with IS 13703: Part 1:1993.

4.7.21.2 Lanterns

All lanterns shall be of the high-pressure mercury or sodium type fitted with high-efficiency lamps and

complete with integral control gear.

4.7.21.3 Socket-outlets and couplers

Commercial-type socket-outlets shall comply with IS 1293:1998, and shall be supplied complete with boxes and fixing screws. Socket outlets shall be white plastic or metal clad pattern according to the installation area and as specified.

Socket-outlets shall be of the flush-mounting type in plastered and tiled areas. In all other areas, socket-outlets shall be of the surface-mounting type.

Industrial pattern socket-outlets and couplers shall comply with IS/IEC 309-1:1988 and IS/IEC 309-2:1989. Industrial-type switched socket-outlets shall be mechanically interlocked to prevent the plug being inserted or withdrawn unless the switch is in the 'off' position. It shall not be possible for the switch to be moved to the 'on' position unless the plug is completely inserted.

Socket-outlets for indoor location in process or damp areas shall have a minimum degree of protection IP55 to IS 12063:1987. For outdoor locations, the degree of protection shall be not less than IPW55.

Socket-outlets for locations in chemical-handling areas shall have plastic enclosures resistant to the particular chemical.

In office and control-room areas, socket-outlets shall be installed at 0.5m above floor level. In plant areas, socket-outlets shall be installed at 1.2m above floor level. The height of socket-outlets shall only be changed with the approval of the Engineer.

Residual-current circuit breakers fitted to socket-outlets shall comply with BS EN 61008-1:1995 and BS EN 61008-2:1995 and shall have a tripping sensitivity of 30mA with an operating time not exceeding 30ms.

4.7.21.4 Switches

Switches shall comply with IS 3854:1997 and shall be supplied complete with box, cover plate and fixing screws. Switches shall be white plastic or metalclad type according to the installation area and as specified.

At multi-switch positions for lighting, the switches shall be contained in multi-gang boxes.

Multi-phase switch assemblies shall be phase-segregated and a separate cover shall be fitted over each phase section. The phase shall be marked on the covers and a label warning of the presence of a three-phase supply shall be fitted.

Switches shall be of the flush-mounting type in plastered and tiled areas. In all other areas, switches shall be of the surface-mounting type.

External lighting switches shall have rotary switch action and, unless otherwise specified, a hot-dipped galvanised cast-iron enclosure with tapped spouted entry.

Switches for indoor locations in process or damp areas shall have a minimum degree of protection IP55 to IS 12063:1987. For outdoor locations, the degree of protection shall be not less than IPW55.

4.7.22 STRUCTURAL WORK

4.7.22.1 Description

Requirements specified in this section will form a part of detailed specifications for items of works falling under this category. Indian Standards shall apply as if included herein. Design of structure shall be in compliance with Indian Standards IS: 800 Code of practice for general construction in steel.

Principal items are:

1. Structural steel member
2. Steel joists
3. Plates and connections
4. Steel chair assemblies
5. Pipe supports and hangers for piping in all locations
6. Pipe railings
7. Ladders and stairs
8. Miscellaneous metal work for water supply and sewage disposal installations.

4.7.22.2 Quality assurance

Unless otherwise specified all work specified herein and shown on the drawings shall conform to the applicable requirements of the following specifications and codes:

A. Fabrication and erection of structural steel shall be in accordance with IS: 800.

B.Welding Inspection**:** The Concessionaire shall perform all structural field welding under continuous inspection of a special inspector representative of the Employer. Notice will be given at least 24 hours in advance of needed inspections.

4.7.22.3 Submittals

A. Shop Drawings: The Concessionaire shall submit shop drawings for approval before fabrication of any of the work. Complete fabrication details with material and specification lists showing all welds, fabrication and finish details, and shop painting will be shown in the drawing. In approving shop drawings, the Owner does not assume responsibility for accuracy of the work by itself or relative to other components as constructed.

4.7.23 Shop fabrication

4.7.23.1 General

A. The maximum possible fabrication of structural steelworks shall be manufactured off-site in a fabrication shop.

B. Shop connections shall be welded or bolted unless otherwise indicated.

C. In so far as possible, all works shall be fitted and assembled in shop ready for erection.

4.7.23.2 Members

A. All members shall be free from twists, kinks, buckles, or open joints.

B. All members, holes and their splicing shall be so accurately made that when assembled the parts shall

come together and bolt without distortion.

C. Parts assembled with bolts shall be in close contact, except where separators are required, where unlike metals are in contact, to insulate as necessary to prevent corrosion.

D. Bolt holes will be provided to secure special items, if any to structural members.

E.Bearing Surfaces shall be planed to true beds. Abutting surfaces shall be closely fitted. Steel requiring accurate alignment shall be provided with slotted holes and/or washers for aligning the steel.

F. All materials shall be delivered in the order in which they will be required so as to avoid all delay in completion of the project.

4.7.23.3 Welding

A. Welding in shop and field shall be done by qualified operators who have experience of similar work. The standard for welders will be as required by IS: 817.

B. All steel before being fabricated shall be thoroughly wire brushed, cleaned of all scale and rust, and thoroughly straightened by approved methods that will not injure the materials being worked on. Welding shall be continuous along the entire line of contact except where tack or intermittent welding is permitted. Where exposed, welds shall be cleaned of flux and slag and ground smooth.

4.7.24 Erection

A. Erection shall include the installation and erection of all structural steel as called for in this section. The Concessionaire shall verify correctness before starting erection.

B. As erection progresses, the structure work shall be securely bolted up to take care of all dead-load, wind and erection stresses.

C. No final bolting or welding shall be done until each portion of the structure has been properly aligned and plumbed.

D. Bolts shall be drawn up tight and threads set so that nuts cannot become loose.

E. Damaged Members:During erection, members which are bent, twisted or damaged shall be straightened or replaced as directed. If heating is required in straightening, heat method shall be used which will ensure uniform temperature throughout the entire member. Members which in the opinion of the Owner are damaged to an extent impairing their appearance, strength or serviceability, shall be removed and replaced with new members.

F. Anchor Bolts and Anchors:Anchor bolts and anchors shall be properly located and built into construction work. Bolts and anchors shall be identified by the use of templates or such other methods as maybe required to locate the anchors and anchor bolts accurately. Embedded anchor bolts that are submerged in process water or pump room floors, or are in enclosed tanks or space exposed to process gas or moisture, shall be of stainless steel with nuts of same material. To such stainless steel bolts, non-oxidising lubricant grease will be applied before bolting.

G. Bearing plates: Bearing plates shall be provided under beams and columns resting on walls or footings. Bearings plates may be attached or loose and aligned on steel wedges or shims. After the supported members have been plumbed and properly positioned and the anchor nuts tightened, the entire bearing area under the plate shall be dry-packed solidly with bedding mortar. Wedges and shims shall be cut off flush with edge of bearing plate, and shall be left in place.

H. Substitutions: Unless otherwise directed, the exact sections, shapes, thickness, sizes, weights, and the

details of construction shown for the structural steelwork shall be furnished. However, the Concessionaire, because of his stock or shop practices, may suggest changes if the net area of section is not thereby reduced, if the section properties are at least equivalent and if the overall dimensions are not exceeded. All substitutions or other deviations from drawings and/ or specifications shall be specifically noted or "clouded" on the shop drawing submittals.

I. Flame cutting: Flame cutting by the use of a gas cutting torch in the field for correcting fabrication errors will not be permitted on any major member in the structural framing. The use of a flame-cutting torch will be permitted only on minor members, when the member is not under stress, and only after the approval of the Owner has been obtained.

J. Storage of materials: Structural material, either plain or fabricated, shall be stored above ground upon platforms, skids, or other supports. Materials shall be kept free from dirt, grease, and other foreign matter and shall be protected from corrosion.

K. Steel stairs: To be fabricated true to size and details and provided complete with all attachments, steel pipe rails and handrails, checkerplate, nosed grating type treads and landings. Shop and setting drawing shall be submitted beforehand for approval of the Engineer.

L. Ladders

Contingent upon designated requirements for different locations, galvanized steel units will be fabricated conforming of requirements shown on drawings. Rails where indicated will be provided.

M.S. Ladders: The M.S. ladders with stringers as specified and the steps of M.S. bars of specified dia. shall be provided. The handholds shall be curved. The size and dimensions shall be specified or as shown in the drawings.

M. Ladder rungs: To be manufactured true to size and configuration. These shall be erected in timely manner with setting diagrams to assure proper embedment and alignment in cast-in-place concrete. Rungs shall be of approved design and galvanized.

N. Galvanised steel pipe rails and railings: Complete with stanchions or channels or angles, toe plates, welded and bolted fittings and attachments shall be fabricated true to size configurations and details shown on drawings. The welds shall be grooved and polished flush and smooth. Curves, where indicated or necessary shall be bent to suitable radius. The G.I Pipes of specified dia. with requisite specials in number of rows as specified shall be provided.

O. Steel checkered plate: Steel checkered plate and frames shall be galvanized from fabrication unless noted otherwise. All assemblies shall be reinforced on concealed faces as necessary to support the service loads required. Aluminium shall be isolated from dissimilar metals, concrete, masonry and plaster to prevent electrolytic deterioration.

P. Stair abrasive safety nosings: Extend nosings to within 150mm of wall or stringer and equip each with embedded anchorage secure attachment. Finish flush with concrete at all cast-in-place concrete stairs, except or otherwise designated.

Q. Test reports: Certified physical and chemical mill test reports for material used for major structural members shall be furnished. All tests shall be performed in accordance with applicable IS standards.

4.7.25 Materials and workmanship

A. Structural steel and miscellaneous metal works

General: This work shall include the furnishing and installation of all structural steel and miscellaneous metal work and related work including grating and grating supports, pipe hangers and supports, tanks, manhole steps, equipment guards, anchors and other appurtenances, and any other work shown on the drawings or herein specified. All materials shall be new, sound and of the best quality available.

Material: Steel rolled sections, plates, and bars shall conform to the latest editions of IS: 2062 and IS: 8500.

B. Steel pipe: Where used for columns or other structure purposes, pipe shall conform to IS: 1161.

C. Steel joints: These shall be fabricated true to size and details shown on drawings in strict conformance with requirements of reference standards.

D. Checkered plate: Plate shall be of regular quality carbon steel of the thickness shown on the drawings. The raised lugs shall be diamond shaped and have an angled and opposed pattern.

E. Nuts & bolts: Bolts and nuts shall conform to IS : 1363, , 1367, 3640, 3757.

F. Welding electrodes: The electrodes shall conform to the requirements of IS: 814.

G. Shop painting: Structural steel not designated to be galvanized shall be shop-coated using priming coat of red lead as specified in painting section of these specifications. The portion of steel to be embedded in concrete shall not be painted.

H. Galvanising: All metal work shown or specified to galvanized shall be zinc coated as per IS: 2629. The zinc coating should be free from defects and shall have uniform thickness of coating.

a. Galvanised coatings marred or damaged during erection or fabrication shall be repaired by any approved process as directed by the Engineer.

I. Shop painting: Before leaving the shop all steel not shown or specified to be galvanized shall be given one coat of ready mixed brushing primer coat as per IS: 104. Final painting shall be in specified coats of approved brand paint. The portion of steel to be embedded in concrete shall not be painted.

J. Test reports: Certified physical and chemical mill test reports shall be furnished by the Concessionaire for material used for major structural members.

K. Shop drawings: Five sets of shop drawings shall be submitted to the Engineer for approval before fabrication of any of the work. In approving shop drawings, the Engineer does not assume responsibility for accuracy of the work or work relative to other plant components as constructed.

L. Anchor bolts: Anchor bolts shall be galvanized and fabricated as shown, or specified by the equipment manufacturer.

Suitable expansion bolts may be used in lieu of anchor bolts at certain locations. It shall be the responsibility of the Concessionaire to request the substitution and obtain the Engineer's approval regarding type and location of expansion bolts proposed to be used prior to pouring concrete.

M. Steel grating: Seat angles and anchors shall be of steel. Grating and support shall be galvanized. Gratings to the supplied and installed as detailed in the drawings.

N. Pipe handrails: These shall be fabricated of 3.8cm diameter standard weight steel pipe. The railing

shall be mounted so as to produce a finished appearance that is plumb, straight, and true to dimension, free of links, twists, and abrasions. Curves, where indicated or necessary shall be bent to a radius of not less than 15 cm. Safety chains shall be 1.25 cm link aluminium chain with a harness type snap. Railing will have a height not less than one meter unless otherwise specified.

O. Mechanical equipment guards: All rotating belts, pulleys, and shafting shall be covered and guarded in conformity with applicable safety requirements or as directed by the Engineer.

P. Hollow metal doors and frames: The Concessionaire shall furnish and install all hollow metal door and window frames as indicated on the drawings and as specified in the detailed specifications.

Frames and doors shall be installed in accordance with plans and approved shop drawings in a rigid, substantial manner and shall be square, plumb, and level.

Metal doors shall be thoroughly cleaned and all rough or uneven spots dressed down and all pits, depressions, or scratches in exposed surfaces shall be filled with metal putty. Exposed surfaces shall be primed with one shop coat metal primer, which shall form a satisfactory base for final finish. Back of frames shall be protected with a coat of rust-inhibitive metal primer.

All metal doors and frames shall be thoroughly cleaned and any spots where shop coat is damaged shall be touched up with same paint used for shop coat.

Q. Rolling metal doors: Before fabrication, shop drawings of works will be prepared and submitted for approval. Shop drawings shall be based upon drawings, specifications and field dimensions. Doors shall be chain operated. Curtains shall be constructed of 10 gauge, No.4 galvanised steel slate with continuous and end locks and wind locks every fourth slate. Hood shall be of the same material as curtain. Device for padlock locking shall be provided.

Doors shall be installed by the door manufacturer or his authorized representative and shall be adjusted to operate smoothly throughout the full range of operation.

R. Miscellaneous structural works: Steel fabricated components, units and assemblies for various equipment for water supply installation shall be fabricated as per drawings and conforming to various standard codes of manufacture as specified and applicable.

4.8 Painting and Protective Coatings

4.8.1 General

The work included in this Section consists of the furnishing of all labour, materials, apparatus, scaffolding, and all appurtenant work in connection with the painting in accordance with these Specifications.

Surfaces to be painted:

In general, the following surfaces are to be painted:

A. All exposed piping and other metal surfaces, interior and exterior.

B. All submerged metal surfaces.

C. All structural and miscellaneous steel including tanks.

D. The interior of tanks and wet wells as specified in the painting schedule.

E. Exterior above ground concrete and brick masonry as specified and shown on the plans.

F. The interior of structures as specified in the painting schedule and shown on the plans.

G. Equipment furnished with and without factory finished surfaces, except as specified and shown on the plans.

H. Doors, woodwork, and architectural trim work as specified and shown on the plans.

Surface not to be painted:

The following surfaces in general shall not be painted.

A. Plastic surfaces.

B. Non-ferrous metal unless otherwise noted or indicated (Galvanised metal shall not be considered a non-ferrous metal).

C. Mechanical equipment with approved factory finish as specified herein.

D. Electrical equipment with approved factory finish as specified herein.

E. Piping which is specified as galvanized.

4.8.1.1 Materials

All paint material shall be first quality products manufactured for the exposures involved, as approved by the Engineer. The materials used for (1) Prime Coat, (2) Intermediate Coat, and (3) for Finished Coat and method of applications will be as described in the detailed specifications.

4.8.1.2 Workmanship

Protection of the Work: The Concessionaire shall take all the necessary steps to protect the work during the time his work is in progress. The Concessionaire shall be responsible for any and all damage to the work. Paint shall be applied only during the period of favourable weather.

Preparation of Paint: All materials specified or selected for use under these specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Engineer. Paint containers shall be opened only when required for use. Paint shall be thoroughly stirred or agitated to uniformly smooth consistency suitable for proper application. In all cases, paint shall be prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. No paint shall be reduced or applied in any way except as herein specifically called for or if not specifically called for, then it shall be applied in accordance with the manufacturer's recommendations.

Preparation of Surfaces: The Concessionaire shall examine carefully all faces to be finished and before beginning any of his work shall see that the work of the other trades has been left or installed in a workmanlike condition to receive paint. Metals shall be clean, dry and free from mill scale, rust, grease and oil.

Workmanship: Each coat of paint shall be applied at the proper consistency and brushed evenly, free of brush marks, sags, runs, with no evidence of poor workmanship. Care shall be exercised to avoid lapping

paint on glass or hardware. Paint shall be sharply out of lines. Finished paint surfaces shall be free from defects or blemishes.

Protective Coverings: Protective covering or drop clothes shall be used to protect floors, fixtures and equipment. Care shall be exercised to prevent paint from being spattered onto surfaces which are not to be painted. Surfaces from which such paint can not be removed satisfactorily shall be painted or repainted, as required to produce a satisfactory finish.

Brushing: All paint shall be applied by brush unless otherwise specifically approved by Engineer. The brush size and type shall be got approved.

Instructions: All coating shall be performed by personnel experienced in the application of said coating systems and in accordance with the manufacturer's printed instructions. The final appearance shall exhibit a uniformly textured and coloured coating free of excessive gloss or dull spots, blemishes, sags, runs, pinhole and other defects.

Safety Measures: The Concessionaire shall take adequate safety measures while painting in enclosed places or when painting is carried out by spray gun.

Right of Rejection: No exterior painting or interior finishing shall be done under conditions which may jeopardize the appearance or quality of the painting or finishing in any way. The Engineer shall have the right to reject all material or work that is unsatisfactory, and required the replacement of either or both at the expense of the Concessionaire.

4.8.2 Oil painting

4.8.2.1 Paints

The paint shall be of colour, shade and quality as approved by the Engineer. The paint shall comply with the relevant IS standard depending on the type of paint (i.e., undercoating finishing etc. purpose wise) and mode of application (i.e. by brush, by spraying etc) as specified in the item. The paint shall show no curdling, caking, colour separation and shall be in a smooth and homogenous state. It shall show no runnings or sagging tendencies when applied to smooth steel surfaces. The brand (manufacturer) and shade of the paint shall be got approved from the Engineer before producing the paint. Ready mixed paints shall only be used.

4.8.2.2 Application

The primer coat of the paint shall be applied as soon as the surface has been cleaned to avoid deterioration of the surface by rust, dirt and dust. The paint shall not be applied when atmospheric conditions are misty or unsatisfactory in the opinion of the Engineer. The surfaces not accessible to brushes shall be painted by sprayer or other approved method. The paint shall be applied to produce uniform even coating over the entire surface free from streaks and other irregularities. In case of iron and steel works, red lead shall be used for primer coat unless other coat is specified.

4.8.2.3 Protection

Painted surfaces shall be protected from sun, rain, contamination and damage till they fully dry.

4.8.2.4 Painting new wood work

The surface shall be finished smooth with plain and rubbed smooth with sand paper of coarse grade ($2^1/_2$) followed by rubbing with medium grade sand paper ($1^1/_2$). No scratches should be left. Approved type of priming coat shall then be applied. The minor defects like small holes, cracks, open joints as already

allowed by the Engineer shall be stopped with putty made from pure whiting mixed to proper consistency with raw linseed oil. The work shall be lightly rubbed down smooth before receiving subsequent coat. The coat shall be crossed (across grains) and laid off (along grains) to give uniform coating. The subsequent coats as specified shall be applied only after prior coat dries thoroughly and is lightly rubbed down. Unless otherwise specified the inner surfaces and exposed surfaces shall be applied two or three coats respectively exclusive of primer coat.

4.8.2.5 Scaffolding

Specifications given under section of plastering and painting shall apply.

4.8.3 Providing and applying white wash in 1/2/3 Coats

4.8.3.1 General

The item refers to white washing over old and new concrete, stone masonry, brick or plastered surface and asbestos cement sheets.

4.8.3.2 White wash

White wash shall be prepared from fresh burn white stone, lime or shell item. The item shall be dissolved in a tub with sufficient quantity of water (about 4.50 Lit/Kg of lime) and the whole mass well and thoroughly mixed and stirred until it attains the consistency of thin cream. The wash shall be taken out in small quantities and strained through a clean coarse cloth. Alternatively ready-wear whiting complying with IS 63 may also be used. Clean gum dissolved in hot water shall then beaded to proportion of 2 gm.of gum to a litre of lime or whiting to prevent the white wash coming off easily when rubbed.

4.8.3.3 Scaffolding

This may be double or single according to requirement and shall conform to relevant specification given under the section on 'Cement Plastering'. If ladders are used, pieces of old gunny bags or cloth rags shall be tied on their tops to avoid damage or scratches to the wall. Proper stage scaffolding shall be erected when white washing the ceiling. The Concessionaire shall be responsible for accidents, if any, take place.

4.8.3.4 Preparation of surface

The surface shall be prepared by removing all mortar dropping and foreign matter and thoroughly cleaned with wire or fibre brush or other means as may be directed by the Engineer to produce an approved and clean and even surface. All loose pieces and the scales shall be scrapped off and the holes stopped with mortar. After cleaning the surface the unwanted nails shall be removed and all nail holes, cracks and crevices stopped with mortar similar in composition to the surface to be stopped. The mortar should be cured.

4.8.3.5 Application

On the surface so prepared, the white wash shall be laid. Each coat shall be laid on with a brush. The first stroke of the brush shall be from the top downwards and another from bottom upwards over the first stroke and similarly one stroke from right and another from left over the first brush before it dries. This will form one coat. Each coat must be allowed to dry and shall be subject to inspection before the next coat is applied. When dry, the surface shall show no signs of cracking. It shall present a smooth and uniform finish free from brush marks and it should not come off easily when rubbed with finger.

No portion in the surface shall be left out initially to be patched up later on. For new work, the white washed surface shall present a smooth and uniform finish. For old work, patches and repairs shall be

white washed paint with the required number of coats.

Doors, windows, floors and other articles of furniture etc. shall be protected from being splashed upon. Splashing and dropping, if any, shall be removed and the surface cleaned.

4.8.4 Providing washable distemper

4.8.4.1 Distemper

Washable distemper of approved make, colour and shade shall be used. It shall conform to IS 427. Approved quality distemper shall only be used. The brand shall be got approved from the Engineer, who shall be necessary, call for the sample and ask for sample painting on the surface to be painted before approval.

4.8.4.2 Scaffolding

This may be double or single as per section of plastering and pointing.

4.8.4.3 Preparation of surface

The surface to be distempered shall be cleaned and all cracks, holes and surface defects shall be repaired with gypsum and allowed to set hard. All irregularities shall be sand papered smooth and wiped clean. The surface so prepared must be completely dry and free from dust before distempering is commenced. In the case of walls newly plastered, special care shall be taken to see that it is completely dry before any treatment is attempted, for old surface which had been earlier distempered the surface shall be cleaned of grease, dust etc. The flaking of previous coatings, if any shall be taken off. All cracks, holes and surface defects shall be repaired with gypsum and allowed to set hard then sand papered smooth and wiped clean. But in case the surfaces are coloured or white washed, the wash must be removed thoroughly first.

4.8.4.4 Priming coat

The priming coat shall be applied over the completely dry surface in the manner recommended by the makers in case of patented distempers. When no priming coat is specified by the manufacturer, a finely powdered chalk mixed with a thin solution of glue shall be applied to prepare a good, hard background, the coating when dry being rubbed as cleaned smooth as possible.

4.8.4.5 Application

The instructions of makers shall be followed regarding preparation of the surface and application of priming and finishing coats. Distemper shall not be mixed in a larger quantity than actually required for a day's work. Hot water should be used to prepare the mixture. Distempers shall be applied in dry weather with a broad stiff brush in long parallel strokes. The treated surface shall be allowed to dry and harden. The next coat of distemper shall be laid on in exactly the same manner as the first one but only after the earlier coat, laid has thoroughly dried. The number of coats to be applied shall be as mentioned in the item. The brushes used should never be allowed to rest on the bristles and after the use they should be cleaned. The number of coats as specified in the item shall be applied.

4.8.5 Providing & Applying washable oil bound distemper

4.8.5.1 General

The Specifications given under washable distemper shall apply except that washable oil bound distemper of approved shade, colour and quality, conforming to IS: 428 shall be used after applying primer coat as recommended by makers of distemper.

4.8.6 Cement painting in two coats

4.8.6.1 General

Cement paint; with a base of white Portland cement of approved make, colour and shade shall be used. Approved quality cement paint shall only be used and shall be brought to site in original airtight containers with seals intact.

4.8.6.2 Scaffolding

As per Specifications under 'Plastering and Pointing'

4.8.6.3 Preparing the surface

The surface to be painted shall be cleaned of all loose dust and dirt, old paint and all cracks, holes and surface defects shall be repaired with cement plaster, cured and allowed to set hard. Before painting is commenced, the surface is wetted well and water is allowed to run off. Any grease, oil paint, shall be removed by approved methods.

4.8.6.4 Application of paint

Mixing of paint and procedure of painting shall be as specified by the manufacturer. When no specifications are furnished, following specifications shall generally apply.

The dry cement paint shall be thoroughly mixed with clean fresh water to produce paint of required consistency (normally that of ordinary paints). The paint shall be kept stirred and used within one hour of mixing. Hardened or damaged paint shall not be used.

The paint shall be applied by brushes in the manner specified by the manufacturer. The number of coats shall be as mentioned in the wording of the item. When more than one coat is to be provided, the subsequent coats shall be applied after the preceding coat has thoroughly hardened, inspected and approved as per manufacturer's specifications.

4.8.6.5 Curing

Each application of paint should be wetted at the end of the day with a fine water spray. Depending on climatic conditions, wetting should be done only after an interval of at least 6-8 hours after the application. In dry weather the painted surfaces shall be kept damp for at least two days and protected from direct sun.

4.9 Bearing Piles

4.9.1 Scope

4.9.1.1 Coverage

This Part contains requirements which, where relevant to this Contract, shall apply to bearing piles of the following types:

— precast reinforced concrete;

— precast prestressed concrete;

— driven cast-in-place concrete;

— bored cast-in-place concrete;

— continuous flight augered cast-in-place concrete;

— steel piles of H-section or box section.

4.9.1.2 Definitions

Bearing piles are piles supporting structures in the Permanent Works. They may be required to resist vertical loads in a downward or upward direction, or both. Some bearing piles may be raked to resist lateral loads.

4.9.2 Reference standards

Following standards are referred to in the Specification:

IS 2062 Steel for general structural purpose.

IS 2063 Weldable structural steels

IS 800 Code of practice for general construction in steel.

IS 9595 Process of arc welding of carbon and carbon manganese steels

IS 1785 High strength deformed steel bar & wires.

IS 456 Code of practice for plain & reinforced concrete.

IS 2911 : Part 1 : Section 1 Code of practice for design & Construction of pile foundations –

Part 1 : concrete piles – Section 1 : Drives cast in situ concrete.

IS 2911 : Part 1 : Section 2Code of practice for design & Construction of pile foundations –

Part 1 : concrete piles – Section 2 : Bored cast in situ piles.

IS 2911 : Part 1 : Section 3Code of practice for design & Construction of pile foundations –

Part 1 : concrete piles – Section 3 : Driven precast concrete Pile.

IS 2911 : Part 1 : Section 4Code of practice for design & Construction of pile foundations –

Part 1 : concrete piles – Section 4 : Bored precast concrete Pile.

IS 2911 : Part 4 Code of practice for design & Construction of pile foundations –

Part 4 : load test on piles.

IS 2911 : Part III Code of practice for design & Construction of pile foundations –

Part III : under reamed piles.

4.9.3 Design and materials

4.9.3.1 General — piles of all types

Bearing piles shall be designed to carry safely the working loads shown in the Drawings. The ultimate bearing capacity, as determined by test in accordance with Clause 26.6.1, shall be at least twice the working load. The ultimate bearing capacity is defined as the load which, applied at the head of the pile, causes the head of the pile to settle a distance equal to one-tenth of the pile diameter. In the case of non-circular piles, 'diameter' shall be taken to mean the diameter of the circle having an area equal to the cross-sectional area of the pile or, in the case of steel H-piles, to the area bounded by the flanges and lines joining the edges of the flanges.

The approximate length of bearing piles shall be determined from any geological information included in the Specification or obtained by preliminary site investigation or shall be determined from load tests carried out on non-working piles.

The final length of driven piles shall be determined by driving to a 'final set', expressed as the penetration in millimetres per 10 blows, approved by the Engineer. The final set may be calculated using an established pile-driving formula but shall not exceed the average of final sets recorded when driving non-working piles which have achieved the required ultimate bearing capacity.

The final length of bored or augered piles shall be not less than the average length of non-working piles which have achieved the required ultimate bearing capacity.

Precast concrete piles and pile casings shall be designed to develop the strength necessary to withstand without damage the stresses arising during transportation, handling and driving. The design shall be such that the compressive stress in the concrete during handling and pitching and under the working load does not exceed 0.275 f_{cu} due to direct load or 0.366 f_{cu} due to bending, where f_{cu} is the 28-day works cube stress.

Where not otherwise specified herein, the design of all piles shall comply with the relevant recommendations of IS: 2911.

4.9.3.2 Precast reinforced concrete piles

Depending upon the nature of the ground through which the piles are to be driven, and the nature and concentrations of dissolved salts in the groundwater, concrete for use in piles shall be made with ordinary Portland cement, sulphate-resisting Portland cement or super-sulphated cement, as per IS 2911 Section 3. The maximum size of aggregate shall be 20mm and the minimum cement content 370kg/m³ of finished concrete. Except where otherwise specified, the maximum free water/cement ratio shall be 0.4. The minimum cube strength at 28 days shall be 25N/mm².

Concrete mixes shall be specified in accordance with the requirements of the Specification given elsewhere.

The cover to all reinforcement including binding wire shall be not less than 50mm. Hoops and links shall fit tightly against longitudinal bars and be bound to them by welding or soft iron wire with the free ends turned inwards. The longitudinal bars shall be held apart by spreader forks not more than 1.5m apart.

The main longitudinal bars shall be level at the top of the pile and fit tightly into the shoe if one is used. Joints in the main longitudinal bars shall be made by full-penetration butt welding in accordance with IS 816-1969.

Piles shall be provided with flat or pointed co-axial shoes of steel or cast iron if the concrete at the tip of the pile is liable to be damaged by driving.

Reinforcement shall comprise mild steel deformed bars and shall meet the following minimum requirements:

(a) longitudinal reinforcement shall be at least 10% of the gross concrete area;

(b) lateral reinforcement shall be in the form of hoops or links having a diameter of at least 6mm;

(c) the volume of lateral reinforcement shall be at least 0.2% of the gross volume except near the top of the pile where, for a distance of three times the width/diameter of the pile measured from the top of the

pile, the volume of lateral reinforcement shall be not less than 0.6% of the gross volume, and for an equal distance below this where there shall be a gradual transition in the lateral reinforcement from at least 0.6% of the gross volume to at least 0.2%.

Manufacture, curing, transport and storage shall be in accordance with the recommendations of Clause 7.4.2.4 of BS 8004.

4.9.3.3 Precast pre-stressed concrete piles

Design shall be in accordance with the recommendations of Clause 7.4.3.3 of BS 8004 except that the cover to pre-stressing steel and reinforcement shall be not less than 50mm.

Concrete shall be as specified in Clause 26.4.2.

Pre-stressing steel shall be in accordance with IS 1343, IS 2090, IS 6006 & IS 14268. Ordinary reinforcement shall be in accordance with the recommendations of IS 456.

Manufacture, curing and transfer of stress shall be in accordance with the recommendations of Clause 7.4.3.4 of BS 8004.

4.9.3.4 Driven cast-in-place piles

Driven cast-in-place piles shall have a casing of steel or concrete which shall be driven to a set and filled with concrete. The casing may, and where specified shall, be left in place as part of the Permanent Works. The casing shall be suitable for the proposed method of installation and for the purpose of forming a pile.
Precast concrete casing shall be reinforced either with steel bar or mesh or with polypropylene fibres. Concrete for casing and for shoes shall be as specified in Clause 26.4.2. Concrete casings and shoes shall be marked with a reference number and the date at the time they are made. They shall not be used in the Works until they are at least 28 days old.
Concrete casing may be delivered to the Site in short lengths ready for jointing. The use of damaged or cracked lengths of concrete casing will not be permitted.
Steel casing shall be of mild steel to IS: 2062 and shall be delivered to the Site in as long lengths as the Concessionaire can reasonably handle.
Concrete for filling the casing shall be as specified in Clause 26.4.2 except that the maximum free water/cement ratio shall be 0.45. It shall have adequate workability for the method of placing used to form the pile. The average compressive stress under working load shall not exceed 25% of the specified works cube strength at 28 days calculated on the total cross-sectional area of the pile.

Unless otherwise specified, the cast-in-place concrete shall be reinforced over the whole length with mild steel deformed bars to IS: 1786. The Concessionaire shall provide such steel as is necessary to comply with the provisions of IS: 456 for resisting stresses with a minimum longitudinal reinforcement of 0.8% of the gross concrete area in the top 3m of the pile. The cover to all reinforcement, including binding wire, shall be not less than 50mm measured to the inside of the casing, suitable spacers being provided to ensure this. Joints in the main longitudinal bars shall be made by full-penetration butt welding in accordance with IS: 816.

4.9.3.5 Bored cast-in-place piles

Bored cast-in-place piles shall have a casing of steel which shall be filled with concrete. The casing may, and where specified shall, be left in place as part of the Permanent Works. The casing shall be suitable for the method of installation and for the purpose of forming a pile.
Steel casing and concrete for filling it shall be as specified.
Unless otherwise specified, piles shall be reinforced over the whole of their length as specified in the last paragraph of Clause B9.4.4.

4.9.3.6 Continuous-flight augered piles

Continuous-flight augered piles are piles formed by boring with a continuous-flight auger and pumping concrete or grout down the hollow stem of the auger during retraction.

Concrete shall be in accordance with Clause B9.4.2 except that the maximum free water/cement ratio may be increased as necessary to achieve the required workability. The mix shall be so designed that there is no segregation and only a minimum of bleeding.

Unless otherwise specified, the upper part of the piles shall be reinforced down to the depth specified or approved. Reinforcement shall be as specified in the last paragraph of Clause B9.4.4 and shall be made up into cages designed to be inserted through the already-placed concrete or grout.

4.9.3.7 Steel bearing piles

Steel bearing piles shall be either of H-beam section or fabricated box piles.

Steel sections, whether plain or fabricated, shall comply with IS 2062 & SP6 (All parts).

The cross-sectional area of the steel shall be sufficient to withstand the blows of the hammer during driving and to carry the working load on the pile. The stress in the steel at working load shall not exceed 30% of the yield stress. Where the finished pile projects above the ground level the working stresses shall be reduced by the appropriate buckling coefficient.

The working load shall be transmitted to the pile through a capping plate, dowel bars or cleats.

Unless otherwise specified, fabricated box piles shall be filled with concrete, made with sulphate-resisting cement and with aggregate of 20mm maximum size. The minimum cement control shall be 330 kg/m^3 and the maximum free water/cement ratio shall be 0.50. Minimum works cube strength at 28 days shall be 25N/mm^2.

The bottom end of box piles shall be closed with a welded flat plate or a shaped shoe of cast iron, cast steel or fabricated steel.

4.9.4 Installation

4.9.4.1 General — piles of all types

The Concessionaire's method of working shall be such that the installation of the piles shall not cause any damage to adjacent structures or foundations.

The Concessionaire shall select his method or times of working or both to limit the noise of driving to reasonable levels and to comply with environmental legislation.

The sequence of working shall be to the approval of the Engineer and shall be arranged so as to minimise the vertical and lateral displacement of completed piles. Levels of the tops of adjacent piles shall be measured at intervals while a pile is being driven. Piles which have risen shall be re-driven or forced down to the original resistance.

Piles shall be constructed within the following tolerances:

(a) in plan, at the working level of the piling rig, 75mm in any direction from the position shown in the Drawings;

(b) 1 in 75 from the vertical for a vertical pile;

(c) 1 in 25 from the specified rake for a raking pile.

Where not otherwise specified herein, installation of all piles shall comply with relevant recommendations of BS: 8004.

4.9.4.2 Precast reinforced concrete piles

Piles shall be driven by a hammer of such a type and weight and with such a stroke that no damage is caused to the pile.

When the 'final set' has been achieved, repeat sets shall be carried out only with the approval of the Engineer.

The driving conditions when taking the 'set' shall be the same as those used when the sets on the non-working piles, described in Section B9.6, are obtained.

The pile head shall be protected during the driving with packing of resilient material evenly spread and held securely in place. A helmet shall be placed over the packing and provided with a dolly of hardwood or other suitable material not thicker than the width of the pile.

Pile heads shall be stripped down carefully, so as not to damage the pile, to a level such that the remaining concrete will project 50mm into the pile cap. The reinforcement shall be exposed for a length of 40 times the diameter of the main longitudinal bars, to permit it to be bonded into the cap. Any cracked or defective concrete shall be cut away and replaced with new concrete properly bonded to the old.

Where a pile has to be lengthened the concrete at the top of the original pile shall be cut down to expose not less than 200mm of the longitudinal reinforcement. Additional reinforcement shall be joined by full-penetration butt welding in accordance with BS 5135. Alternatively, the joint may be made by lapping the reinforcement, in which case the reinforcement at the head of the pile shall be exposed for a distance of 40 times the diameter of the bars and the new bars overlapped over this distance.

4.9.4.3 Pre-stressed concrete piles

Driving shall be in accordance with Clause 4.5.2 above and with the recommendations of Clause 7.4.3.5 of BS 8004.

The bonding of the pile into the pile cap shall be in accordance with the recommendations of Clause 7.4.3.6 of BS 8004.

Any lengthening of piles shall be in accordance with the recommendations of Clause 7.4.3.7 of BS 8004.

4.9.4.4 Driven cast-in-place piles

Steel casing shall be bottom driven by an internal drop hammer.

Concrete casing shall be driven on the pile shoe using a mandrel.

If steel casing has to be lengthened joints shall be made by butt welding in accordance with BS 5135 so that the full strength of the original section is developed. The joints shall be designed to maintain the true alignment and position of the pile section.

Concrete casing shall be jointed by coating the meeting faces with a plastic jointing compound and covering the closed joint with a steel strap.

All joints in the casing and between the casing and shoes shall be watertight during driving and on completion. The casing shall be inspected from the top after installation to check that it is neither damaged

nor deformed.

The casing shall be completely filled with concrete, every precaution being taken to prevent waisting or the formation of voids.

The bonding of the pile into the pile cap shall be in accordance with Clause B9.5.2 above.

4.9.4.5 Bored cast-in-place piles

During boring, the inflow of soil and the formation of cavities in the surrounding ground shall be prevented by adopting one or more of the recommendations of the first paragraph of Clause 7.4.5.4.1 of BS 8004.

Shelling out shall be done with a tool at least 75mm smaller in diameter than the casing and at such a speed that piping of the soil at the bottom of the boring does not occur.

Where the hole is dry, concrete shall be poured through a funnel and tube so that the flow is directed and does not hit reinforcement bars or the side of the hole. Where the cut-off level is below the groundwater level, a pressure shall be maintained on the unset concrete equal to or greater than the groundwater pressure.

Concreting under water or drilling mud shall be in accordance with Clause 7.4.5.4.2 of BS 8004.

The bonding of the pile into the pile cap shall be in accordance with above.

4.9.4.6 Continuous - flight augered piles

Boring shall be by a continuous-flight auger capable of penetrating the ground without drawing surrounding soils into the bore. The auger shall not be raised until the required depth has been reached and until concrete or grout is being pumped down the hollow stem of the auger.

The rate of withdrawal of the auger shall be so controlled that the concrete or grout forms a continuous monolithic pile having the specified or approved cross section at all levels.

The reinforcement cage shall be inserted into the concrete with the minimum of delay after completion of concreting or grouting and shall be supported in its correct position with the required projection above the cut-off level.

The bonding of the pile into the pile cap shall be in accordance with Clause B9.5.2 above.

4.9.4.7 Steel bearing piles

Piles shall be driven by a hammer of such a type and weight and with such a stroke that no damage is caused to the pile.

When the ‘final set’ has been achieved, repeat sets shall be carried out only with the approval of the Engineer.

The driving conditions when taking the ‘set’ shall be the same as those used when the sets on the test piles, described below are obtained.

The pile head shall be protected during the driving with packing or resilient material evenly spread and held securely in place. A helmet shall be placed over the packing and provided with a dolly of hardwood or other suitable material not thicker than the width of the pile.

Piles that have to be lengthened shall be jointed by butt-welding in such a manner that the full strength of the original section is developed in accordance with IS 2911 (all parts). The joints shall be designed and

constructed to maintain the true alignment and position of the pile sections. The joints in box piles shall be watertight.

Where any part of the pile is exposed to the atmosphere or to backfill the thickness of the steel over that required by the design criteria shall be increased on each exposed face by 4mm.

4.9.4.8 Recording of pile installation

The Concessionaire shall keep records of every pile as follows:

— pile type;

— pile number;

— original ground level related to Ordnance Datum Newlyn;

— nominal diameter or dimensions;

— date driven or bored;

— date concreted;

— depth from ground level to toe of pile;

— depth or height from ground level to cut-off level of pile;

— depth or height from ground level to top of the concrete;

— final set for driven piles, weight and drops of hammer;

— details of any obstructions observed.

The Concessionaire shall also take a full driving record for all non-working piles and up to 20% of all the driven piles as directed by the Engineer. This full record shall include the number of blows for each 250mm of driving until the target toe level is approached or until the driving resistance increases to the calculated set value, whichever occurs first; thereafter the number of blows for each 50mm of driving.

All records shall be accurately kept in duplicate as the work proceeds and one copy shall be handed to the Engineer as soon as practicable after driving and not later than the completion of each day's work.

Testing

The Concessionaire shall carry out maintained load tests on piles as per IS: 2911 Part 4.

(a)non-working piles, constructed for test purposes at positions selected by the Engineer, shall be tested to the ultimate bearing capacity. These test piles shall be constructed in the same manner and to the same set (where applicable) as the working piles.

(b)Working piles (meaning piles forming part of the Permanent Works) will be selected at random by the Engineer and tested to a load of one and a half times the working load.

Piles shall not be tested until crushing tests on control cubes from the same mix and cured in the same way as the piles, show strengths greater than the specified works cube strength at 28 days.

The test procedure shall be in accordance with the recommendations of IS 2911 part 4.

If a non-working pile fails to achieve the specified ultimate bearing capacity, the Concessionaire shall submit for the approval of the Engineer his alternative proposals for piles to meet the Specification. If, in

the opinion of the Engineer, a test on a working pile indicates that the pile does not have the specified ultimate bearing capacity, the Concessionaire shall submit for the approval of the Engineer his proposals for:

(a) further testing of working piles and

(b) measures to ensure the integrity of the foundation.

4.10 Roadworks

4.10.1 Scope

This specification covers the furnishing of all materials, plant, labour, equipment, tools and services for the complete and proper construction of pavements from water-bound macadam with bituminous surfacing treatments and cross drainage works. It shall apply to new roads and reinstatement.

4.10.2 Reference standards

Unless otherwise specified, roadworks and footpaths shall comply with the relevant Reference Standards listed below.

4.10.3 C10.3 Submissions by the Concessionaire

The Concessionaire shall submit the following items to the Engineer for his approval in advance of constructing the Works.

(a) Proposals/samples for:

- sub-base material;
- road base material;
- bituminous emulsions;
- coated macadam;
- flexible surfacing;
- road marking paint;
- precast concrete paving blocks;
- vitrified clay pipes and ducts;
- precast concrete pipes;
- precast concrete channels kerbs and edgings;
- precast concrete flags.

(b) Certificates:

- suppliers' certificates of compliance with specified requirements for the above.

4.10.4 Materials

4.10.4.1 General

All materials shall be obtained from local sources and shall be subject to approval by the Engineer prior to use. Substitution of material shall be on an "Approved equal" basis as determined by the Engineer and shall result in finished roads as designated in this Specification and at no additional cost to the Employer.

Mineral aggregates shall consist of natural or crushed stone, gravel or sand, shall be of reasonably uniform quality throughout, and shall be clean and free from soft or decomposed particles, excess clay, foreign, organic, or other deleterious matter.

4.10.4.2 Coarse aggregate for sub-base, base and semi grout

Coarse aggregate shall be crushed or broken stone and shall conform to the physical requirement given below.

Physica1 Requirements of Crushed Stone for Road Work:

Sr. No.	**Test**	**Limiting Value**	
		For aggregates to be used for Road base and surfacing	For aggregate to be used for sub-grade
1.	Specific Gravity	Not less than 2.6	Not less than 2.0
2.	Water Absorption	Not more than 2%	Not more than 5%
3.	Flakiness Index	Maximum 25%	--
4.	Elongation Index	Maximum 40%	--
5.	Aggregate Impact Value or Aggregate Crushing Value	Not more than 30%	Not more than 40%
6.	Los Angeles Abrasion Value	Not more than 30%	Not more than 50%
7.	Stripping Test	Maximum 15%	--

The crushed or broken stone shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter. Crushed or broken stone shall conform to the grading given below.

Grading Requirements of Coarse Aggregates:

Grading No.	**Size Range**	**I.S. Sieve Designations**	**Percent by Weight passing the sieve**
Grade	90 mm to 40	100 mm	100

1	mm	80 mm 63 mm 40 mm 20 mm	65 - 85 25 - 60 0 - 15 0 - 5
Grade 2	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
Grade 3	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

4.10.4.3 Screenings

Screenings shall consist of predominantly non-plastic materials such as sandy gravel or gravel (other than rounded river borne material) with Liquid Limit and Plasticity Index below 20 and 6 respectively and fraction passing 75micron sieve not exceeding 10%. The material shall be sound and hard, free from all impurities and shall be screened at the quarry. Gravel shall comprise large, coarse, siliceous grains, sharp and gritty to the touch, thoroughly free from dirt and impurities. Screenings shall conform to the grading indicated below.

Grading for Screenings:

Grading Classification	**Size of Screenings**	**I.S. Sieve Designation**	**Percent by Weight passing the Sieve**
A	12.5 mm	12.5 mm 10.0 mm 4.75 mm 150 microns	100 90 - 100 10 - 30 0 - 8
B	10.0 mm	10.0 mm 4.75 mm 150 microns 75 microns	100 85 - 100 10 - 30 0 - 10

4.10.4.4 Blinding material

Any non-plastic material such as gravel/grit/dust/sand/brick powder may be used to act as blinding to fill in the voids in the coarse aggregates. The plasticity index of the material shall not exceed six.

4.10.4.5 Bituminous macadam

The grading, composition and characteristics of bituminous macadam shall be as follows:

Aggregate Grading, 50mm graded:

IS Sieve Designation	Percentage Passing
50mm	100
40mm	60-100
25mm	30-70
20mm	20-70
6.3mm	10-20
2.36mm	0-5
Bitumen (Grade S65)	**3.7 to 4.3% by weight of total mix**

Aggregate Grading, 25mm graded:

IS Sieve Designation	Percentage Passing
25mm	100
6.3mm	10-40
2.36mm	0-5
Bitumen (Grade S65)	**3.7 to 4.3% by weight of total mix**

Aggregate Grading, 12mm graded:

IS Sieve Designation	Percentage Passing
12mm	100
6.3mm	10-40
2.36mm	0-5
Bitumen (Grade S65)	**3.7 to 4.3% by weight of total mix**

4.10.4.6 Seal coat

The grading, composition and characteristics of 6mm seal coat shall be as follows:

Aggregate grading

I.S. Sieve designation	Percentage passing
6.3 mm	100

2.36 mm	70 - 100
600 microns	25 - 50
300 microns	0 - 10

Bitumen (Grade S65) Content: 7% to 8% by weight of total mix.

4.10.4.7 Binder

Binder shall be straight run Bitumen of grade S35 or S65 and shall conform to the requirements for Bitumen Binder specified below.

Sr. No.	Characteristic	Requirement for Grade		Method of Test Reference to
		S 35	S 65	
1.	Specific gravity at 27°C, Min.	0.99	0.99	IS : 1202
2.	Water percent by weight, Max	0.2	0.2	IS : 1211
3.	Flash point, Pensky Martens closed type °C, Min.	175	175	IS : 1209 (Method A)
4.	Softening point, °C	50-65	40-55	IS : 1205
5.	Penetration, at 25°C, 100 g, 5 sec in 1/100 cm	30-40	60-70	IS : 1203
6.	Ductility at 20°C in cm, Min.	50	75	IS : 1208
7(a)	Loss on beating, percent by weight, Max.	1	1	IS : 1212
(b)	Penetration of residue (expressed as percentage of item 5), Min	60	60	IS : 1203
8.	Matter soluble in carbon disulphide, percent by weight, Min.	99	99	IS : 1216

4.10.4.8 Slab culverts

Concrete for Cast in-situ culverts shall be of reinforced M20 concrete unless otherwise shown. Masonry and brickwork shall comply with the section of this Specification concerning Building Works. Pre-cast concrete culverts shall be to the approval of the Engineer.

4.10.4.9 Pipe drains

Pipes for road drainage shall be precast concrete pipes Class NP2/NP3, and shall conform to IS:458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by the

Engineer at the place of manufacture or at Site before their incorporation in the Works.

4.10.5 Workmanship

4.10.5.1 Setting out

The Concessionaire shall provide all labour and materials such as line, strings, pegs, nails, bamboos, stones, mortar, concrete, etc., required for setting out, establishing bench marks and giving profiles. The Concessionaire shall maintain any established setting out items such as bench marks, profiles and other stakes and marks as long as they are required for the work in the opinion of the Engineer.

4.10.5.2 Earthwork

Earthworks shall comply with the provisions of the section of the Specification for Earthworks.

4.10.5.3 Preparation of sub-grade

Sub-grade shall be cleaned of all foreign substances, vegetation, etc immediately prior to laying sub-base. Any ruts or soft spots shall be corrected and the sub-grade dressed off parallel to the finished profile. The sub-grade camber shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section.

The prepared sub-grade shall be lightly sprinkled with water as necessary, and rolled with a powered roller of 10-12 tones. The roller shall make a minimum of five passes. Any undulations in the surface that develop due to rolling shall be made good with approved earth and sub-grade re-rolled.

4.10.5.4 Depth of coursing

Each course shall be constructed to the final minimum compacted thickness shown in the table below, based on the type of road indicated. In the case of National, State, District, City and Municipal roads, the details shall be agreed with the relevant Authority and may vary accordingly.

Type of Road		Sub-base	Base Course	Wearing Course
National Highway	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	150	75	40
State Highway	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40
District Road	Material	Grade 2	Grade 3	12mm graded + seal coat
	Thickness	75	75	20
City/Municipal Road	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40
Village Road	Material	Grade 2	Grade 3	12mm graded + seal coat

	Thickness	75	75	20
Service Roads	Material	Grade 2	Grade 3	25mm graded + seal coat
	Thickness	75	75	40

4.10.5.5 Sub-base

General

Sub-base shall not be constructed on wet sub-grade. The sub-base course shall be 150 mm wider on either side than the wearing course.

Spreading and rolling

Spreading shall be uniform and even upon the prepared sub-grade. The spreading shall be done from stock piles along the side of the roadway. In no case shall the aggregates be dumped in heaps directly on the prepared sub-grade nor shall hauling over an uncompacted or partially compacted base be permitted. The surface of the aggregate shall be carefully checked with templates and all high or low .spots remedied by adding or removing aggregate. No segregation of large or fine particles shall be allowed.

The material shall be rolled immediately following spreading and shall be done with three wheeled, powered rollers of 10 to 12 tonnes capacity or tandem or vibratory rollers of a type approved by the Engineer. Rolling shall begin from the edges gradually progressing towards the centre, with the roller moving parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be continued until the material has been thoroughly keyed and forward movement of stones ahead of the roller is no longer visible. Slight sprinkling of water may be done if necessary.

Application of blinding

Blinding shall be applied by spreading approved dry screened material uniformly and brushing it into the voids and shall continue until the voids are filled. Once the voids are filled with dry material the surface shall be wetted thoroughly and additional blinding added if necessary to top up any voids. The final surface shall be well bound and void free. This procedure shall be applied to both layers.

4.10.5.6 Water bound macadam base course

4.10.5.6.1 Preparation of base

The sub-base shall be .prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

4.10.5.6.2 Spreading coarse aggregate

Coarse aggregates shall be spread uniformly upon the prepared base and compacted to 80 mm.

Spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots

remedied by removing or adding aggregate. No segregation of large or fine particles shall be allowed.

Coarse aggregate shall not be spread more than 3 days in advance of the subsequent operations.

4.10.5.6.3 Rolling

The material shall be rolled immediately following spreading and shall be done with three wheeled, powered rollers of 10 to 12 tonnes capacity or tandem or vibratory rollers of a type approved by the Engineer.

On super elevated portions rolling shall proceed from inner to outer edge. Otherwise rolling shall begin from the edges gradually progressing towards the centre, with the roller moving parallel to the center line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space to permit application of blinding. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the sub-grade or sub-base is soft or yielding or when it causes a wave-like motion in the sub-grade or base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall blinding be permitted to make up depressions.

4.10.5.6.4 Application of blinding

Blinding shall be applied by spreading approved dry screened material uniformly and brushing it into the voids and shall continue until the voids are filled. Once the voids are filled with dry material the surface shall be wetted thoroughly and additional blinding added if necessary to top up any voids. The final surface shall be well bound and void free. This procedure shall be applied to both layers.Blinding material shall be spread and finished in the same day.

4.10.5.6.5 Setting and drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. The next morning the surface shall be inspected and any voids blinded, and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed surface if in his opinion it would cause excessive damage.

4.10.6 Tack coat

4.10.6.6 Preparation of base

The base course surface shall be prepared, shaped and conditioned to the specific lines, grade and cross section by repairing all potholes, patches and ruts. Potholes shall be drained of water and cut to regular shape with vertical sides. All loose and disintegrated material shall be removed. Potholes shall be repaired by painting the sides and bottom of the hole with bitumen and either:

Filling with coarse aggregate and screenings, compacted with heavy hand rammers or approved mechanical tempers; or

Filling with premixed chippings with binder (bitumen grade S 35/ S 65) content of 3 percent by weight of total mix, after painting the sides and bottom of the holes with a thin application of bitumen,

4.10.6.7 Application

The surface shall be cleared of dust and loose matter. The binder used for tack coat shall be bitumen of suitable penetration grade within S35 to S65 conforming to IS:73. Binder shall be heated to the temperature appropriate to its grade and as approved by the Engineer. The binder shall be sprayed on the prepared base at the rate of 1.0 kg/sq.m. The binder shall be applied uniformly with the aid of either self-propelled or towed bitumen pressure sprayer with self-heating arrangement and spraying nozzle arrangement to provide a uniform spread. The tack coat shall be applied just ahead of laying asphalt macadam.

4.10.7 Bituminous macadam

4.10.7.6 Application

The bituminous macadam shall be laid by mechanical compactor and finisher, the final consolidation being by means of power roller weighing not less than 10 tonnes. The finished surface shall not vary by more than 12.5 mm above or below the designed level and the average thickness shall not be less than 65 mm after consolidation.

The bituminous macadam may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

4.10.7.7 Protection of pavement

During the period between initial compaction of the coarse aggregate and completion of the seal coat, the surface shall be protected from all traffic other than absolutely essential to its construction.

4.10.7.8 Premixed seal coat

After the aggregate has been rolled, the interstices shall be completely filled with pre-coated grit of the following composition:

The premixed seal may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case, mixing shall be carried out in a power driven pugmill mixer and shall be continued until all the aggregate is coated.

The premixed seal must be brushed to fill in the interstices, additional material being applied during rolling if found necessary. The quantity of premixed seal required for this purpose shall be 1.22 cu.m. per 100 sq.m.

4.10.8 Quality control

4.10.8.1 General

All works performed shall conform to the lines, grades, cross sections and dimensions as specified or as directed by the Engineer subject to the permitted tolerances described hereinafter.

4.10.8.2 Horizontal alignments

These shall be reckoned with respect to the centreline of the carriageway as specified. The edges of the carriageway as constructed and all other parallel alignments shall be corrected within a tolerance of ± 20 mm.

4.10.8.3 Longitudinal profile

The level of any point on the various surfaces after compaction shall comply with the following

Surface	Tolerance from specified level
Sub-grade	± 25 mm
Sub-base	± 20 mm
Base course	± 15 mm
Wearing course	± 10 mm

However, the negative tolerance for wearing course, shall not be permitted in conjunction with the positive tolerance for the base course, if the thickness of the wearing course is thereby reduced by more than 6 mm.

4.10.9 Slab culverts

4.10.9.1 Graded gravel free draining backfill

Free draining backfill 200mm thick shall be provided on each side of uncoursed rubble walls supporting slabs. The material for this backfill shall be granular, consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and organic matter. It shall be graded to the approval of the Engineer.

4.10.10 Pipe drains

Surface water drainage for roads shall consist of open ditches or of piped drainage. Where practicable, drainage work under the roadway shall be completed before roadworks are commenced.

Open ditches shall be excavated to the appropriate cross-section with the sides dressed fair throughout and the bottoms accurately graded to regular falls.

French drains shall be excavated and backfilled to the appropriate cross-section and filled with free-draining granular material and shall incorporate porous or perforated pipes as necessary.

Trenches for piped drainage shall be excavated to the minimum dimensions necessary for the proper construction of the Works, and after pipes have been laid, tested and surrounded with gravel or concrete, the trenches shall be back-filled with selected excavated material and compacted to a dry density equal to that of the adjacent ground. Surplus excavated material shall be disposed of to the Concessionaire's tip. Trenches shall be kept free from standing water.

Pipes shall be laid with a permitted tolerance of 20mm in line and level. Where directed by the Engineer pipes shall be haunched or surrounded with concrete. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert. All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. The ends of the pipes shall be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

The pipe strength and surround for crossings under the roadway shall be designed to take account of final

vehicle loading. The Concessionaire shall at no extra cost to the Employer take all necessary precautions to avoid damage occurring to the pipes as a result of construction traffic. Should any damage occur to the pipes as a result of construction traffic, the Concessionaire shall at no extra cost to the Employer replace the damaged pipes to the satisfaction of the Engineer. Porous or perforated pipes shall be laid dry-jointed and shall be surrounded with gravel.

Where the Concessionaire is required to lay ducts for Statutory Undertakers then these shall be laid in the appropriate positions, draw ropes laid inside the duct and the Concessionaire shall adequately record or mark the position of the ducts as instructed by the Engineer.

Precast concrete manholes and gullies shall be constructed complete with cast iron covers or gully gratings. No cover or grating shall be set at such a level relative to final pavement level that, in the opinion of the Engineer, it constitutes a danger to pedestrians or traffic.

4.10.11 Inspection and testing

The longitudinal profile shall be checked with a 3.0 m long straight edge, along the centreline of the road. The transverse profile shall be checked with a camber board at intervals of 30 m. Permitted tolerances are specified below: Permitted tolerances of Surface Regularity for Pavement Courses

Sl. No.	**Type of Construction**	**Longitudinal Profile (Maximum permissible undulation when measured with a 3 m straight edge) (mm)**	**Cross Profile (Maximum permissible variation from specified profile when measured with a camber template) (mm)**
1	Sub-grade	18	12
2	Sub-base	18	12
3	Base-Course Asphalt	12	10
4	Macadam	10	8

4.10.12 Repairing defects

Where the surface irregularity of sub-grade and the various pavement courses falls outside the specified tolerances, the Concessionaire shall rectify these in the manner described below and to the satisfaction of the Engineer.

(a) Sub-grade

Where the surface is high it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by adding fresh material.

(b) Stabilized sub-base

Where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described below:

When the time elapsed between detection of irregularity and the time of mixing is less than 2 hours, the

surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed material as necessary and recompacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to specification. In either case the area treated shall not be less than 5 m long by 2 m wide.

Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted. The area treated at a place shall not be less than 5 m long and 2 m wide.

(c) Bituminous construction

For bituminous construction other than wearing course where the surface is low, the deficiency shall be corrected by adding fresh material and compacting to the Specification. Where the surface is high, the full depth of the layer shall be removed and replaced with fresh material and compacted to the Specification.

For wearing course where surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to the specification. In all cases where removal and replacement of bituminous layer is involved, the area treated shall not be less than 5 m long and 2 m wide.

4.10.13 Quality control test during construction

The Concessionaire shall do the quality control tests described below. The testing frequencies given are the desirable minimum and the Engineer shall have the authority to order tests as frequently as he may deem necessary.

(a) Earthworks for embankment construction:

Sl. No.	Test	Frequency
1.	Plasticity	As directed by the Engineer
2.	Density	Each soil type to be tested. 1-2 tests per 8000 cubic metres of soil
3.	Deleterious Content	As directed by the Engineer
4.	Moisture content	1 test for every 250 cubic metres of soil
5.	CBR test	As required by the Engineer

(b) Construction testing:

Sl. No.	Type of Construction	Test		Frequency
1.	Sub-base	i)	Gradation	1 test per 2000 m2
		ii)	Plasticity	As required

Sl. No.	Type of Construction	Test		Frequency
		iii)	Deleterious Constituents	As required
		iv)	CBR test	As required
		v)	Moisture content prior to compaction	1 test per 250 m2
		vi)	Dry density	1 test per 500 m2
2.	Water Bound Macadam	i)	Gradation	1 test per 1000 m2
		ii)	Flakiness index	1 test per 2000 m2
		iii)	Plasticity of binding material	1 test per 1000 m2
3.	Bitumen Macadam	i)	Quality of binder	As required
		ii)	Aggregate impact value	1 test per 50-100 m2 of aggregate
		iii)	Flakiness index	1 test per 50-100 m2 of aggregate
		iv)	Grading of aggregates	2 tests per day per plant, both on the individual constituents and mixed aggregates from the dryer (one at plant and one at Municipal Lab)
		v)	Binder content	Periodic subject to 2 tests per day per plant

Sl. No.	Type of Construction	Test		Frequency
		vi)	Control of temp. of binder and aggregate for mixing and of the mix at the time of laying and rolling	At regular close intervals
		vii)	Rate of spread of mixed material	Regular control through checks on layer thickness
4.	Seal Coat	i)	Quality of binder	As required
		ii)	Aggregate Impact Value	1 test per 2000 m2
		iii)	Flakiness Index	1 test per 2000 m2
		iv)	Aggregate grading	2 tests per day
		v)	Temp. of application	At regular close intervals
		vi)	Rate of spread of materials	2 tests per day

Where a specific procedure is not indicated for quality control tests in these specifications, it shall be carried out as per the relevant Indian Standard code of practice.

4.10.14 Compaction control

Density shall be measured once per 500 square metres of compacted area. The determination of density shall be in accordance with IS:2720 (Part 28). Test locations shall be chosen only through random sampling techniques. Assessment shall be based on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 5, as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08 g./cm3.

However, for earth work in shoulders and in the top 500 mm portion of the embankment below the sub-grade, at least one density measurement shall be taken for every 500 square metres of the compacted area

provided further that the number of tests in each set of measurements shall be at least 10.

4.11 Miscellaneous

4.11.8 Lightning conductor

4.11.8.1 General

The item pertains to the providing and fixing of copper lightning conductor including upper terminal, tape conductor, earth plate.

4.11.8.2 Copper tape conductor

Materials

This include copper tape conductor of 25mm x 3mm, solid copper rod upper terminal 19mm dia x 1.5m long with knob at the end with a conical spike on top. Copper earth plate 1.5mm thick and one sq.m in area suitable clamps to fix the conductor charcoal and sand fir filling.

Fixing

The upper terminal shall be fixed vertically at the highest point of the structure and shall be at least 1.5m long. The conductor tape shall be attached to the upper terminal at the lower end by double riveting and soldering and shall be fixed along the building face from outside most exposed to rain, with suitable holdfasts at 1.3M intervals. The conductor shall preferably be in one piece. The lower-most portion of tape for 3m above ground level shall be enclosed in 60mm dia G.I. pipes. All metal surfaces, ridges, rods, gutters etc, shall be connected to the conductor with metal connections.

The tape shall be taken for 1M depth under the ground. Necessary trench and pit shall be excavated for laying of the conductor and copper plate. The copper plate shall be buried 60cm to one metre., below subsoil water level in the driest season of the year. All the joints from the upper end of the top terminal to the earth plate shall be mechanically and electrically perfect. The earth plate shall be surrounded with charcoal.

Testing

The entire installations shall be checked for earth resistance (which shall be less than ten Ohm) and certificate should be produced.

Measurement

The mode of measurement shall be as specified in the bill of quantities (viz., either on number basis or on running meter basis). When it is on running meter, the length, shall be taken from top of terminal to lower end and of copper plate.

4.11.8.3 Aluminum conductor

The lightning conductor shall be in conformity with IS:2309. The type of aluminium conductor as specified in the tender shall be provided.

4.11.9 Water level indicator

It shall consist of providing glazed enamel gauge plate of sufficient height and width of 150 mm as directed having markings in cm and meters, measurable correct upto half the cm. The necessary copper float pulleys, wooden supports, guides at end, steel wires and suitable brass indicator shall also be provided by the Concessionaire at his cost. The whole assembly shall be properly fixed so that it gives the water level above the bed level of the indicator and the arrangement shall not be disturbed by the inflow of water, and

shall operate smoothly. If it does not operate properly, necessary modifications shall be carried out. The unit for payment shall be on per number basis.

4.11.10 Providing & constructing B.B. masonry chambers (Water Supply)

The size of the chamber shall be as mentioned in the description of item and as shown on the Plans. It shall be the internal size. This is a complete item if provided on number unit.

The tender item covers excavation required in wet and dry, C.C. at bottom on well rammed surface and B.B Masonry walls with inside cement plaster and cement pointing from outside and C.C. coping on the top of B.B. Masonry. The work of C.C. and B.B. Masonry shall be carried out as per detailed specifications of respective items. The covers shall be of C.I. M.H. framed cover or precast slab as specified in description of item and as per detailed plans. C.I. M.H frame and cover of specified duty conforming to IS:1726 as relevant shall be provided.

The frame shall be embedded in top coping concrete properly including giving two coats of anti-corrosive black paint to frame and covers, providing locking arrangement as specified.

The work shall be carried out as per detailed drawing of the chamber supplied by the Engineer. The chamber shall be flush with road surface and shall not cause any hindrance to the traffic. The measurements shall be on the basis of number or as specified.

The precast covers shall be of the dimensions as specified in the drawings. Wooden or steel forms shall be built up to give the required dimensions of the slab. The reinforcement as specified shall be fabricated and placed in the form keeping the specified cover. The slab shall then be cast in the form. The concrete may be mixed and compacted manually if not specified otherwise. The side forms shall be removed after 24 hours and sides finished with 1:2 cement mortar immediately. The top of slab shall be suitably marked when the concrete is green. The bottom form if provided may be removed carefully after 7 days. The concrete shall be cured for 14 days after casting. The necessary lifting arrangement as specified will be provided. The slabs shall be fixed with the marked top at the top over the chamber.

This shall include the cost of reinforcement, concrete pre-casting curing, conveyance and fixing the R.C.C. Precast cover.

4.11.11 Spiral stair

This will be in R.C.C. pre-cast steps of one meter width or as shown in the drawing from the ground level to roof of R.C.C. structure with suitable approved railing, central column, intermediate platform and sufficient number of stiffeners at intermediate levels. The tread width at maximum should be at least 250mm and rise not more than 200mm. The payment of this item shall be made on running meter basis (Vertical Lift) above the ground level. The column and column footing below ground level shall be measured in respective concrete items. The specifications for R.C.C. work covered elsewhere shall apply. The work shall be carried out as per dimensions in the drawings using mixes as shown on drawing or as specified

4.11.12 Bulk – Type Water Meter

The water meters shall be helix Woltmann type designed for long life, and to maintain accuracy at all flow rates with minimum wear and minimum head loss. It shall conform BS 5728 or ISO 4064 or IS 2373 and shall be of Class B. The mechanism shall be removable type. It shall be suitable for water at 45˚C.

The measuring mechanism shall comprise a magnetic drive between the measuring element and the sealed

counter unit. Counter units shall provide a clearly legible seven-figure counter incorporating a centre sweep hand which enables precise readings to be taken. The meter shall be with internal regulating arrangement with temper-proof arrangement. Water meter shall be suitable for the ambient temperature of 50˚ C with suitable dirt box. The meter body shall be cast in spheroidal graphite iron BS EN 1563:1997 with end flanges drilled to suit the piping installations. The meter shall be provided with dirt box.

Material in contact with water shall be resistant to corrosion and shall be non-toxic, non-tainting.

The bulk water meter shall be tested as per relevant standard and the test shall be witnessed by the Engineer's representative or independent authority approved by the Engineer.

Certificates as follows shall be furnished

i Test certificate including calibration over flow range.
ii Certificate for material of construction for vital components and body.

Flange adaptor, reducers and other fittings as necessary shall be provided. The water meter with fitting shall be installed in suitable chamber.

5 MECHANICAL SPECIFICATIONS

5.1 General

This part of specification shall cover mechanical items, which are to be used in this plant.

The major equipment, which will be used are listed below, this list is not exhaustive, the bidder is to provide all necessary equipment required for achieving the project objectives and as required in scope of work:

Pumps-Centrifugal,Submersible,ProgressiveCavity(Screw)pumps,MeteringPumps,DrainagePumps,etc.

Blower-Rotary twin lobe positive displacement type, Centrifugal blowers

Compressor-Screw type compressor

Valves-Gate, Butterfly, Ball, Knife gate, diaphragm, Pneumatically and electrically operated

Gates and Penstocks-CI/MS electrically/pneumatically operated

Pipes & Fittings -
CI/DI,MS/PVC,UPVC,HDPE,SS,Copper;forWater/Sludge/Chemical/AirServices.

Agitators -Sludge balancing tank, Thickened sludge sump, Chemical Mixing,etc.

Scrapers -Clarifiers, Thickeners

Centrifuge -SolidBowlCentrifugeofSS316construction

Thickener -For thickening sludge before feeding to centrifuge

Pneumatic System-Air filter lubricator, air regulator, pneumatic cylinder

Miscellaneous items- EOT, Chain pulley block with traveling trolley, weighting machine, ventilation equipments, constant head tanks, reduction gears, valve actuators, level switches, level gauges, analysers.

All equipments shall be of best quality conforming to the standards mentioned else where in the NIT.

Vendor has to submit detailed data sheet, specification, drawings both general arrangements and detailed drawings of different parts along with curves (wherever necessary), testing methods and quality assurance plan, inspection methods etc. for approval. If any materials, which need pre-dispatch clearance, are dispatched without dispatch clearance they shall be liable to be rejected.

Rotating equipments like pumps, blowers, compressors, etc. shall produce noise less than 85 dBAatadistanceof1.85metresfromtheouterendoftheequipment.

5.2 Pumps

5.2.1 Centrifugal Pumps

Centrifugal pumps shall have head/flow drooping characteristics with maximum pressure at shut- off condition. The rotating parts of pumps shall be balanced properly to prevent undue vibration of noise. The design of the pumps shall be such that no thrust is transferred to the driving motor. The thrust and journal bearings shall be capable of carrying at least 10% more than the maximum calculated design load and shall be capable of reversed rotation at 130% of full speed.

Pumps of a particular category shall be identical. Identical pumps shall be suitable for parallel operation, with equal load division. Components of identical pumps shall be interchangeable. Suction and delivery ends of all pumps shall have flanged ends.

The rating of the pump motor shall be 110% of the maximum power required by the pump over the entire operating range. The casing shall be of robust construction. Liquid passages in the casing shall be finished smooth. Casing drain and vent connection shall be provided. Casing shall withstand the usual moments and thrust without expansion joint. The impeller shall be properly balanced so as not to cause any vibration during operation.

Impeller shall be made in one piece and securely keyed to the shaft. Means shall be provided to prevent loosening during operation including rotation in reverse direction. Impeller fastening nuts (if provided) shall be of cap type and shall tighten in the direction of normal rotation.

Wearing rings shall be of renewable type. These shall be held in place by screwing against rotation, press fit and locked with pins. Opposed wear surfaces or hard enable material shall have a hardness difference of at least 50 BHN. The rotary components shall have higher Brinell hardness.

Shaft Sleeves

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 without removing any part other than the gland and lantern ring. Stuffing boxes shall be so designed that standard packing can be removed and replaced by mechanical seals, or vice-versa, when desired.

Pumps shall be furnished complete with an approved type of flexible coupling. Spacer type couplings shall be provided when required to permit dissembling the pump without removing the pipe connections or to permit. Both halves of the couplings shall be furnished by the pump supplier. Coupling halves shall be bored and keyed to fit shafts of the pump and the motor. Both halves of the coupling shall be match marked.

Coupling guards, made of expanded metal and bolted to the base plate shall be furnished for all coupled pumps.

The common base plate for pump and motor shall be in one piece. Suitable holes shall be provided for grouting and they shall be so located that they base can be grouted in place without disturbing the pump and motor. All pumps and motors shall be properly aligned, bolted to the base plates. Between pump drain \connections and base plate of a minimum 15mm drain piping shall be installed.

Tappings for pressure gauges shall be provided on suction and delivery flanges.

All incidental pipe (including valves) required for sealing, lubrication and cooling for stuffing box packing and or bearing or pump shall be furnished.

A standard hydrostatic test shall be conducted on the pump casing with water at 1½ times the maximum discharge pressure on the head characteristic curve or twice the rated pressure, whichever is higher.

Pump shall be tested in the Manufacturer’s Works with job motors. Pumps shall be given running test over the entire operating range covering from the shut off head to the run-out flow. A minimum of five readings approximately equidistant shall be taken for plotting the curves.

Major rotating components of the pumps like impellers, balancing drums, etc. shall be statically balanced.

In addition to static balancing, pumps shall be balanced dynamically also in the following cases:

For speeds in excess of 1500 rpm. if rated capacity is more than 60 cum/hr. and impeller diameter is more than 150 mm.

After installation, the pumps offered will be subjected to testing at field. Acceptance test shall be as per BS 5316-Part 2.

Materials of the various pump components shall be in accordance with the relevant standards. Test certificates for these if required shall be furnished for approval.

Necessary test certificates for the various tests shall be furnished by the Concessionaire for the Engineer's approval.

Performance curves capacity vs. total head, efficiency, NPSH and KW requirement ranging from run-out flow to shut off head shall be furnished by the Bidders along with their tenders.

Each pump shall be provided with a name plate indicating the following details:

Design capacity

Total head

Speed

Motor rating

Model number

Manufacturer's serial number

Weight of equipment

Tag number

5.2.2 Chemical Transfer Pumps

Pumps shall be selected taking into account the chemical being pumped, form of chemical, wear leakage and resistance to corrosion. Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded-area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/ operation can be detected.

Pump transferring chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical.

Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

5.2.3 Sump Drainage Pumps

Sump drainage pumps shall be of the open impeller centrifugal type vertically mounted close coupled to their fully submersible electric drive motors.

Sump pumps of 1.5 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitable fused three phase or single-phase low voltage supply and with supply isolation at the building distribution board.

Sump pumps over 1.5 kW shall be controlled and started from the building distribution board and be fed with a 3 phase supply, control shall be via adjustable float level switches mounted adjacent to the pump.

The pumps shall be supplied with all necessary discharge pipework, including non-return and isolating valves and suitable lifting gear lowering and removing the pump from the sump. Pumps weighing 40 kg and more shall be lowered in the sump via guide rails and be located to their respective discharge pipework with an angle flange connection and self-locating clamps.

The pump impeller shall be designed to pass solids of sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 20 mm diameter.

5.2.4 Submersible Pumps

Submersible pumps shall be of the totally submersible centrifugal or mixed flow type, of suitable application, capable of operating below 15 m head of water. The pumping unit shall be suitable for continuous operation, designed to meet the desired performance and capable of handling the pumped medium without undue wear and tear.

A built-in coating system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not. The motor shall be direct coupled to its pump and rated for continuous full load operation above or under water. The insulation rating of the motor shall be Class F. The motor shall have degree of protection IP 68.

The cable termination shall be watertight and provided with a cable sleeve and strain relief. The motor shall have ball type bearings permanently greased and maintenance free.

The pump and motor shall be separated by two mechanical face seals. The lower seal shall rotate in the water medium and the upper seal shall rotate in an oil bath medium.

The pump shall have a non-overloading performance characteristic and its efficiency shall be high at the duty point and remain at a reasonably high level over the duty range of the pumping system.

Rotating assemblies of pumps shall be statically and dynamically balanced and shall be designed so that the first critical speed of the pump and its drive is at least 50% greater than the maximum operating speed. The pump wear rings shall be easily replaceable.

5.3 Air Blowers

Back wash air blower shall be rotary twin lobe positive displacement type. Blowers shall be provided with a suction air filter and silencer, outlet silencer, pressure release valve, delivery pressure gauge and delivery isolating and no-return valve and acoustic enclosure of proper design shall be provided, so that decibel

level shall be maintained as specified elsewhere. A metallic bellow joint is provided on the delivery side of each blower.

Vibration pads shall be provided at foundation level to keep vibration of the equipment within limits as specified elsewhere in the specification.

Casing of the blower shall be robust construction and shall be machined to proper tolerance. Rotor along with other un-machined rotating part shall be properly balanced so as not to cause any vibration during operation. Rotor shall be made in one piece.

Means shall be provided to prevent loosening during operation including rotation in reverse direction.

Blowers shall be driven by squirrel cage motor through a matched V-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. The horsepower rating of the blower motor (including the service factor) shall not be less than 110% of blower design point BHP. Blowers shall not run above 1500 rpm.

Inlet to blowers shall be at the top and discharge at the bottom, the axes of both being vertical. Connecting pipe work shall be designed for a maximum velocity of20 to 25 m/sec. Delivery end of the blower shall be flanged connection of appropriate specification.

5.4 Air Compressor

Compressor systems for the supply of air for the operation of valves, and instruments shall be screw type and shall comprise compressors, after-coolers and air-driers, together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators as required.

Electrically driven air compressor sets shall operate upto 10 bar working pressure. Standby compressor sets shall be provided complete with the following:

a. Pressure relief safety valve
b. Isolating valve
c. Air filter and silencer
d. Common bed plate or compressor and motor with foundation bolts and nuts
e. Necessary temperature indicators and pressure gauge etc.
f. V-belt and guard
g. Air receivers with stand-by unit.

Compressors shall be connected for automatic changeover on failure of the duty unit. 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 supported adequately so that sufficient space is available for easy access. Receivers shall be provided with drain traps piped to drain, pressure gauges and relief and check valves. Interconnecting pipework shall be arranged to avoid low points which may trap water. Unavoidable low points shall be provided with drain cocks piped to waste.

5.5 Valves and Gates

All valve bodies shall give the following information:

Manufacturer’s name

Hydraulic test pressure

Size of valve

Direction of flow ‘Arrow’

The operating gear of all valves shall be such that one man can open and close the valve against an unbalanced head 15% in excess of the maximum encountered in service. Valve of 50 mm nominal bore and above shall be fitted with position indicators showing the amount by which the valve is open or closed in relation to its full travel.

All valves shall be open-end tested to 1½ times the rated pressure for a duration of 10 minutes during which there should not be any leakage.

Sluice valves shall be double flanged and shall have gate and body of close grained cast iron. The seats and faces shall be of zinc-free bronze. Valves of 300 mm nominal bore and above shall have ‘shoe’ and ‘channel’ arrangement (to facilitate the gate to be guided throughout its travel) with side clearance of less than 1.5mm. If specified, the valves of nominal bore 300 mm and above shall be provided with bypasses and isolating valves.

Butterfly valves shall be of wafer type double flanged and short body type to relevant IS codes or AWWA suitable for installation with the valve shaft in any position. The body and disc shall be of close-grained cast iron. The shaft shall be of stainless steel to grade 431 S29. Body seat shall be of stainless steel and disc seat of nitrile rubber. The disc shall rotate through 90 deg. From the full open to the tight shut position. Suitable stops shall be provided inside the body so as to present further rotation beyond fully open or fully closed position. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation. The driving end sealing shall preferably be of the gland and stuffing box type. The stuffing box shall be easily accessible for adjustment and replacement of packing without disturbing any other part of the valve or operator assembly. The depth of the stuffing box shall not be less than 50 mm or the diameter of the shaft, whichever is lower. As an alternative, ring type sealing may be provided at the driving end. The gear unit of the valves shall be grease-lubricated with proper sealing and packed with grease for lifetime service. The valve shaft shall have a minimum shaft diameter extending through the valve bearings and into the valve disc and specified in the relevant codes. The shaft should also be sized to withstand the maximum torque that will be imposed by the operator. Stub shaft construction, if offered, shall have each stup shaft inserted into the disc hub for a distance of at lest 1½ times the shaft diameter.

Butterfly valves for pneumatic operation shall be fitted with actuator and limit switches for auto operation. Time of opening and closing of valves shall be between 10-30 secs. Pneumatically operated valves shall also be fitted with hand wheels for manual operation. Double acting solenoid valves shall be used for air connection to each valve /gate. Each valve shall be provided with lifting lugs.

Butterfly valves shall be installed into the pipe works in such a manner that they can easily be removed from the line for dismantling and replacement of the seats which shall be of rubber unless otherwise specified. For the rubber seated valves, the valves shall be air tight in the closed position with a disc differential pressure as specified.

Handwheels of butterfly valves shall be made of malleable iron with arms and rims of adequate strength. The handwheel diameters shall not be more than 600 mm. Handwheels of diameter 300mm or less shall be of cast iron of rugged design and shall provide positive grip on the chain even under the most severe

operating conditions. The operator shall be complete with chain guides. The chains for the chainwheels shall be of endless type.

Non-return valves on the pump delivery branches shall possess high speed closing characteristics, with minimum shock on closing. The body and door shall be of closed grained cast iron; the seats and faces shall be of zinc-free bronze and the hinge pins shall be of stainless-steel Grade 431 S29.

Packed valves glands shall be arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipe.

Each valve or its operating equipment, shall bear an approved nameplate.

The handwheel for the valves of sizes 80 mm and above shall be turned in a anti-clockwise direction to open the valve and shall be clearly marked with the words 'OPEN' with arrows in the appropriate directions.

Hand wheels shall be fitted with a integral locking device to prevent operation by unauthorized persons. A padlock and chain will not be acceptable.

Each valve or gate headstock shall be fitted with damp proof limit switches at extremes of travel to provide remote "OPEN" and "CLOSED" indication.

Penstocks or sluice gates shall conform generally to IS: 3042. Leakage shall not exceed the limits given in AWWA-C-501 or other applicable standards. Spindle shall be of the non-rising type. The frame and door shall be of cast steel to SS ASTM A743 CF8M. Spindles, shall be of stainless steel as per ASTMN A193 B8M and ASTM A194 8M respectively. Far face and seat rings, trim and spindle nuts, stainless steel to ASTM A743 CF8M shall be used.

Frames shall be of unit construction and shall have a robust spigot of an appropriate length, cast integral at the back for case of support in the waterway and to provide an effective seal. A stainless shall be fixed to the frame on each side by studs and extending over the travel of the door. A stopper shall be cast integral immediately below the waterway and central with it to limit the travel of the door.

The door shall have reinforcement ribs cast integral at the back for strength. On each side there shall be tapered stainless steel taper strips not less than three, machined to match similar taper faced side guide strips on the frame. Two integrally cast lugs drilled to take a bearing pin shall be provided in doors for use with rising spindles. Integrally cast pocket suitably reinforced to accommodate a nut shall be provided on doors with non-rising spindles. A stopper to match that on the frame shall be cast integrally at the bottom.

Facing shall be so secured by rivet pins in the machined grooves of the frame and door and machined and hand-finished, that with the door fully shut a satisfactory water-tight seal is formed on the waterway. The contact between the facing shall be sufficiently close at every point in their perimeter so as to produce a uniform bearing all round. The attachment of the facing to the frame and door shall be so carried out that when finished they shall remain in place free from distortion or loosening during effective life.

Guide shall be adequately secured to the main by stud bolts and provision shall be made for appropriate longitudinal movement to adjust degree of wedging consistent with sealing properly. There shall be little lateral movement and tongues, keys shoulders or lugs may be provided for the purpose.

Concessionaire shall provide a portable type diesel operated compressor, which shall be used in case of power failure.

5.6 Pipe Work

5.6.1.1 Caste Iron / Ductile Iron Pipework

Cast iron and spun iron pipework shall be manufactured and tested to specifications given in relevant IS standards unless specified otherwise.

Flanges shall be as per IS: 1538 and shall be machined over the whole face and edge. After machining, flanges shall be flat and normal to bore of the pipe to within 0.125mm over the flange diameter.

DI pipes shall be manufactured as per IS:8329, K-9 grade and fittings shall conform to IS:9523.

5.6.1.2 Steel Pipework

Steel pipework, depending upon the duty shall be manufactured in accordance with the relevant BIS standards or international standards where BIS standards are not available.

Flanges shall be as per IS: 6392 and shall be machined after welding. Flanges shall be machined over the whole face and edge. After machining, flanges shall be flat and normal to the bore of the pipe.

Hydrostatic shop test for pipes and fittings shall be as per code/ standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure. Buried pipes shall in addition be designed to withstand external loading exerted by soil, water and live loads as relevant. The external ground water shall be taken at 1m below natural ground level for design purposes.

Saddle type/ bracket type support wherever required shall be designed and supplied for the above ground pipe lines. All pipe joints shall be of the buttwelded type. End preparations and fabrication requirements shall generally conform to IS: 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved. Laying of welded steel pipes shall meet the requirements of IS: 5822.

The following stage wise inspection shall be required:

a. Material identification
b. Welder qualification
c. Edge preparation
d. Mechanical tests
e. Hydrostatic test
f. 10% of all welds shall be radiographed.

Pipework Protection

Pipes shall be given external and internal protection as per relevant BIS codes. Testing of pipe protection shall be done as directed by the Engineer using elctometers, coating thickness gauges, bond test and holiday detectors.

All underground pipework having a cover less than 1.5 m and more than 4.5 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns.

No internal and external painting to be given to SS pipes.

5.6.1.3 Flexibility in Pipework

The Concessionaire shall provide flexibility in the pipe work at joints in the main structures and shall

submit proposals for the approval of the engineer. Flexible joints or collars and cut pipes shall be allowed on all pipework where necessary to allow for some margin of error in the building work. Wherever possible, dismantling joints shall be provided to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for ease of erection and future dismantling. Particular care shall be taken to ensure that pipework thrusts are not transmitted to machinery or associated apparatus. The Concessionaire shall indicate on his detailed drawings of thrust blocks provided to anchor pipework supplied by him.

5.6.1.4 Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer's prior approval.

5.6.1.5 Small Bore Pipes and Hoses

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joints or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provide to enable the pipework to be removed in sections without working from on end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipe work through as required.

All pipes and hose shall be labeled to enable individual lines to be identified throughout their run. Wherever possible racks or trays shall be fixed to duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pies and racks or trays proposed, shall be supplied at the time of tendering.

5.7 E.OT. Crane and Hoists

The crane shall be of double girder type in pump houses and chemical house. All cranes shall be electrically operated.

The crane shall be of the single girder type suitable for installation where the clearance between the crane rail and the lowest roof obstruction is limited and it is not essential for the full height of lift between the underside of the bridge and the floor to be utilized.

Suitable crane rails complete with fixing bolts, nuts, washers and anchor plates shall be supplied for each crane.

The bridge structure shall be formed by a single cross girder with the hoist units traveling along the lower flange of the bridge grider.

The end carriages shall be fabricated adequately stiffened throughout their length to produce a section with high torsional resistance designed to eliminate and tendency for the bridge to cross whip. The carriage wheel base shall be adequately proportioned in relation to its span to give a widely distributed load on the crane rails and ensure freedom from cross working.

Each end carriage shall be driven by independent but concurrently run drive motors through necessary reduction gears. Wherever required the motor enclosure shall afford protection to IP 55 of IS: 4691

and have cooling facility to IS 41 of IS: 362. Each drive motor shall be fitted with an automatic electromagnetic brake to stop the crane on interruption of the power supply whether intentional or accidental power failure.

Suitable end stoppers/buffers shall be provided on the bridge girder and at each end of crane rails.

The crane shall also be suitable for manual operation from the floor by means of chain and pulley arrangement via a safety clutch, for use in the event of a power failure.

Hand operated chain hoist complete with trolley running along the same flange of girder in addition to the electric hoist, shall also be provided for use in the event of power failure.

The crane and hoists shall conform to IS: 3177, IS: 3832 and IS: 3938, Class 2, medium duty and meet specified operational requirements.

Power feed to the crane shall be from a shrouded conductor rail system and that to the hoist shall be through close looped flexible cable suspension system with carriers sliding along a wire across the full span of the crane.

Flood lights of an approved design shall be fitted to the end carriages and arranged to illuminate the entire area under the crane.

All the hoist functions shall be controlled from a single pendant push button station. The pedant unit shall be suspended from a special track spanning the bridge length using a non-metallic cord and not the control cable. The pendant shall operate on a low voltage (typically 110 volts AC) source, incorporated with a key operated switch to prevent unauthorized operation and indicators to indicate all crane or hoist movements including start and stop.

The electric hoist unit shall be equipped for two speed lift and single speed traverse with separate motors for each function. The operating speed shall not exceed the following criteria unless otherwise approved by the Engineer-in-Charge.

Lifting speeds : Low 0.9 m/min High 9.0 m/min

Cross travel speed : 10 m/min

10m/min. automatic reset type limit switches shall be provided for all movements of the hoist and the crane to prevent overtravel.

The hoist shall comply with performance requirements of IS: 3938/IS: 3832 class 2.

The electric hoist shall be fitted with right and left-handed spiral grooved cast iron drum with a rope hoist arrangement with spring loaded rope bands and guards to ensure accurate rope guidance and location.

Hoist rope shall be extra flexible, improved plog plough steel rope with well lubricated hemp core and having six stands of 37 wires per strand with an ultimate tensile strength of 160/180 kg/sq.mm. the breaking loads for the hoist rope shall be as per IS:2266.

Electromagnetic brake shall be provided to hold suspended load instantly, securely and automatically in the event of the electric current being cut off whether intentionally, accidentally or due to power failure.

The lifting hooks shall be single ‘C’ type complying with the requirement of IS: 2758/IS: 2759 made from Grade 30 carbon steel or equivalent. The hook shall have a safety latch to prevent rope coming off the

hook.

5.7.1.1 Monorail

Monorail shall comply with the following requirements:

The hoist shall be operated on monorail (I-Beam). The load chain shall be of Alloy Steel Grade 80 of IS: 3109 or equivalent and the hand chain shall be of calibrated mild steel construction.

Load chain shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction. The factor of safety shall be as per the applicable standards.

Load wheel, main arm holding upper hook and the block holding bottom hook shall be made of heavy-duty malleable castings.

The hand chains for the hoisting and traverse mechanism shall had well clear of the hook and both the chains shall be on the same side. Hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding, to prevent snagging and fouling of the chain.

All the gearing shall conform to latest applicable standard and shall be totally encased. Gears shall be cut from solid cast or forged steel blanks and pinions shall be of forged carbon or heat-treated alloy steel. Proper lubricating arrangement shall be provided for bearings and pinions.

The trolley track wheel shall be single flanged and shall have antifriction ball bearings. The wheel shall be machined on their treads to match the flanges of the track joint.

The traveling trolley frame shall be made of rolled steel. The side plats shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalizing pin.

Axles and shafts shall be made of carbon steel and accurately machined and properly supported. Hooks shall be of solid, forged, heat treated alloy or carbon steel and of rugged construction.

They shall be of single hook type provided with a standard depress type safety latch.

The brake for the lifting gear shall be automatic and always in action. It shall be either of screw or of friction disc type self- actuating load pressure brake or of any other standard design. The brake shall offer no resistance during hoisting.

The hoist and trolley shall have facility for lubrication of the moving parts with ease and convenience.

Proof testing of each chain pulley block shall be carried out as per latest applicable standards. The chain block after passing the proof test, shall be permanently and legibly stamped with the safe working load, grade of load chain and the manufacturer's name, initials or trade mark. The safe working load shall be marked in such a way that it is clearly legible from the operating level.

5.8 Drum Weighing Equipment

Equipment provides for weighing chlorine drums shall be spring type loaded with circular scale indicator and shall conform to IS:1438.

The weigher shall be designed suitable for suspension from the load hook of crane or hoist.

The weigher shall be suitable for operation with a working load of not more than 200 kg. The indicator scale shall be calibrated in 5 kg. divisions, with the zero at the top of the scale and the pointer vertical with

no load. The pointer shall incorporate means of tare adjustments upto 20% of the indicator scale. The indicator dial shall be slanted from the vertical plane so as to minimize parallax errors when the indicator is read from the floor with the unit hoisted to a high level.

The weigher shall have an overall accuracy of better than 1% of the full scale deflection and the unit shall be unaffected by the temperature variations in the range 4 to 50 deg.C.

5.9 Chlorine Plant

5.9.1.1 Drum Connector Tubes

The tubes connecting the liquid chlorine drums and the liquid chlorine header system shall be equipped with adapters to accept drums supplied by the corporation.

5.9.1.2 Chlorine Pressure Gauges

Pressure gauges for use with chlorine shall be of the bourdon tube type with a special diaphragm isolating the tube from the liquid or gaseous chlorine. Pressure gauges shall have dials not less than 150 mm diameter except where they form an integral part of an equipment such as a chlorinator. No aluminium shall be used in the construction of the gauges; the dials and bezels shall be of bronze and internal components shall be of stainless steel or other alloy or material resistant to corrosion by chlorine.
Where necessary, pressure gauges shall be fitted with adjustable electrical contacts for initiation of alarm conditions with either rising or falling pressure.

All pressure gauge piping shall include isolating valves at each point of connection to the main piping.

5.9.1.3 Automatic Drum Changeover Panels

The automatic drum changeover panels shall be specially designed units capable of selecting liquid chlorine containers for duty on an alternate basis. The unit shall be capable of working in conjunction with four liquid chlorine drums (two duty, two standbys).

The panel shall satisfy the following duty functions in chronological order:

a. Check pressure in the line between electrically actuated valve and the liquid chlorine cylinder, initiate changeover and alarm if pressure is low.
b. Shut the delivery valve of the drums that have just become empty and open the valve of the standby drums on-line.
c. Re-check pressure as in (a) above and initiate alarm if pressure is still low.
d. Proceed until next changeover is initiated then repeat sequence.
e. At each step, the operation of valves shall be modified using position feedback limit switches and valves failing to operate in a set time shall immediately initiate an alarm.

5.9.1.4 Chlorine Gas Pipework

Pipework conveying chlorine gas shall be of solid drawn steel tube to BS 1387 with BSP taper thread to BS 21. All fittings shall be of malleable iron. Chlorine gas pipework shall be adequately supported. Threaded joints shall be sealed using jointing compound compatible with chlorine. Polytetrafluroethylene tapes shall not be acceptable.

5.9.1.5 Chlorine Gas Valves

Valves for gaseous chlorine duty shall be specifically designed for chlorine service with florged steel bodies, monel valve plug with Polytetrafluroethylene sleeve.

5.9.1.6 Chlorinators

The chlorinators shall be vacuum operated aqueous solution feed type units working in conjunction with wall mounted injectors.

The units shall be discrete floor standing cabinets of plastic/composite construction. Where specified it shall be possible for the chlorinators to be arranged in a single console built up from discrete modules. The chlorinators shall be suitable for manual feed rae control and incorporate a flow metering device for precise regulation of chlorine gas over a 20:1 flow range with a metering accuracy of plus or minus 4% of the indicated gas flow rate.

Each chlorinator shall be fitted with the following principal components:

a. gas inlet pressure regulating valve
b. pressure/vacuum relief valve with safety vent.
c. Vacuum regulating valve.
d. Gas feed rate regulator preferably of the 'V' notch cylindrical plug and variable area orifice type.
e. Variable area type flowmeter with liner feed ray indicator calibrated in kg/h.
f. Thermostatically controlled gas inlet heater.
g. Vacuum failure detector switch to initiate alarm.
h. Wall mounted injector preferably of adjustable throat type.
i. Polyethylene tube to the wall mounted injector.

Chlorinators shall be provided with panel mounted indicators for the chlorine gas inlet pressure injector vacuum, motive water pressure, chlorine solution pressure immediately downstream of injector and a feed rate adjustment knob.

Chlorine gas feed piping shall be provided with valves to allow isolation of each chlorinator without disturbing the operation of the other chlorinators.

Rigid UPVC chlorine vent piping shall also be provided and arranged to discharge at a high level outside the room housing the chlorinators to ensure safe atmospheric dilution.

The chlorine supply to the injectors shall shut down automatically if:

a. The water supply to the injectors shall fail.
b. The injector vacuum line should break
c. The chlorine solution line should be accidentally shut down by the closing of a chlorine solution dosing valve.

A carefully selected check valve shall be provided between chlorinator and injector to prevent accidental back-flow of water into the chlorinator. This shall be consistent with the injector design with respect to gas flow and water pressure. While effectively preventing backflow, this valve shall allow requisite gas flow.

Additionally, safety devices shall be incorporated in the equipment to prevent hazards to the operators or damage to the components under normal operating and shut-down conditions.

All electrical services and control signal lines (where applicable) shall be wired to a single termination board within the chlorinator cabinet. The termination board shall preferably be totally enclosed in a junction box with glanded cable entries and fitted with a clearly labeled warning sign stating the supply voltages. Electrical supply isolating switches shall also be provided in each chlorinator cabinet.

5.9.1.7 Chlorine Solution Pipework, Distributors & Injection Fittings

The chlorine solution delivery lines shall be of UPVC or approved equal. The valves on these lines shall be diaphragm type with cast iron body rubber lined. Diaphragms shall be of PTFE with piston backing.

The quantum of motive water and sizing of motive water pumps/pipework and solution pipework shall be based to limit chlorine solution concentration to a maximum valve of 2500 mg/1, while the materials in the solution pipework shall be compatible with a concentration of at least 3500 mg/1, at operational fluid temperature upto 33 deg.C.

Where chlorine solution is to be dosed into flow in an open channel, chamber, contact tank or downstream of a hydraulic jump it shall be applied using a chlorine solution distributor.

The distributor shall be either tube drilled PVC tubular diffuser, designed to ensure uniform distribution of the specified flow rate of chlorine solution at the point of application.

Porous ceramic distributor material where used shall conform to BS 3505 class 'E'.

The distributor shall be adequately supported and designed to withstand the stream velocity at the point of application and any flow or turbulence induced vibrations.

Where chlorine solution is to be dosed into flow in pipelines it shall be applied using an injection fitting/device designed for specified duty flowrate.

In the case of pipelines less than 600 mm diameter, the injection tube shall extend two-thirds of the pipeline diameter into the fluid stream. For larger pipelines the injection tube shall extend right across the pipe bore and be supported with ends located in diametrically opposite flanged branches.

The injection tube shall be drilled at predetermined centres to ensure uniform distribution across the flow profile.

The injection filling shall be installed in diametrically opposite flanged branches with their axis making an angle of 45 deg. With the horizontal in a plane normal to the direction of low within the pipeline.

Withdrawable type injection fittings shall be used in applications upto 600 mm diameter pipelines.

The injection fittings shall be adequately supported and designed to withstand the flow velocity at the point of application and any flow or turbulence induced vibrations.

Chlorine solution distributors or injection fittings shall be supplied complete with necessary non- return and isolation valves.

5.9.1.8 Chlorine Residual Monitoring Equipment

Chlorine residual monitoring equipment where specified shall comprising measuring cells, transmitters and indicator units. These shall be arranged for continuous monitoring of chlorine residual levels from samples delivered to measuring cells from locations stated in the specification.

The chlorine residual measuring cells shall be either located in floor standing plastic/composite cabinets of modular construction, or in wall mounted cabinets arranged to receive samples on a continuous basis from the sample pumps. Each measuring unit shall include a bimetallic cell generating a micro-ampere signal proportional to the residual chlorine level in the sample passed through the cell. Each unit shall incorporate the facility for addition by syphonic means of a buffer solution to minimize the effect of pH variations on cell output. The sample flowrate through the cell shall be adjustable by means of a spring

and diaphragm regulator or similar device. The materials of construction and sealing shall be compatible with the specified sample fluid. Cells shall incorporate means of maintaining the electrodes free from fouling; this may take the form of a grit recirculation system.

Each cell shall be capable of measuring both free available chlorine and total chlorine, the selection being made during commissioning or later during operation of the plant.

The chlorine residual indicator/recorder/controllers where specified shall be housed in floor mounted plastic/composite cabinets of modular construction capable of being arranged to form part of a console and shall be operated by the signals generated by the residual chlorine measuring cell units.

The chlorine residual recorder units where specified, shall preferably be circular chart type, with scale calibrations arranged to have zero at the chart periphery.

The chlorine residual controllers where specified shall be arranged to control the residual chlorine level in the specified range within plus or minus 1.5 per cent of fullscale deflection. The controller unit shall incorporate panel mounted indicator lamps indicating increasing residual, decreasing residual, feed alarm, mains on, high alarm, and low alarm. The units shall be capable of automatic stop/start control. Set point and alarm levels shall be adjustable from the front of the panel.

In addition to local indication and control where specified, the units shall also be capable of providing d.c. output signals for remote indication/recording of residual chlorine levels and shall have volt-free contacts for remote annunciation of high and low residual alarms.

5.9.1.9 Chlorine Leak Detectors

Chlorine leak detectors provided, shall be of the bi-metallic cell amperometric type. The leak detectors shall have an alarm level of 5 m1/cum of chlorine gas in the atmosphere to detect any significant leakage from the chlorine drums and chlorine plant equipment.

The units detecting the presence of chlorine gas shall be compact wall mounted devices located at low level remote from the instruments.

The units shall be sufficiently sensitive to detect increases in the concentration of 0.1 m/cum at a concentration level in the range of upto 4.0 or 5.0 m/cum.

The electrolyte medium shall be inserted in replaceable capsules. The detectors shall incorporate relays providing potential free contacts to initiate alarms on the local control panel, outside the building and for re-transmission to remote panels. Detectors shall be arranged automatically shut down the ventilation fans preventing unregulated discharge of chlorine fumes into the atmosphere.

The units shall incorporate test buttons on the front panels facilitating quick checks of satisfactory operation of the electronic circuits. These circuits shall include input mains filters and high noise rejection components to afford protection from transients and to make the unit suitable for industrial environments.

5.9.1.10 Self-Contained Emergency Air Breathing Apparatus

Self-contained emergency air breathing apparatus where specified shall provide complete respiratory protection independent of the surrounding toxic or oxygen deficient atmosphere for about 35 minutes depending the degree of exertion. The unit shall combine total reliability with a high degree of mobility to facilitate unhindered emergency rescue or maintenance work.

5.9.1.11 Emergency Safety Shower and Eye-Bath

The safety shower and eyebath unit where specified shall incorporate nozzles specially designed to create an intense deluge of water for rapid decontamination and an additional horizontal spray at approximately waist height level to direct water onto the lower body and legs.

The eyebath unit shall be fitted with fine mesh filters with built in pressure regulating device to ensure a safe rate of flow to prevent foreign matter being further embedded into the eye and instead flush away contaminates.

5.9.1.12 Pre and Post Chlorination

Pre and post chlorination shall be provided for maximum flow (Flow with hydraulic overload).An electrically operated monorail of minimum 3 tonne capacity, shall be provided onR.S. Joists of suitable section for hoisting the chlorine cylinders and for removing them outside the chlorination house. The height of this room shall be sufficient for the operation of the pulley block in handling the chlorine cylinders.

Suitable size and number of exhaust fans shall be provided in the Chlorine room near the floor, rolling shutter shall be provided for the chlorine room, to provide access for transportation of chlorine cylinders.

For water required under pressure for chlorinators, booster pumps of adequate capacity shall be provided and the filter water shall be drawn from the pure water channel in the wash pump house. The bidder shall include the cost of all piping and valves for the chlorinator units.

5.10 Flash Mixer

A flash mixer shall be used to intimately mix the coagulant and the raw water as rapidly as possible. The flash mixing shall be done in a stirred tank constructed from reinforced concrete, rectangular in cross-section. Flash Mixing Tank shall be designed for retention time of 40-60 seconds. All internal and external surfaces of the Tank shall be provided with 20 mm thick smooth cement plaster in 1:4 CM. All internal surfaces shall also be provided with food grade epoxy paint. Inlet and outlet to flash mixer shall be designed so as that velocity of water flow remain in the range of 0.6 to 0.8 m/sec. Flash Mixing Tank shall be provided with suitable electrically operated mixing device.

The flash mixer design shall be such that short-circuiting is minimised and the coagulant is thoroughly mixed with the water in the flash mixer. Also there shall be perforated baffle at the Flash Mixer inlet zone, so as to avoid direct hydraulic shock to the Flash Mixer Impeller.

5.10.1 Agitator for Flash Mixer Tank

Electrically operated, Vertical top entry type, slow speed, propeller or turbine mixer shall be provided in Flash mixing Tank. Impeller diameter shall not be below 30 % of the tank diameter. Mixer should be able to create velocity gradient of 450-s. Power input shall be in the range of 1.5 to 3 watts /m3/hour flow.

The mechanical equipment for flash mixers shall comprise stainless steel (SS-316) agitating paddles fixed on stainless steel (SS-316) shaft with thrust bearing support, driving gear consisting of a motor coupled to a reduction gear of appropriate ratio. The motor and gear box arrangement shall be appropriately covered and any spillage of oil from the gearbox shall be prevented from entering the raw water. Electrically operated Sluice Gates shall be provided to isolate each of the duty and standby flash mixers.

5.11 Flocculator

Flocculators shall be slow speed vertical shaft top entry type with four-blade gate paddles or other proven

paddle arrangement. The drive unit shall be suitable for 24 hour a day continuous operation. The drive unit shall consist of an electric motor and gear reduction unit with a flexible coupling provided between the motor and the gear reduction unit. The flocculator shaft shall be rigidly coupled to the output shaft. The coupling to the flocculator shaft shall be readily accessible so that the gearbox may be easily removed and replaced without entry of personnel into the mixing chamber or shutdown of the flow. Gear reduction units and motor bearings shall be oil or grease lubricated.

The arrangement of the paddles, their dimensions and the tip speed shall be of a design to provide efficient flocculation of the chemically treated water.

Flocculator paddles and paddle shaft shall be constructed of stainless-steel type 316. Alternatively, suitably protected teak is acceptable as a material for paddles. Flocculators shall be suitable for installation in concrete tanks. The flocculators and the tanks shall be designed to achieve uniform mixing of chemically dosed water to produce flocs of characteristics suitable for the downstream solid-liquid separation process.

5.12 Lamellar Clarifier - Deleted

5.13 Filter Media

The proposed source of sand and pebbles (location and producer) shall be stated into the schedule of particulars. Tenderers shall describe the methods of selection of correctly graded materials, and of the transport, storage on site and placing in filters in the schedule of particulars. Following acceptance of his tender the Concessionaires shall supply a 10 kg. sample of each medium to the Engineer's Representative for testing and approval. Only when the Engineer's representative has approved the samples shall orders be placed.

Test certificates shall be produced from the origin of supply to the approval of the Engineer's Representative and in no case shall delivery be effected to site when the quality or grading materially departs from that of the approved sample. If the source quality changes during processing then the Concessionaire shall supply further 10 kg. samples of the media to the engineer's representative for testing and approval.

i Test at source shall meet the following medium requirements:
   a. Check quality of screened media daily.
   b. Produced test certificates for each 50 cum of media. Certificates shall include sieve analysis and grading curves, and state media 'effective size' and 'uniformity coefficient;
   c. In addition to 9b) above certificates for each 100 cum shall include tests to determine 'loss on acid washing' and 'specific gravity'.
   d. In addition to (a) and (b) above certificates for each 500 cum shall include a 'friability' analysis.

ii On delivery to site a kg of media shall be taken from each bag until 10 or 12 kg is obtained. The samples should then be mixed and quartered before testing as follows:
   a. Pebble layers – a sample shall be taken from each delivery and graded. Samples shall be examined to ensure they are similar to the initial 10 kg samples.
   b. Sand media – samples shall be taken from each delivery to site as described in (ii) above. Tests shall include sieve analyses, preparation of grading curves and give media 'effective size', 'uniformity coefficient' and 'specific gravity'. A visual inspection shall also be carried out to ensure it is similar to the initial 10 kg sample. In addition to the above tests, certificates for each 100 cum shall incorporate tests to determine 'loss on acid washing'.

The form of packing and storage for shipment and transportation and the manner of placing shall be such as to eliminate obvious causes of degradation of media.

i Filter pebbles or gravel shall be rounded or waterworn stones, which when placed in layers in a filter above or around the under drains effectively distributes wash water. The proposed depths and gradings of each layer of gravel shall be stated in the schedule of particulars.

ii Filter Sand - Filter sand be a hard grained quartz or silica sand having no constituent in any way friable or liable to mechanical breakdown when subject to pressure. The sand shall contain no carbonaceous matter, clay or silt and the loss on acid washing and ignition shall in each case be less than 2% by weight. The specific gravity shall be not less than 2.40.

The sand shall be supplied substantially free of fines and coarse material and at least 95% by weight shall be between the grading limits specified by the Concessionaire.

The effective size is defined as the size of the aperture through which 10% of the sand (by weight) passes.

The uniformity coefficient is defined as the ratio of the size of aperture through which 60% of the sand passes to the effective size.

Fines are defined as the particles which pass through a size of aperture 0.9 times the effective size, and not more than 1% shall pass through the nearest sieve size.

All sand shall be obtained from an approved source and supplier and shall be washed, heat dried, graded and packed in plastic or polyethylene bags as approved by the Engineer-in-Charge for delivery to or storage at site.

Hessian bags, and bags made of similar materials which may deteriorate during transit or in open storage will not be accepted. The bags shall be stacked at site n not more than six layers. The empty bags shall be the property of the corporation. It shall be full responsibility of the Concessionaire to protect the filter media at site upto taking over of the plant.

5.13.1.1 Back Wash Equipment

For back washing, pumps (of suitable capacity) shall be provided in the annexe of wash pump house and shall pump the filtered water from a sump connected to the filtered water channel. The filtered water channel shall be provided with necessary recess, so that the pump would have positive suction. The recess in the floor shall be at least 0.61 m deep and of sufficient width. Pumps shall have 100% standby. The pumps shall be designed for a suitable load, so as to wash effectively the last filter bed. The residual pressure at wash water valve of each filter shall be approximately 9.2 m.

The wash water main shall be of adequate size to maintain the velocities mentioned in these specifications and shall be looped at both ends of filter house.

5.13.1.2 Air Scour Equipment

For filter cleaning compressed air shall be used, direct from air blowers.

The air main shall be of cast iron of suitable diameter and looped at ends. The air blowers shall be of standard make as specified. The blowers shall be of adequate capacity to clean the entire filter bed. Sectional wash of filter beds should not be provided.

5.13.1.3 Waste Water from Filter House

The waste water channel from the filter house shall be looped together at the end of the filter house. The waste water shall be recycled after proper treatment.

5.14 Mixers and Agitators

All mixer and agitators shall be designed considering the liquid density, viscosity, turnover ratio, impeller diameter, depth, number of blades, type of blade, rpm and pH and temperature. Agitator for alum, polyelectrolyte shall be made of SS-316, shaft and impeller.

5.15 Sludge Thickener

Gravity thickener(s) where provided shall be continuous flow top feed thickener with picket fencing arrangement.

The thickener shall be of circular RCC construction. The thickener shall have a sloping bottom with central hopper. The flow shall enter the thickener into a central stilling box. The central filling box shall extend 100mm above maximum sludge level and shall be designed to prevent short circuiting.

The overflow weirs shall be made from stainless steel plates and all fittings and fixtures shall be stainless steel SS:316. Fixing holes through SS plates shall be oblong to facilitate adjustment.

A fixed bridge shall be provided to give access to center of the thickener.

The thickened sludge at bottom of the thickener shall be collected by means of rotating scraper mechanism with a vertical picket fence in the central hopper at bottom of the thickener. The thickened sludge can be hydrostatically withdrawn through a SS pipe having diameter of not less than 250mm. This pipeline shall be provided with sluice valves suitable for timer operation and Tee with vertical telescope pipe with valve, which shall be provided in a chamber outside the thickener.

5.16 Centrifuge with Accessories

a. Decanting type centrifuge (also known as a solid bowl and scroll centrifuge) shall be used for the sludge dewatering operating.
b. The operation of each centrifuge and its associated dedicated sludge feed pumps, polyelectrolyte dosing system, flushing system and other plant shall be automatic once the startup procedure has been initiated by the operator.
c. A typical startup sequence shall proceed as follows:

- Start lubricating oil pumps
- Start bearing seal water pumps
- Start cake conveyors
- Start centrifuge
- Start polyelectrolyte pump
- Start sludge feed pump

d. The polyelectrolyte and sludge feed pumps shall not start until centrifuge has reached its full speed.
e. The shutdown sequence shall be a reversal of the aforementioned 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.
f. The operation of low-level sensor in the thickened storage tank shall automatically start the flow of sludge to the centrifuge.
g. Polyelectrolyte shall be dosed to the sludge flow via an in-line injection system and to be designed

to achieve rapid and even distribution throughout the sludge.

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; and
- Control system.

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel 316. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.

The whole rotating assembly shall be enclosed by a cast iron (BSEN 1561 Gr. EN-GJL with 1.5 to 2% Nickel) casing incorporating a centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360° peripheral weir at its cylindrical end to control the depth of the centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

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 b provided on the sludge fed system and the centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

5.16.1.1 Centrifuge feed sump and pump house

Centrifuge feed pumps shall be of positive displacement screw type.

5.16.1.2 Pumps Design Requirements

a. The pump should be capable of developing the required total head at rated capacity.
b. Pumps should be suitable for single as well as parallel efficient operation at any point in between the minimum and maximum system resistance indicated in the system resistance curves.
c. The total head capacity curve should be continuously rising towards the shut off. The pump should deliver at least 125% of its rated capacity at 75% of the specified total head.
d. The required NPSH at duty point should be at least 1.0 M less than the available NPSH.
e. Pumps shall run smooth without undue noise and vibration. The velocity of vibration should be within 4.5 mm/sec. The noise level should be limited to 85 dBA at a distance of 1.8 M.
f. The power rating of the pump motor should be the larger of the following
g. The maximum power required by the pump from zero discharge to shut- off head.

1) 115% of the power required at the duty point. Considering the pump efficiency with 1% negative tolerance on quoted figure of efficiency (with zero negative tolerance).
2) Combined pump efficiency shall not be less than 0.78. Pump Efficiency less than 0.78 shall not be accepted.

h. The pump set should be suitable for starting with discharge valve open, as well as closed.

5.16.1.3 Features of Construction

a. Pump should be clear water split casing horizontal axially centrifuge. It shall have single suction. Rotating assembly accessible for inspection or maintenance by removing upper casing without disturbing suction and delivery piping motor.
b. Pumps should be identical and suitable for parallel operation with equal load division. Components of identical pumps should be interchangeable.
c. Pump casing should be of robust construction Liquid passages should be finished smooth and designed so as to allow free passage of liquids. The volute tongue should be straight across and filed to a smooth rounded edge. Casing should be provided with hardened renewable wearing ring.
d. Impeller should be enclosed type with smooth blunted ges and large water ways so as to allow free passage of large size solids. It should be free from sharp corners and projections like lyto catch and holdrags and stringy materials. Impellers should be provided with hardened wearing ring. Hardness of the Impeller ring should be atleast 50BHN more than that of casing ring.
e. The first critical speed of the rotor should be 30% above the operating speed. Complete rotor should be statically and dynamically balanced.
f. Replaceable shaft sleeves should be provided to protect the shaft where it passes through stuffing boxes. Surface hardness of shaft sleeve should be minimum 350 BHN.
g. Pumps should be provided with anti-friction bearings. Bearings should be easily accessible for inspection and maintenance. Bearings should be grease lubricated.
h. Stuffing box should be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection should be provided at the lowest point so that no leakage accumulates in it.
i. Lantern ring should be of axially split type. Grease should be used for stuffing box sealing. Water will be available for this purpose. Gland should be of split type.
j. Pump should be furnished complete with flexible coupling.
k. Coupling guard bolted to the base plate should be furnished.
l. Base plate for pump and motor should be common. Suitable holes should be provided for grouting. Foundation bolts should be complete with nuts and washers.
m. Tappings should be provided at suction and discharge nozzles for pressure gauge connection.
n. Hand holes should be provided in the casing to allow easy access to the impeller as well as to the

casing throat. Casing drain connection with stainless steel collared plug should be provided.

5.16.1.4 Material of Construction

a. Casing : CItoIS:210GRFG600with1.5to2%Nickel.
b. Impeller : StainlesssteelSS316
c. Wearing rings : SStoAISI43
d. Shaft : SStoAISI431
e. Shaft sleeves : SStoAISI410
f. Packing : AsbestosyarncoatedwithMoS2
    a. (Molybdenum Di-Sulphide).
g. Packing : CI/MS fabricated.
h. Baseplate : CI/MS fabricated.
i. Gland : Cast Iron

5.16.1.5 Shop Testing – Witnessing

The following shop tests should be witnessed by Authority/Consulting Engineer.

Standard Running Test as per IS:5120, at rated speed, in manufacturer's works to measure capacity, power and efficiency at various head. Bidder to quote pump efficiency with zero negative tolerance (and not 5% as indicated in IS:5120). Pump with a limit of max. 1% drop in efficiency should be accepted. Pumps with more than 1% negative tolerance shall not be accepted. These tests shall form the basis for Pump acceptance except for vibration and noise. The pumps should be tested over the range covering from shut off head to the maximum flow. The duration of the test should be minimum one hour. Minimum five readings approximately equidistant should be taken for plotting the performance curve.

6 ELECTRICAL SPECIFICATIONS

6.1 Scope of works and responsibility of the Concessionaire

The Concessionaire is advised to peruse the document in full and understand the scope of work as detailed elsewhere in this document. He is / they are also advised to make himself / themselves aware of the site requirements and conditions before submission of his / their bid. Clarification, if any, required shall be made with the consultant before submission of bid.

However, nothing shall absolve the Concessionaire to carry out and complete the entire works including those minor / incidental works required for the completion of the work whether it is explicitly brought out in this document or not.

The Concessionaire shall make appropriate arrangement for power supply provisions during Construction Period. All power and lighting circuits shall be constructed with due regard for personnel safety and shall comply with recognized codes of practice and local regulations. All circuits shall be fitted with earth leakage systems.

This specification is a general specification and the applicability of various component requirements shall be as per actual requirements from site-to-site basis

6.2 Interpretation

All the technical terms referred in this document shall have the interpretation as per the relevant Indian standard code / Indian Electricity Rules / Indian Electricity Act etc., In case on any doubt in any of the meanings / interpretations, the tenderer shall get the same clarified from the owner prior to submission of bid.

6.3 Electrical 's license

The electrical works shall be carried out by persons holding valid competency certificate issued / recognised by the Licensing Board of the locality / State in which the works is to be done. The Concessionaire holding valid Licence / Authorisation from the Licensing Board of the locality / State for carrying out the installation work of such nature and voltage grade.

6.4 Design philosophy

All equipment offered by the Concessionaire shall offer the following features: -

a. Safety to personnel and equipment during operation and maintenance.
b. Reliability of Services.
c. Ease of maintenance.
d. Facility for ready addition of future loads.
e. Convenience of operation.
f. Maximum Inter-changeability of equipment.
g. Minimum fire risk.

6.5 Codes and Standards

Whether explicitly mentioned in this specification document or not, all the engineering, systems, equipment, materials and works being provided by the Concessionaire for this project shall conform to the requirements of the respective latest editions / amendments of the Indian Standards Specifications. In

particular cases where relevant Indian Standards are not available, other International Codes and Standards may be accepted, subject to Executing Agency's specific approval.

The design and the installation shall be in accordance with established and sound engineering practices, standard specifications and must conform to the statutory regulations applicable.

The equipment and installation shall conform to (but not be limited to) the following (Latest versions/editions).

a. Indian Electricity Act, 1910
b. Indian Electricity Rules, 1956
c. The Factory Act, 1948

In case of conflict between various documents, specifications and codes / standards etc. the following order of procedure shall govern:

1) Job specification
2) Codes and Standards.

6.6 Electrical system

Unless and until specified, otherwise the complete electrical system shall be suitable to work satisfactorily with the following system parameters

System Voltage (High Voltage)	:	11KV 3wire 50Hz AC system of supply and subject to permissible variations as per IE Rules
System Voltage (Medium Voltage)	:	415Volts, 3phase, 4Wire AC system of supply subject to permissible variations as per IE rules
System Voltage (Low Voltage)	:	240VoltsSinglephase3wireACsystemofsupplysubject to permissible variations as per IE rules
Frequency	:	50HzandsubjecttopermissiblevariationsasperIErules
Neutral Earthing	:	Solidly earthed
Fault Level	:	50kAatMain/ Incomer level
Control Voltage	:	110VoltsAC

6.7 Service conditions

All equipment to be supplied against this specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

Maximum ambient temperature(degC)	:	50
Maximum temperature in shade (degC)	:	45
Average temperature in air(degC) in shade	:	35
Relative Humidity (%)	:	60 to 80
Operating Environment	:	Moderately hot and humid tropical climate conducive to rust & fungus growth

6. 8 Drawings and data

The Concessionaire shall furnish the following drawings and data as part of the work:

a. General arrangement showing plan, elevation and typical section views.
b. Foundation plan showing location of fixing channels, floor openings etc.
c. Schematic wiring drawings for each breaker.
d. Technical literature on the equipment offered.

e. Make/Model No. of various major electrical equipment

The Concessionaire shall also furnish the following drawings for each major equipment such as HV panels, Transformers, MV panels, APFCR Panel, Street lighting Poles etc., after the award of contract.

a. Overall outline dimensions and general arrangement including plan, front elevations, clearances required in front and back etc.
b. Schematic control diagrams to cover controls, protection, interlocks, switch
c. instruments, space heaters, etc., for each type of module.
d. Itemized bill of material for each module, listing all devices mounted and cable glands, indicating all type, rating quantity and special notes, if any.
e. Detailed internal wiring diagram of each type of module, including terminal block
f. number, ferrule numbers and the external cable connection designations.
g. Inter panel interconnection wiring diagram including terminal numbers and ferrule numbers.

6. 9 Acceptable makes / Brands of electrical equipment / items

The list of preferred brands / makes of various electrical equipment / items is furnished in the Tender Vide clause 11. The tenderer are free to choose any one of the make / brand listed therein and have to clearly bring out the same in their tender. However, the owner reserves the right to insist for any specific / particular brand from the list without any additional financial implication.

6.10 Specific project requirements for electrical equipment

6.10.1 11 kV Metal enclosed switch gear

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.

IS : 13118	Circuit Breakers
IS : 3427	Metal enclosed switchgear
IS : 2705	Current Transformers
IS : 3156	Voltage Transformers
IS : 5576,11353	Arrangement for switch gear, busbars, main connections and auxiliary wiring
IS : 2544	Busbar support insulators
IS:13947(PartI)	Degree of Protection
IS:3231,3842	Electrical relays for power system protection
IS:1248	Electrical indicating instruments
IS:9385	High voltage fuses
IS:722,8530	AC Electricity Meters
IS : 613	Specification for copper rods and bars for electrical purposes
IS : 6005	Code of practice for phosphating iron & steel
IS : 9920	Alternating current switches for voltages above 1000V
IS : 13703	Low voltage fuses
IS : 3452	Toggle switches
IS : 10118	Code of Practice for selection, installation and maintenance of switch gear and control gear
IS : 6875	Control switches

Features of construction

a. The switch gear shall be outdoor, metal enclosed with separate compartments for
    i. Circuit breaker

ii. Control, metering and relaying devices
iii. Busbars
iv. Instrument transformers
v. Power cable terminations

b. Adjacent switchgear cubicles shall be provided with side sheets on either side to ensure complete isolation. The bottom of the switchgear shall be fully covered by sheet steel.
c. Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.
d. All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt, and sward 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 the primer, two coats of finishing synthetic enamel paint over baked / stoved shall be applied.
e. The circuit breaker shall be fully draw out type. The circuit breaker shall have distinct service and test positions. In the test position, the circuit breakers shall be capable of being tested for operation without energizing the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.
f. The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.
g. The switchgear shall fully house the breaker both in the service position as well as in the test position.
h. The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.
i. The cable compartment shall house all power cable connections along with associated cable terminations. Wherever zero sequence current transformers are provided for earth fault protection, these shall also be located inside the cable compartment.
j. Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Safety interlocks and features

a. Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.
b. Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out.
c. Operation of a disconnecting switch shall not be possible unless the associated circuit breaker is open.
d. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.
e. Caution name plate with inscription ‘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, e.g. incoming terminals of main disconnecting switch.
f. A draw-out with breaker of given rating shall be prevented from engaging with stationery element of higher rating.

Main Bus Bars

a. Busbars shall be fully insulated by encapsulation in epoxy resin, with mould caps protecting all joints.
b. Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short

circuit.

c. Busbars shall be of electrolytic aluminum conductor of hard drawn and high conductivity.

Circuit Breakers:

(a) Auxiliary contacts:

Auxiliary switch mounted on the fix portion of the breaker and directly operated from the breaker operating mechanism shall be provided and shall have minimum 6 'NO' and 6 'NC' potential free contracts for Purchaser's use. Any auxiliary relays required for contact multiplication for other requirements shall be provided. The contacts shall be rated for 10 amps, 240 V A.C and 1 Amp. (Inductive breaking), 110 V D.C. The above auxiliary switches shall not operate when the breaker is withdrawn to test position and operated.

(b) Spring operated mechanism:

The operating mechanism shall be complete with motor, opening and closing springs, limit switches for automatic charging and all necessary accessories. Facility for manual charging of the closing spring shall be provided. The operating mechanism shall be trip-free and non-pumping electrically. An anti-pumping relay to achieve electrical anti-pumping feature shall be provided even if the breaker has provision for anti-pumping by mechanical arrangement.

Earthing:

a. An earthing bus shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the framework of each unit and each breaker earthing bus.
b. All non-current carrying metalwork of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.
c. Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

Annunciators:

Faciaannunciators, suitable for operation on24VDCshallbeprovided.

Facia annunciators shall be:

i Equipped with 'Sound Cancel', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp Test' push button for each annunciator on individual panels;
ii Provided with two lamps connected in parallel on each facia window with series resistors;
iii Suitable for normally open indicating contacts of either 'hand' or 'self' reset type;
iv Suitable for annunciating subsequent faults with the specified sequence, immediately after acknowledging the previous fault;
v Facia window of minimum size of 35 mm. x 50 mm;
vi Designed for an operating sequence indicated below:

Alarm condition	Fault contact	Audible alarm	Visual alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing

Sound Cancel	Closed or Open	Off	Flashing
Acknowledge	Closed or Open	Off	Steady on
Back to Normal	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

Switchgear accessories and wiring

a. Switchgear shall be supplied completely wired internally upto equipment and terminal blocks and ready for external cable connections at the terminal blocks. Inner panel wiring between cubicles of same switchgear shall be provided.
b. All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall not be less than 1.5 sq.mm.
c. Terminal blocks shall be of stud type, 650 volts, 10 amps, rated complete with insulated barriers.
d. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
e. Accuracy class for indicating instruments shall be 1.0. Instruments shall be 110 mm. Square with 240o scale for flush mounting with only flanges projecting.
f. Ammeters, voltmeters, shall be of moving iron type. The accuracy class shall be 1.0. The range shall be indicated on the drawing / data sheets. Digital microprocessor based power monitor shall be provided to monitor all electrical parameters, such as KVA, KW with resettable maximum demand recorder and indicator, KVAR, KWH,KVARH, Power Factor PF, Frequency, Voltage current etc. The power monitor shall operate off a PT secondary of 110 volts, suitable for operation on 3-phase, 3-wire system and to measure unbalanced loads.
g. Relays shall be suitable for flush mounting with only flanges projecting.
h. All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose. All auxiliary relays and timers shall be supplied loose. All auxiliary relays & timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.
i. Control and instrument switches shall be rotary type provided with inscription plates clearly marked to show operating position and suitable for semi-flush mounting with only switch front plate and operating handle projecting out.
j. Breaker control switches shall be pistol grip black and selector switches shall be oval or knob and black. Breaker control switches shall be three-position spring return to neutral type. Instrument selector switches shall be of the maintained stay -put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used.
k. All push buttons shall have two normally open and two normally closed contacts unless specified otherwise. The contacts shall be able to make and carry 5 A at 110V DC and shall be capable of breaking 1 A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
l. Indicating lamps shall be panel mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.
m. Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240V, 1 pH, 50 Hz supply. They shall be complete with HRC fus es, isolating switches and thermostat to cut off heater at 45o C.
n. Each switchgear panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps, 3 pin receptacle

with switch located in a convenient position.

o. An interior illuminating lamp together with operating door switch and protective fuse shall be provided.
p. Provision shall be made for receiving, distribution, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating, etc. The fuse ratings shall be so chosen as to ensure selective clearance of sub circuit faults.
q. Fuses shall be HRC cartridge type mounted on plug in type fuse base.
r. The D.C. and A.C. auxiliary supply shall be distributed inside the switchgear with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

Instrument transformers

a. The CTS shall withstand momentary and short time current ratings of the associated switchgear. CTS and PTS shall be of the cast resin type and completely encapsulated.
b. The core balance CTS shall be suitable for the respective outgoing feeders and shall be suitably supported.
c. PTS shall be single phase, draw out type. PTS shall be provided with fuses on both primary and secondary sides, except those terminals that are required to be connected to earth. These shall have an isolating link. Fuses on primary side shall have rupturing capacity equal to the switchgear rating.

Cable termination

a. Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.
b. Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper / aluminium depending on cable conductor and of solder less crimping type.
c. All necessary materials required for terminating the power cables such as tapes, filters, binding wires, armour clamps, brass glands etc., shall be supplied.

Drawings and data

a. The Tenderer shall furnish the following drawings & data as part of the Tender:

i General arrangement showing plan, elevation and typical section views.
ii Foundation plan showing location of fixing channels, floor openings etc.
iii Schematic wiring drawings for each breaker.
iv Technical literature on the beakers offered.
v Bill of material listing equipment designation, make type, rating etc., of various equipment mounted on switch gear panel.

b. The Concessionaire shall furnish the following drawings for each panel & switchgear after the award of contract.

i Overall outline dimensions & general arrangement including plan, front elevations, clearances required in front and back, details of busduct connections, if any.
ii Overall outline dimensions & general arrangement including plan, front elevations, clearances required in front and back, details of busduct connections, if any.
iii Schematic control diagrams to cover controls, protection, interlocks, instruments, space heaters, etc., for each type of module.
iv Itemized bill of material for each module, listing all devices mounted and cable glands, indicating all type, rating quantity and special notes, if any.
v Detailed internal wiring diagram of each type of module, including terminal block number, ferrule numbers and the external cable connection designations.
vi Inter panel inter connection wiring diagram including terminal numbers and ferrule numbers.

Guaranteed Technical particulars for 11 KV panel

Sl. No.	Description	Parameter/value	Offered parameter/value (to be filled in by the tenderer)
I	Tag No. of Panel		
	Quantity		
	Location		
	Service	Outdoor	
	Functional Requirement	Transformer primary control	
	Type		
II	**11KVBusBar**		
	Current Carrying Capacity	800Amps.	
	Short time rating current for 3secs	31KA	
	Insulation of busbar	Air	
III	**Parameters for VCB**		
	Type	Metal enclosed	
	No of Phases	3	
	No.of poles	3	
	Rated voltage	12KV	
	Operating voltage	11KV	
	Rated lightning impulse withstand voltage	75KV	
	Rated power frequency withstand voltage	28KV	
	Insulating gas	Air	
	Rated filling level for insulation	As per governing IS	
	Isolating distance between ON and OFF position in isolator	80mm(min).	
	Rated short time current	31KA	
	Rated short time	3s	
	Rated peak withstand current	50KA.	
	No of operations in short circuit	15Nos(minimum)	
	Operating mechanism	Circuit breaker with spring assistedantire flex /trip free mechanism.	
	Rated current(Bus)	800*A*	
	Ratedcurrent(breaker)	200A	
	Circuit Breaker interrupter	VCB	
	Rated frequency	50Hz	
	Rated operating sequence	O-3min-CO	

6.10.2 11 kV XLPE Power cables

Scope

The specification covers design, manufacture, shop testing, packing and delivery of 11 kV multi core, cross-linked polyethylene insulated power cables suitable for effectively earthed neutral system.

Standards

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the HT XLPE power cables shall conform to the latest revisions available at the time of placement of order of all the relevant standards as listed in, but not limited to table below:

IS:8130-1984	Conductors for insulated electric cables and flexible cords.
IS:7098(Part2)-1985	XLPE PVC sheathed cable for working voltages from 3.3Kv upto and including 33kV.
IS:5831-1984	PVC insulation and sheath of electric cables.
IS:3975-1988	Mild steel wires, formed wires and Tapes for armouring of cables
IS:10462(PartI)-1983	Fictitious calculation method for determination of dimensions of protective coverings of cables.

General constructional requirements

The HT multi core power cables shall normally be with stranded compacted H2/H4 grade aluminium conductor as per IS: 8130 - 1984, provided with conductor screening (of extruded semi-conducting cross link material) and shall be insulated with XLPE of natural colour.

Identification of cores shall be by colour, as per provision of clause 13.1 of IS: 7098 (Part 2) - 1985. The insulation (XLPE) screening shall be provided consisting of extruded semi- conducting cross link material in combination with a metallic layer of copper tapes. Three such screened cores shall be laid up together with fillers and/or binder tapes where necessary and provided with extruded inner sheathing of heat resistant PVC conforming to type ST-2 of IS:5831- 1984.

Maximum continuous operating temperature shall be 90 deg C under normal operation and 250 deg C under short circuit condition Armouring shall be provided consisting of single galvanized round steel wires (In case of Single core cable armouring shall be of Non- magnetic material) conforming to IS:3975 - 1988 (amended upto date) and over the armouring a tough outer sheath of PVC compound shall be extruded. The PVC compound for the outer sheath shall conform to type ST-2 of IS: 5831 - 1984 (amended upto date). The colour of the outer sheath shall be black. The cable shall be manufactured strictly conforming to IS:7098 (Part 2) – 1985 amended upto date and shall bear ISI mark.

Sequential marking of length of cable

Non-erasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length. The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions

Discharge free construction:

Inner conductor shielding, XLPE insulation and outer core shielding shall be extruded in one operation by special process (viz. Triple Extrusion Process) to ensure that the insulation is free from contamination and voids and perfect bonding of inner and outer shielding with insulation is achieved. The bidders are requested to elaborate the manufacturing technique adopted by their manufacturers to achieve this motive.

The Company will order the verification of triple extrusion process at manufacturer's works as a pre-qualification if it is technically accepting the bid. During verification if it is found that the firm is not manufacturing the cable with triple extrusion process the offer shall be rejected.

Continuous A.C. Current carrying capacity:

Continuous a.c. current capacity shall be as per Table given below.

Conductor sizes insq.mm.	**Continuous a.c. current capacity in Amps. at maximum Amps. At maximum conductor temp. of 90 deg.C.**	
	Whenlaiddirectinthegroun d30deg.C	**Whenlaidinair40deg.C**
70sqmm	160	165
95sqmm	190	200
120sqmm	215	230
150sqmm	240	265
185sqmm	270	310
240sqmm	315	345
300sqmm	355	396
400sqmm	405	460
500sqmm	450	590

6.6.1.1 Short circuit current

Short circuit current of 11 kV XLPE cable shall be as per Table given below.

Duration of Short Circuit in sec	**Area of Al. Conductor**	**Short circuit current ink A**
t	A	I=0.094xA/sq.rt(t)
1	70sq.mm	6.58
1	95sq.mm	8.93
1	120sq.mm	11.28
1	150sq.mm	14.10
1	185sq.mm	17.39
1	240sq.mm	22.56
1	300sq.mm.	28.20
1	400sq.mm.	37.60
1	500sq.mm	47.00
1	630sq.mm	59.20

6.6.1.2 Routine tests

All the Routine tests as per IS: 7098 (Part 2) - 1985 amended upto date shall be carried out on each delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, essential that the manufacturer should have the appropriate type of facility to conduct this test, which is routine test.

Acceptance tests

All Acceptance tests as per IS: 7098 (Part 2) - 1985 as modified upto date including the optional test as per clause no 18.4 and Flammability Test shall be carried out on sample taken from the delivery lot.

Packing and marking:

Identification marks on cable:

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not

exceeding one meter throughout the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

a. Manufactures name and/or Trade name.
b. Voltage grade.
c. Year of manufacture.
d. Successive Length.
e. Size of cable
f. ISI mark

The cable shall be supplied in continuous standard length of 250 running meters with plus or minus 5% tolerance wound on non-returnable wooden drum of good quality and non- standard lengths not less than 100 meters upto 5% of the ordered quantity shall be accepted. Alternately, cable can be supplied wound on non-returnable steel drum without any extra cost to the purchaser. Packing and marking shall be as per Clause No. 21 of IS:7098 (Part 2) - 1985 amended up to date.

6.6.2 Transformers

6.6.2.1 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.

IS : 2026	Power Transformer
IS : 3639	Fittings and Accessories
IS : 1180	Distribution Transformer
IS : 6600	Loading of oil immersed transformer
IS : 335	Insulating oil
IS : 2099	Bushings for>1000 V,AC
IS : 7421	Bushings for≤1000 V,AC
IS : 13947(PartI)	Degree of Protection
IS :1271	Electrical insulation classified by thermal stability

6.6.2.2 Features of construction

a. 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 rainwater.
b. 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.
c. 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.
d. 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.
e. The transformer tank, radiators and conservator shall be designed taking into account the loss of thickness due to shot blasting.

f. 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.
g. Each lamination shall be coated with insulation, which is unaffected by the temperature attained by the transformer during service.
h. Core lamination shall be annealed and burrs removed after cutting. Cut edges shall be insulated.
i. The frame work and clamping arrangements of core and coil shall be securely earthed inside the tank by copper strap connection to the tank.
j. Windings shall be of suitably insulated copper wire or copper strip. The windings shall be fully shrunk under vacuum before assembly.
k. High voltage end windings shall be suitably braced to withstand short circuit stresses and stresses set up by surges.
l. All taps shall be provided on the HV winding.
m. The core and coil assembly shall be dried out and impregnated under vacuum.
n. 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.
o. All auxiliary wiring from current transformers, winding temperature indicators, etc., shall be marshalled to a separate weatherproof and vermin proof marshalling box with an independent access cover.
p. 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.

6.6.2.3 Performance requirements:

a. Transformers shall operate without injurious heating at the rated KVA at any voltage within + 10 percent of the rated voltage of that particular tap.
b. 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.
c. 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.
d. Transformers shall operate below the knee of the saturation curve at 110 percent voltage to preclude ferro-resonance and non-linear oscillations.
e. 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.
f. The neutral terminal of windings with star connection shall be designed for the highest over current that can flow through this winding.
g. 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.
h. The Engineer's Representative 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 Concessionaire's cost.
i. If the commissioning of the project is likely to be delayed by the rejecti on of a transformer, as mentioned under h) above, the Engineer's Representative 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 Concessionaire's cost.

6.6.2.4 On Load Tap Changing Gear for transformer:

a. 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.
b. 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.
c. 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.
d. Oil, in compartments of OLTC which do not contain the make and break contracts, 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.
e. 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.
f. OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weatherproof cabinet with IP 55 protection, which shall include:

i Driving motor(415V,3-phase,50Hz, AC squirrel cage).
ii Motorstartingcontactorwiththermaloverloadrelays,isolatingswitchandHRCfuses.
iii Control switch: Raise /off/lower (spring return to normal type).
iv Remote/local selector switch (maintained contact type).
v Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
vi Limitswitchestopreventmotorover-travelineitherdirectionandfinalmechanical stops.
vii Brake or clutch to permit on lyone tap change at a time on manual operation.
viii Emergency manual operating device (hand crank or head wheel).
ix Afive-digit operation counter.
x Electricity interlocked reversing contactors(preferably also mechanically interlocked)
xi 240V,50Hz,ACspace heater with switch and HRCfuses.
xii Interior lighting fixture with lamp door switch and HRCfuses.
xiii Gasketted and hinged door with locking arrangement.
xiv Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
xv Necessary relays, contactors, current transformers etc.

a. Control Requirements for OLTC:

The following electrical control features shall be provided:

i 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.
ii Only one tap change from each tap change impulse even if the control switches or push button is maintained in the operated position.
iii 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.
iv Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

b. Automatic Control of OLTC:

Automatic OLTC control shall include the following items:

i Voltage setting device
ii Voltage sensing and voltage regulating devices
iii Line drop compensator with adjustable R and X elements
iv Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation
v Adjustable dead band for voltage variation

c. OLTC panel:

The OLTC remote control equipment shall be suitable for 24 V 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 IP 54, 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.

The panel shall consist of:

i Control Switch: Raise / Off / Lower (spring return to normal type)
ii Auto / manual selector switch (maintained contact type)
iii Tap position indicator
iv Facia type alarm annunciators with "accept" and "lamp test" facilities
   a. Supply failure
   b. Drive motor auto tripped
   c. Tap change delayed.
v Necessary auxiliary relays
vi Lamp indications for:
   a. Tap change in progress
   b. Lower limit reached
   c. Upper limit reached
vii Cable glands for power and control cables
viii 240 V rated panel space heater with ON-OFF switch
ix Fluorescent type interior lighting fixture with lamp and door switch
x HRC fuses
xi Terminal blocks
xii Internal wiring
xiii Earthing terminal

6.6.2.5 Fittings and accessories:

The following fittings and accessories shall be provided with transformer:

a. Inspection manhole in the cover
b. Lifting lugs for both the transformer and the core
c. Two earthing terminals on opposite ends of the transformer tank
d. Name plate, rating plate and diagram plate
e. Detachable radiator banks, complete with top and bottom shut-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.

f. 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 degree C
g. Oil level indicator with minimum marking.
h. Weather proof dehydrating breather with activated alumina or silicagel as the dehydrating agent.
i. Magnetic type oil level gauge with low oil level alarm contact, mounted on the conservators with waterproof and WT Proof terminal box.
j. Gas detector relays with separate alarm and trip contacts complete with shut -off valves.
k. Separate drain valve, oil sampling valve with plug and top filter valve shall be provided on the tank.
l. 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.
m. Separately mounted, water proof and duWTProof 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.
n. For transformers rated 500 KVA and above, adequate number of air vents for reliving trapped air during oil filling and during maintenance.
o. Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.
p. Four jacking pads for lifting the transformer with jacks.
q. Pulling eyes and skids for the movement of the transformers. (r) Bi-directional wheels for movement of the transformers.
r. Accessories for clamping the wheel mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2 g.
s. Noise level of transformers shall be less than 80 dB.
t. Transformer shall be supplied complete with insulating oil required for first filling plus 10% excess oil.

6.6.2.6 Drawings and data

The following drawings shall be submitted for the Employer's approval:

a. General outline drawing as submitted at the tendering stage but with binding dimensions and weights within 2 months of award of contract.
b. 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:
   i OLTC (Local and Remote) cabinets
   ii Marshalling box
   iii Cable boxes
   iv Disconnecting chambers
c. Cable junction box details, mounting details, make and type number, current and voltage rating, creep age distances and principal characteristics.
d. Rating and diagram plates
e. OLTC cabinets: schematic circuit diagram and actual detailed wiring diagram giving terminal numbers within 5 months of award of Contract.

f. Marshalling box terminal connections wiring diagram.

6.6.2.7 Guaranteed Technical particulars for Transformer

Sl. No.	Description	Owner'srequirement	As offered Particulars (to be filled in by the tenderer)
1	Make		
2	Service	Outdoor	
3	Rating	As per requirement of individual facility in KVA	
4	**Rated Voltage**		
a	HV winding		
b	LV winding		
5	Number of Phases	3phase	
6	Rated Frequency	50Hz	
7	Vector group	DYn11	
8	Type of cooling	ONAN	
9	**Taping**	**on11kVside**	
a	Range	+5%,to-15%	
b	Number of steps	8 steps 9 position	
c	Losses at 75°C & Principal tapping	As per IS 1180	
10	No load loss at rate voltage and frequency	As per IS 1180	
11	Load losses at rated current	As per IS 1180	
12	Total loss at maximum rated power	As per IS 1180	
13	**Impedance voltage at 75°C**		
A	At principle tapping		
B	At Maximum tapping		
C	At minimum tapping		
14	Hottest spot temperature in winding limit		
15	**Efficiency at 75°C and 0.9PF**		
A	At full load	As per IS 1180	
B	At75%load	As per IS 1180	
C	At50%load	As per IS 1180	
16	Maximum efficiency	As per IS 1180	
17	**Maximum current density at rated power**		
A	HV winding		
B	LV winding		
18	**Maximum flux density in iron at rated voltage & Frequency**		

Sl. No.	Description	Owner'srequirement	As offered Particulars (to be filled in by the tenderer)
A	At 100% rated voltage		
B	At 110% rated voltage		
19	**Maximum clearances in air**		
A	Between phases (HV/ LV)		
B	Between phases & earth		
20	**Insulation level**		
A	Impulse		
B	HV		
C	LV		
21	**Power frequency**		
A	HV		
B	LV		
22	**Winding type**		
A	HV winding		
B	LV winding		
23	**Details of core**		
A	Core lamination material		
B	Insulation of lamination		
C	Thickness of lamination		
D	Type		
E	Specificlossofcoresteelat1.5		
24	**Details of tank**		
A	Material		
B	Thickness of side		
C	Thickness of bottom		
D	Thickness of cover		
E	Thickness of tube		
F	Maximum internal pressure withstanding capacity of the tank		
G	Details of Radiator		
H	No.of Radiator tanks		
I	Thickness of radiator plate		
J	Weight of each radiator tank		
K	Cooling surface area		
L	Volume of conservator		
M	Total oil required		
N	Whether first filling of oil with 10%	Required	
25	**Details of bushing**		
A	Type		
b	Voltage class		
c	Creepage distance		
d	Weight of bushing		
e	Current rating		

Sl. No.	Description	Owner'srequirement	As offered Particulars (to be filled in by the tenderer)
f	Insulation level		
g	Impulse		
h	Power frequency dry KV		
i	Power frequency wet		
j	Length of insulator		
k	Loss angle at working		
26	**Explosion vent material**		
A	Thickness		
B	Maximum rupturing pressure of the diaphragm		
27	**Tank pressure test**		
A	Pressure		
B	Duration		
C	Tankvacuumtest		
D	Pressure		
E	Duration		
28	Maximumnoiselevel		
29	**Overall dimensions including coolers & fittings**		
A	Height		
B	Breadth		
C	Length		
C	Crane lift for dismantling core and coil assembly		
D	Weight of core & winding		
E	Tank & Fittings weight		
F	Oil weight		
G	Total weight including radiator, OLTC,andoil		

6.6.3 MV Panel Board / LV Switch Board construction

All MV and LV panel boards / switch boards, unless and mentioned otherwise, shall meet the following requirements. For particular requirements and data sheets as applicable to the subject project, refer section 9.9 of this tender document.

Type	:	➢ Floor mounting, free standing, single front, fully compartmentalized, totally enclosed, dust & verm in proof, modular in construction & fully extensible on either sides
Conforming to	:	IEC60439

Construction	:	➢2.00mm thick for frames and other load bearing members ➢1.6mm thick for doors and partitions ➢3.0 mm for gland plates &of non-metallic construction for termination of single core armoured cables
Form of separation	:	Form3B
Bus bar configuration, MOC, busbar supports, busbar insulation, busbar compartments, cable alley and feeder compartments	:	➢ TPN busbars with 50% neutral for all applications not involving harmonic loads and with 100% neutral for loads with harmonics. ➢ Risers (vertical busbars) shall have a continuous current rating atleast 125% of combined feeder ratings of the particular vertical section. ➢ Completely enclosed busbar compartment running horizontally at the top/bottom as per actual panel configuration ➢ Completely enclosed compartments for vertical busbars. ➢ Individual feeder modules in multi-tier modular formation. ➢ Vertical cable alleys with removable gland plates at the bottom/top ➢ Busbar supports Non-hygroscopic/SMC/DMC
Busbar MOC and sizing	:	➢ MOC – High conductivity, high strength Aluminium alloy complying to requirements of Grade E 91E of IS 5082 (or) E.C grade copper ➢ All bus bars to be dimensioned considering the maximum permissible rise in temperature of 50 Degrees over ambient temperature under normal operating conditions.
Earthbus	:	➢ Continuous Aluminium strip of adequate cross section to carry the fault current to be run inside each shipping section. ➢ All compartment doors to be provided with insulated earth continuity conductors / jumper wires

Panel height, door and shipping sections	:	➢ Panel height shall generally not exceed 2100 mm including the bottom mounting channel. ➢ The operating handle of the switchgear at the top most tier shall ➢ be not more than 1800 mm from FFL. ➢ The operating handle of the switchgear at the lower most tier shall be not less than 300 mm from FFL ➢ Panel doors (Front) – Hinged ➢ Panel doors (rear) – Bolted ➢ Bus bar chamber and cable chamber doors – Bolted ➢ Gaskets – Continuous type of neoprene ➢ Locks – Each compartment shall be with interlock to ensure that the doors do not open with switch ON. Interlock defeat also required to be provided ➢ All switchgear compartments to be suitable for LOTO arrangement. ➢ The panel shall generally be made in sections not exceeding 2.50 mtrs long for ease of handling and movement inside panel rooms.
Degree of protection	:	➢IP 42 for indoor panels ➢IP54 for panels meant for use industry and humid operating environment
Finish	:	➢Powder coat finished as per IS3618.
Cable termination	:	➢From top/bottom as per datasheet. ➢Shall be suitable for terminating the number of cable runs and the type of cable as per SLD/datasheet.
Wiring	:	➢All control wiring (Other than CT circuit) to be done using 1.5 Sq.mm PVC insulated wires ➢All CT wiring shall be not less than 2.5Sq.mm PVC
Meters	:	➢All MFMs/Ammeters/Voltmeters and other meters as called for in the SLD shall be suitable for flush mounting type on panel compartment doors and shall be digital versions with RS485 communication feature.
Relays	:	➢Shall be as per SLD/datasheet
Control Supply	:	➢Shall be derived using 415/110VAC control transformer and with MCB protection on both primary and secondary side of the control transformer.
Space Heaters	:	➢All busbar compartments shall be provided with space heater to prevent moisture condensation and maintain cubicle temperature 5degree C above the ambient. The space heaters shall be located suitably and shall be controlled through thermostats with suitable setting with MCB.
Indicationlamps	:	➢LED cluster type. The lamps shall havered, green, amber, Blue and white caps as applicable made out of temperature resistant prismatic glass. The lamp holders and caps shall be guaranteed for continuous operation of lamps without any damage.

Control switches/Push button actuators	:	➢Control and instrument selectors witches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch joint plate and operating handle projecting out. The connection shall be from the back.
Legend plates /name plates/ warning boards	:	➢ Each compartment of the PANEL/MDB/PDB/MCC/PMCC shall be provided with a nameplate engraved with its designation. The name plates shall berear engraved per spex with white letters on black background. The name plate shall also indicate the rating of the switchgear, the equipment fed and its rated power (ink worhp) ➢ Metallic name plate shall be provided on anyone side of the panel/switch board duly indicating as a minimum the name of the panel vendor, the P.O No.& date, the month & year of installation, ➢ Warning stickers with danger signage & text in trilingual (English/Hindi and Local language) red letters on white background shall be provided at appropriate locations.
Mimic display	:	➢The panel front facia shall be provided with mimic key SLD (either red painted or with reds ticker)

6.6.3.1 Control and switchgear specifications

All control gear and switchgear shall be ROHS compliant

All control and switchgear, unless and mentioned otherwise, shall meet the following requirements.

ACB	:	EDO type
Pole configuration	:	Asper equipment requirement
Breaking Capacity	:	Asper system requirements
Protection type	:	O/L,S/C and E/F
Accessories	:	UV, Earth Fault and Shunt release(two of the accessories as per data sheet)
Auxiliary contacts	:	2NO and 2NC minimum
MCCB	:	Panel internal mounted with door mounted rotary handle operated type
ACB	:	EDO type
Pole configuration	:	As per equipment requirement
Breaking Capacity	:	Asper system requirements
Protection type	:	O/L,S/C and E/F
Accessories	:	UV, Earth Fault and Shunt release (two of the accessories as per data sheet)

Auxiliary contacts	:	2NO and 2NC minimum
MCCB	:	Panel internal mounted with door mounted rotary handle operated type
Pole configuration	:	As per equipment requirement
Breaking Capacity	:	As per system requirements
Protection type	:	Thermalmagneticupto250Amps Microprocessor based for ratings 250Amps and above
Cable termination	:	All MCCBs for terminating cables above 35 Sq.mm shall be with spreader links
Accessories	:	UV, Earth Fault & Shunt release (two of the accessories as per data sheet)
Auxiliary contacts	:	2NO and 2NC minimum
MCB	:	DIN rail mounted with dolly handle operated type
Pole configuration	:	As per requirement at individual facility
Breaking Capacity	:	As per Requirement at individual facility
Protection	:	O/L&S/C
Cable termination	:	AllMCBsforterminatingcablesabove16Sq.mmshallbewithspreader links
Fault Level	:	10kAforMCBsratedmorethan25Amps
Motor Starter component rating	:	Basedon Type-2co-ordination charts
Motor starter type	:	Upto and including10HP–DOL Above 10HP and upto and including 30HP–Star Delta starting Above 30HP and upto and including 50HP–Soft start Above 50HP–VFD
Additional protection	:	Current sensing type single phase and phase reversal protection
Metering and CT	:	For motors upto 10HP CT shall be provided in the centre phase complete with ammeter. For motors above 10HP CT shall be provided in all three phases complete with ammeter and ammeter selector switch
Cable termination	:	All terminations for cables above16Sq.mm shall be with spreader links

6.6.3.2 Soft starters for LV motors

The soft starters shall comply with the requirements of IEC 60034, 60947 and IS 325 including those standards referred to therein.

Constructional and performance features

Motor soft starters shall be switched or electronic type.

Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

a) control, metering and current transformers for differential protection, if specified
b) shorting (bypass) arrangement
c) bus bars
d) power cable terminations
e) push buttons with indicating lamps.

Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables.

Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC.

6.6.3.3 Variable Frequency Drives (VFD)

The Frequency drives shall be of Current Source Inverter Pulse Width Modulated (CSIPW M) with GTO/IGBT/IGCT/SGCT/DTC technologies or later version, which performs precise speed and torque control of standard squirrel cage motors with optimum efficiency. Each drive must have a soft starting feature and a by pass arrangement for DOL starting of motors. All frequency dives shall be suitable for data connectivity with PLC/SCADA system and shall have Ethernet TCP/IP suitable communication 99 port and protocol. The drives must be easily programmable. The drives shall be provided with surge protection, programmable lockable code. The Frequency drive shall have following characteristics:

a) Accurate open loop torque control
b) Torque step rise time typically less than 5 ms
c) Speed control inaccuracy typically 0.1% to 0.5% of nominal speed
d) 150% overload capacity for 60 second
e) Total Harmonic distortion shall comply with the provisions of IEEE 519. Necessary metering, self-diagnostic arrangement (including display and alarm facilities) shall be provided for local/ remote monitoring.

❖ Technical Parameters

- Main connection
  a) Voltage : 3 phase, 3.3 KV / 415 V +/- 10 % permitted tolerance
  b) Frequency : 45 to 65 Hz, maximum rate of change 17%/s
  c) Imbalance : Max. +/- 3% of nominal phase to phase input voltage
  d) Fundamental Power factor : 0.97 (at nominal load)
- Motor connection

a) Voltage : 3 phase, from 0 to applied incoming supply voltage, 3-phase
b) symmetrical
c) Output Frequency : 0 to 250 Hz
d) Frequency Resolution : 0.01 Hz

- Continuous Current : 1.0 * I2N(normal use)
- Short Term Overload
- Capacity (1min./10min)
- I2max = 1.1 * I2N
- Field Weakening point : 8 to 300 Hz
- Acceleration Time : 0 to 1800 sec
- Deceleration Time : 0 to 1800 sec
- Efficiency : Min. 97% at nominal power level
- Environment limits
- Ambient temperature : 0 to 45 deg. Cent.
- General Standard Control Connections or as per Process Requirement
- 3 programmable differential analogue inputs (1 voltage signal, 2 current signals)
- 7 programmable digital inputs
- 2 programmables analogues outputs (current signal)
- 3 programmable digital outputs (from C relays)
- Power Torque Speed value must be configurable to the etherrnet tcp/ip port for their remote data acquisition in PLC/ SCADA. Optional analogue and digital extension modules can be added as well as a wide range of field bus adapters.
- Protection
    a) Over current
    b) Short circuit at start-up
    c) Input phase loss
    d) Output phase loss
    e) Motor overload
    f) Earth fault
    g) Overvoltage
    h) Undervoltage
    i) Over temperature
    j) Motor stall
- Application macros

  The features a selection of built-in, pre-programmed application macros for configuration of inputs, outputs, signal processing and other parameters. It shall have interfacing facilities to communicate data to SCADA system. These include:
    a) FACTORY SETTING for basic industrial applications
    b) HAND/AUTO CONTROL for local and remote operation
    c) PID CONTROL for closed loop processes
    d) TORQUE CONTROL for process where torque control is required.
    e) SEQUENTIAL CONTROL for processes where torque control is required.
    f) USER MACRO 1 and 2 for user's own parameter setting
    g) Comprehensive testing and diagnostic function
- Tests
    a) Each unit of Variable frequency drive shall be tested at the manufacturer's work with the motor they have been assigned to work for at the WTP
    b) Test result must satisfy the efficiencies on various loads and at different frequency levels against their quoted values.

Contactor	:	Air break

Pole configuration	:	Three pole/Four Pole as per data sheet
Auxiliary contacts	:	2NO+2NC
Utilisation category	:	As per data sheet

CT	:	Castres in type
Ratio, class & Burden	:	As per SLD/Datasheet
Insulationclass	:	1.1kV

Control Transformer	:	Castres in type
Voltage Ration	:	415/ 110VAC
Insulation class	:	1.1kV
Rating	:	1000VA

Capacitor		
Type	:	Dry type, Mixed Di-electric versions with self-healing capacity conforming to IS 13340.
Voltage	:	220Volts to 575Volts based on application

Pushbutton Actuators		
Type	:	Panel door mounted – shrouded type for START and Mushroom type for STOP/RESET
Contact ratings	:	6Amps

6.6.4 1.1 kV XLPE cable

6.6.4.1 Scope

This part of the specification covers the requirements of design, manufacture, inspection, testing and supply at site of 1.1 kV grade XLPE power and control cables.

6.6.4.2 Standards

The 1.1 kV grade Power & Control Cables conform to the requirements of the latest Indian

Standard Specifications including but not limited to the following:

IS 7098	:	Cross-linked poly ethylene insulated PVC sheathed cables
IS 3975	:	Mild steel wires, strips and tapes for armouring of cables
IS 10418:1982	:	Drums for electric cables.
IS 10810	:	Methods of test for cables
IS 1554 (PartI)	:	PVC Cables for voltage upto and including 1100volts
IS 8130	:	Conductors for insulated electric cables
IS 5831	:	PVC insulation and sheath of electric cables
IS 3975	:	Mild steel wires, strips and tapes for armouring of cables

6.6.4.3 General Construction

The cables shall be suitable for laying in trays, trenches, ducts, conduits and buried underground installation with uncontrolled backfill and possibility of flooding by water. These shall have following

constructional features.

All power and control cables for use on low voltage system shall be heavy of 1100 V grade with aluminium / copper conductor, XLPE insulated, PVC inner sheathed, armoured and overall PVC sheathed.

The construction of the conductors shall be SOLID for aluminium conductor cables up to 10 mm sq. and for copper conductor cables up to 2.5 mm sq. For cables above 10 mm sq. and for copper cables above 2.5 mm sq. the conductor shall be STRANDED. Conductors of nominal cross sectional area less than 10 sq.mm shall be circular only. Conductors of nominal cross section area 16 sq.mm and above may be circular or sector shaped.

The core insulation shall be with XLPE applied over the conductor by extrusion and shall conform to the IS 7098. Control cables having 6 cores & above shall be identified with prominent & indelible numerals on the outer surface of the insulation. Colour of the numbers shall be white with a spacing of maximum 500 mm between two consecutive numbers.

The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of type ST2 PVC compound per IS 5831. The extruded inner sheath shall be of uniform thickness of size not less than 0.5 mm up to 16 sq.mm, 0.8 mm from 25 sq.mm upto 120 sq.mm and 1.0 mm above 120 sq.mm conductor size. Taped inner sheath shall also be acceptable.

For multi core cables, the armouring shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and galvanized steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanization shall be as per IS 3975 and IS 2611.

The outer sheath for the cables shall be applied by extrusion and shall be of PVC compound and conforming to the requirements of type ST 2 compound per IS 5831. To protect the cables against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.

The dimensions of the insulation, armour and outer sheath materials shall be governed by values given in IS 1554 (Part I).

6.6.4.4 Packing

The cables shall be supplied in standard drum lengths duly wound on non-returnable wooden drums.

Vendor shall ensure that the bending radii of cables are not less than 12 times their overall diameters when wound on drums. Both ends of the cables shall be sealed.

Following information shall be printed on the flange of each cable drum.

a) Type
b) Size
c) Voltage grade
d) Length in meters
e) ISI Mark
f) Gross weight
g) Direction of rolling

6.6.5 Specification for power / lighting distribution boards

6.6.5.1 Scope

This part of the specification covers the requirements of design, manufacture, assembly, inspection, testing and delivery at site of Power/ Lighting Distribution Boards / Panels.

6.6.5.2 Standards

The Power / Lighting Distribution Boards shall conform to the requirements of the latest Indian

Standard Specifications including but not limited to the following:

IS 13947	:	Low Voltage Switch gear and Control gear
IS 11353	:	Guide for Uniform System of marking and identification of conductors and apparatus
IS2705	:	Current Transformers
IS 8623	:	Low voltage switch gear and control gear assemblies
IS 4237	:	General requirements for switchgear and Control gear for voltages not
IS 13032	:	Miniature air-break circuit breakers for voltages not exceeding 1000V
IS 13947	:	Switches, dis connectors, air break Switch (Part3) disconnectors and fuse
IS 13703	:	LV Fuses for voltages not exceeding 1000 Vac or 1500 Vdc Part1 General
IS 1248	:	Direct acting electrical instruments
IS 722	:	AC Electricity Meters

6.6.5.3 Construction & component specification

The boards shall be sheet steel enclosed on all sides and shall be dust and vermin proof, providing a degree of protection equivalent to IP 54. The sheet steel used shall be 14/16 Gauge CRCA.

The distribution boards shall be provided with hinged doors for access to components. Doors shall be provided with gasket all around with neoprene gaskets.

The Power Distribution Boards (PDBs) / Lighting DB, shall be suitable for wall mounting. Cable entries to these boards for incoming as well as outgoing cables shall be from the Top The bus bars of Power Distribution Boards (PDBs) / Lighting DB shall be of electrical grade Copper of adequate size. These shall be supported on SMC/ DMC/ Epoxy non-hygroscopic supports at suitable intervals to withstand the thermal and dynamic stresses developed due to short circuit current of 10KA for Power DBs & Lighting DB.

Internal Earth bus of adequate size of copper flat shall be provided extending through the entire length of the boards

6.6.5.4 Earth Leakage Circuit Breakers (ELCBs)

The ELCBs shall be designed to operate within 30 milliseconds to provide effective protection against electrocution risks and fires caused by earth leakage faults of 30 mA and above. All parts of the switching mechanism shall be of non-corroding self-lubricating material thus providing consistent and trouble-free services. These shall have short circuit withstand capacity of 10 KA.

6.6.5.5 Miniature Circuit Breakers

These shall be hand operated type. The miniature circuit breaker shall incorporate thermal overload and

magnetic short circuit tripping devices. These shall have short circuit withstand capacity of 10 KA.

Provide positive 'ON' locking devices for miniature circuit breakers supplying power to corridor lights, night lights and other circuits requiring continuous supply.

Provide a neatly typed directory on each panel, listing the locations of devices and equipment served by each circuit, mounted on the inside of the front cover in a frame with hard transparent shield.

6.6.5.6 Internal wiring

The boards/ panels shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1100V grade PVC insulated, stranded copper conductor of adequate size (min. 2.5 mm sq.) Identification ferrules shall be provided to correspond with wiring diagrams. All wiring shall be terminated on terminal block. Terminals of Power Distribution Boards / Lighting DB shall covered terminals.

6.6.5.7 Painting

Sheet metal work of the Boards / Panels shall undergo a thorough surface treatment comprising rust removal, degreasing, pickling and phosphating prior to painting. The pre- treated boards/ panels shall be painted / Powder coated with two coats of suitable primer and finished with two coats of Power coated of approved shade as per IS-5.

6.6.6 Specification for cable carrier / cable containment system and accessories

6.6.6.1 Scope

This part of the specification covers the requirements of design, manufacture, assembly, inspection, testing and delivery at site of cable carrier / cable containment system with accessories.

6.6.6.2 C15.10.8.2 Standards

The Cable carrier system with accessories shall conform to the requirements of the latest

Indian Standard Specifications including but not limited to the following:

IS 513	Cold rolled low carbon steel and strips
IS 1079	Hot rolled carbon steel and strips
IS 2629	Recommended practice for hot dip galvanizing
IS 2611	Methods for testing uniformity of coating of Zinc coated articles
IS 1367	Technical supply conditions for threaded steel fasteners.
IS 1663	Method for tensile testingofsteelsheet&stripofthickness0.5mm to3mm

6.6.6.3 Construction

Cable carries, fittings and accessories shall be fabricated out of rolled Mild Sheel sheets free from flaws such as laminations, rolling marks, pitting etc. conforming relevant codes.

Minimum thickness of Mild Steel sheets used for fabrication of cable carries and fittings shall be 1.60 mm up to 450 mm wide trays and 2.0 mm above 450 mm wide trays. The thickness of side coupler plates shall be minimum 3 mm.

All accessories like bends, reducers, tees, crosses coupler plates, etc., shall be pre-fabricated and not

fabricated at site.

Structural supports shall be made out of Mild steel with hot dip galvanized of adequate size and load carrying capacity.

Structural supports shall be located appropriately and the distance between any two supports shall not be more than 1500 mm.

In RCC trenches, the cable carriers shall be of cantilever construction and erected with anchor fasteners / insert plate with adequate load carrying capacity. Fittings like bends, reducers, tees, crosses, etc. accessories like side coupler plates etc. and hardware GI bolts, nuts, springs, washers as may be required shall be treated as part of the supply item.

In masonry brick work the cable carrier support shall be grouted adequately with appropriate supports using cement mortar.

In vertical sections the cable carriers shall be of ladder / perforated construction with one or multi tiers complete with matching fittings like bends, reducers, tees, crosses etc., accessories like side coupler plat etc. and hardware GI bolts, nuts, springs, washers, etc. as may be required.

The standard length of each size and type of cable tray / ladder shall be not more than 2.5 metre.

6.6.6.4 Support system for cable carriers

The support system shall be fabricated from standard structural steel members. The cable carriers and support system shall be hot dip galvanized

6.6.6.5 Galvanizing

Galvanising of steel components and accessories shall conform to relevant code The galvanising shall be uniform, clean, smooth, continuous and free from spots. Should the galvanizing of the samples be found defective, the entire batch steel shall have to be re- galvanised at Concessionaire's cost after pickling.

The amount of zinc deposit over threaded portion of bolts, nuts, screws a washers shall be as per relevant codes. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads have the required zinc coating on them.

The hot dip galvanized thickness shall not be less than 80-micron thickness.

6.6.7 Make of materials (Preferred make or equivalent)

VCB:ABB/L&T/ Schneider/Siemens Transformer Volt amp/ Schneider / Wilson / Indotech
ACB :ABB/ Schneider/ Siemens/L&T
MCCB:ABB/ Schneider/GE/L&T/Siemens
MCB/ RCCB/ RCBO:Legrand/Hager/Schneider/L&T
Capacitor:Epcos/ Duccatti/Frako /MomayaContactor/OLR:Siemens/L&T/ABB
Selector Switches :Salzer / L&T
Meters: AE/ Enercon/Conserve/Rishab
Indication Lamps: Vaishno/AE/Rishab
Current Transformer: Kappa/Kalpa/CurrentElectricals
Push Buttons: Concord/Vaishnav/teknik
Protective & control Relays: Areva /Schneider/C&S/ER/ABB/AVKSEG
Terminal Block: Essen/Elmex

Potential/Control Fuses(HRC):L&T/Siemens/GE
LED Light Fittings :Philips/Crompton/ Bajaj / Greatwhite
Cables:Universal/ KEI / KEC /Polycab/ Unistar/Finolex
HT cable termination : Raychem/ Mseal
Gland : omet/Jainsons/Prabhat/ HMI
Cable Lugs : Dowells / Hax Brass / Lotus / Jainson / Comet
Wires : Finolex / RR kabel /Greatwhite / polycab / KEI
Conduit : AKG / Precsion / BEC
First aid kit : Thadani
Lightning arrester : WS / Lamco / OBO betterman / Galaxy
Insulators : WS / Jayshree /MPI / Oblum
Tag block : Krone

Technical specification for Diesel generator set

6.6.8 General

6.6.8.1 Scope of work

This specification covers the technical requirements and essential particulars for the Design, manufacture, supply, inspection, testing and commissioning of adequate size of Diesel Generator systems as covered in the specification documents and drawings. The Concessionaire shall demonstrate that the DG set satisfies the requirements of the specification and applicable codes as well as CPCB norms latest revision.

6.6.8.2 Diesel Generator

6.6.8.3 Applicable codes and standards

i The DG set shall conform to the latest editions of the codes and standards listed under Clause 2.1.2 below & other applicable standards. Nothing in this specification shall be construed to relieve the Concessionaire of this responsibility.

ii TheapplicableIndianstandardsandcodesshallbefollowedwhereverapplicablefortheDG set. In all cases, the latest revision of the standards shall be referred to. If requirements of this specification conflict with the requirements of the standards, this specification shall govern. The following standards, unless otherwise specified herein, shall be referred to.

IEC34	Rotating electrical machines
BS5000	Part3 Reciprocating IC engines: Performance
IS 10002	Performance requirements of Diesel Engines
IS 10000(OR) Equivalent BS code	Method of tests for IC engines
BS5514 /(ISP3046)	Reciprocating internal combustion engines performance standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods
IS : 2147	Degree of protection provided by enclosure for low voltage switch gear and control gear
IS : 4722	Rotating Electrical Machines
IS : 3043	Code of practice for earthing
IS 8623	Low voltage switch gear & control gear assemblies
IS 5578	Marking of insulated conductors

IS 11353	Uniform system of marking & identification of conductors and apparatus
IS 2705	Current Transformers
IS 7098	Cross linked polyethylene insulated (XLPE) PVC sheathed cables, Part1: For working voltage upto and including 1100V
IS 3156	Voltage transformers
IS 5082	Material data for aluminium busbar
IS 1248	Direct acting electrical indicating instruments
IS 9224	Fuses with high breaking capacity
IS 13947	Low voltage switch gear & control gear
IS 13364	Specification for ac generators driven by Part2, reciprocating internal combustion engine rated above 20 kVA and upto 1250kVA
IS 3231	Specification for electrical relays for power system protection
IS 8686	Specification for static protective relays
IS/ IEC60947	Low-voltage switch gear and control gear

6.6.8.4 Diesel Engine

i The diesel engines shall be approved make, suitable for Prime power rating, direct injection, four stroke, multicylinder, water cooled through base mounted radiator, turbocharged, water cooled type operating, acoustic enclosure & capable of developing requisite BHP rating to drive the Alternator

ii The engine shall be designed to operate at 50°C ambient temperature with out any de-rating factor. The engine & the governing system shall conform to class-A1 governing as per BS5514 and shall be suitable for Prime power rating generating application. The unit shall be suitable for operation on High-Speed Diesel Oil without any modifications.

iii The governing system of the engine shall be of the microprocessor based electronic type suitable to control frequency variation within +/-4% for a sudden load change upto 70% The governor shall ensure that the speed of the set is regulated within 1% of the nominal speed under normal operating conditions

iv The engine shall be electric start and shall be suitable for battery assisted manual/auto/ SCADA system starting. The design shall ensure that the starter will be automatically released when the engine picks up speed beyond 60% of the rated speed.

v All moving parts of the engine and other associated equipment shall be provided with guards to prevent accidental contact. The guard shall be designed to facilitate easy removal and reinstallation

vi The engine fitments shall include but not be limited to the following: -

a) Flexible coupling and flywheel with guard
b) Air inlet system with Dry type air filter with clogged condition indicator & turbocharger
c) Fuel system complete with Fuel Pump, flexible hoses, primary & secondary fuel filters With service indicator and manual priming pump.
d) Exhaust system with dry manifold and residential silencer.
e) Lube oil system with gear type oil pump, oil cooler, filter and crank case heater.
f) Cooling system with engine coolant belt, fan, guard, radiator & low coolant level switch.
g) 24VD.C Starter and battery charging alternator with auto cutoff.
h) Acoustic enclosure suitable for outdoor operation

6.6.8.5 Alternator

The Alternator shall be industrial type, 1500RPM, 415V, 3Phase, neutral, 50Hz, adequate size of DG set in KVA, 0.8PF, star connected, IP-23, horizontal foot mounted, continuous duty suitable for prime power alternator, double bearing, self-excited, self-regulated, brushless excitation machine with exciter and automatic voltage regulator(AVR). The exciter shall be rotating diode type and Class'H' insulated. The

exciter shall be capable of forcing the field for 3seconds (or duration as specified in the datasheet) in the event of short circuit fault at generator terminal. The exciter should be capable of building up voltage from residual magnetism, protection against lowspeed operation & highmotor starting capability. The rectifier shall have in built protection for over voltage and rate of rise of voltage. The generator shall have online greasing facility with grease nipple & relief device. All other parameters shall be as specified in the datasheet and conforming to codes and standards specified in the data sheet or relevant standards.

a) Continuous damper winding fitted on each pole.
b) Thermistor for Hot spot detection with control unit for mounting in the control panel.
c) Terminal box with separately mounted adopter box having bus bars and flexible wiring between Alternator terminals and adopter box drawn in PVC covered metallic flexible conduit. The adopter box shall be suitable for terminating adequate size of 2 runs x 3½ core XLPE armoured Aluminium cable.
d) The Alternator shall further meet the following specification.
e) The alternator shall conform to IS 4722 / BS standards.
f) The alternator shall be suitable for 20% over speed for two minutes.
g) The alternator terminal voltage for any load variation should be maintained within +/ -2%.
h) The transient and steady state frequency variation should be limited to +/-4% for sudden load variation upto 70%. The generator TVD for sudden load variation of 100% shall not be more than 15%.
i) Both ends of each phase winding shall be brought to the terminal box.
j) The alternator shall be capable of carrying 50% overload for a duration of one minute and
k) 10% overload for one hour in 12 hours operation.
l) The alternator shall withstand a 3 phase short circuit at the terminals for a period of 3 seconds
m) The total harmonic distortion shall not exceed 3% and the design shall permit up to 30%
n) unbalance between phases while in operation
o) The efficiency shall preferably not be less than 93% in the normal operating range of 50% to
p) 100% loading

Driven equipment	-	adequate size as required
Output	-	adequate size as required
Terminal voltage	-	415volts under full load conditions
Frequency	-	50Hz
No.of Phases	-	Three
Power Factor	-	0.8lag
Stator Connection	-	Star
Excitation	-	Brushless
Coupling	-	Direct
Operating duty	-	Continuous
Place of Installation	-	Outdoor
Class of Insulation	-	Class 'F'
Impedance	-	Confirming to IS
Voltage Regulation	-	+/-2.5% voltage regulation for a load variation of full load to no load at 0.80lag power factor with

		AVR
Over Speed	-	All rotating part of alternator suitable for 120%overspeedfortwominutes
Excitation	-	AC Brushless static exciter of suitable voltage and of adequate capacity to meet the excitation current of the alternator at full load at 0.80 power factor

6.6.8.6 Acoustic enclosure

1) The acoustic enclosure shall be off reestanding, floor-mounting type integral with the DG set.
2) The enclosure shall be provided with rugged heavy-duty structural steel base frame with chequered plate flooring on which the DG set is to be mounted. The enclosure shall be prefabricated factory-built and modular in construction.
3) The enclosure shall consist of acoustically treated panels housed in rugged steel frames, which shall be bolted together to from the body of the enclosure.
4) Hinged doors shall be provided, on either side, which shall also be acoustically treated, there by providing easy access to the DG set while minimizing the operating space requirements.
5) The construction of the acoustic enclosure shall be such that with both the acoustic doors open on the either side, full access is available to the engine and alternator.
6) Fresh air inlet into the system a parallel baffle air inlet silencer shall be provided. Additionally, to augment the fresh air inlet requirements, a force dairy ventilation duct with associated silencer shall be provided above the alternator.
7) For hot air discharge, an acoustic discharge plenum shall be provided in front of the engine radiator, for discharge of hot air into the surroundings through a parallel baffle air outlet silencer. The enclosure shall have suitable openings in the roof module for exhaust piping.
8) The acoustic panels shall be filled with a special grade high-density mineral wool retained on the inside by perforated GI sheets specially designed for optimum sound attenuation.
9) The outer surface of the Acoustic Panels shall be fabricated of performed 16G corrugated CRCA sheet steel.
10) All structural members such as angles/channels used in the construction of the enclosure frame.
11) All materials used for Acoustic Enclosure shall be fire resistant/fire retardant grade.
12) The sheet steel treatment shall consist of degreasing, de-rusting and phosphating followed by two coats of zinc chromate primer, followed by two coats of Zinpholite surface for superior corrosion resistance and two coats of finish paint.
13) For effective Acoustic sealing, necessary gasket material shall be provided.
14) All hardware and fittings used shall be passivated with zinc.
15) With the above Enclosure, the sound pressure levels when measured at a distance of 1meter outside the Acoustic Enclosure shall be confirming to the CPCB regulation.
16) It shall be ensured that atleast 1000mm(min.) clear space is available all around the Acoustic Enclosure to ensure free air flow for the Gen-set as required and to facilitate accessibility for generator operation and routine maintenance.
17) The enclosure shall be provided with suction fans to ensure that the adequate cooling and combustion air is made available to the engine and the temperature within the enclosure is limited to 5°C above ambient.
18) The fan shall be designed with sufficient static to draw the requisite quality of air from the duct provided for this purpose. Calculations shall be furnished to prove the adequacy of the ventilation system offered. The suction fans shall start automatically when the temperature in the enclosure reaches 40°C and shall continue to run for 5 to 10 minutes after the load is disconnected. A

temperature controller shall be provided for this purpose housed in sheet steel enclosure.

19) Two light points controlled by as witch complete with 36W fluorescent Luminaries and lamps shall be provided. Provision shall also be made for fixing a heat detector inside the acoustic enclosure, which will be connected to the central fire alarm panel.
20) Necessary openings shall be made for the entry of power cable and control cables, fuel piping, exhaust piping, air inlet pipe etc.
21) With the installation of the acoustic enclosure, there shall not be any de-rating of the DG set.
22) Themaximumtemperatureofoilandwatershallnotexceedthelimitsprescribedbythe manufacturer of the engine. The DG set shall give rated output continuously.
23) The ventilation system shall be designed to provide an adequate air volume whenever the DG Set is in operation.
24) The ventilation fan shall be of the axial flow type designed to handle the static pressure estimated based on the inlet air duct size and length.

6.6.8.7 Instrument / Control Panel

Instrument/ControlPanelshallhavetheEquipment's/Instrumentsbutnotlimitedtothe

following

a) AutoStart/ Stop control

b) Local/Remote/ SCADA control

c) MCCB/ ACB for power control

d) MCB for Control wiring

e) Lube oil pressure

f) Coolant temperature

g) Low Coolant Level

h) High Coolant Temperature

i) Over Speed

j) Engine start/ stop key switch.

k) D.C Voltage.

l) Engine RPM

m) Operating Hours Meter

n) Over/Under Voltage

o) Over Current

p) Safety cutouts for low lube oil pressure high coolant temperature, overspeed, emergency stop, low coolant level and fail to start

q) Indications for the above safety cut outs

r) Alternator Voltage and Amperage of all 3 phases

s) Wiring harness using temperature resistant insulation and flexible copper conductor wires. The

wiring should be clamped at regular intervals and terminated using lugs.

t) Stainless steel flexible for engine exhaust

u) Stop solenoid.

v) Panel illuminating lights

w) Emergency stop

x) DG set controller with RS485 Communication/Equivalent portto communicate to

SCADAsystem (supplied by others)to control/ monitor critical and essential system.

6.6.8.8 Accessories

The following accessories shall be supplied with the DG set

a) Common base frame for the Engine and Alternator

b) Anti-vibration mounts of reputed make in requisite quantity

c) Protective guards for all rotating parts

d) 18G galvanized sheet steel trays beneath the engine, day tank and overflow collection tank to collect the oil leakage

6.6.8.9 Batteries

1) The batteries shall be of heavy duty, high performance & rated for continuous duty.
2) Each battery shall be rated 24V. The number and AH capacity shall be selected to suit the engine requirements.
3) Battery shall be suitable for six successive starting attempts each of10 seconds duration with a gap of 5 seconds between successive starts.
4) The battery shall be supplied complete with electrolyte and accessories. The accessories shall include battery stand, battery leads with terminal ends, acrylictop cover and inter battery connectors. First charging of the batteries shall be included.

6.6.8.10 Control cabling

1) The cables shall comply with all currently applicable Indian Standards & IEC standards and the following specific standards and codes:
2) Copper/Aluminium control cables-PVC/XLPE insulated, PVC sheathed 650/1100Vgrade as per IS:1554-I & IS :7098- I. Overall shielding if required with Aluminium My lartape with 100% coverage & 25% overlap on laid up cores for static noise reduction.
3) Flexible, chord cables and wiring cables-PVC insulated & sheathed upto 1100V as per IS:694, single and multicore.
4) Coaxial cables-RG and UR series as specified and as per MIL-C-17/Bs:2316/ IS5068/Is11967 and suitable for 50/75/100/125ohms
5) Signal cables as per BS:5308, DINVDE0815 &816, IS:1554, IEC:189
6) Conductor shall be stranded/solid, circular/ shaped-electrical grade aluminium/copperas per IS:8130 and IEC:60228/ BS:6360.
7) Cable Insulation as per IS:5831/ IS:7098 and BS:6746/ BS:5467/ IEC:60502
8) Inner sheath & outer sheath shall be PVC/HRPVC/ PVCFRLS/ PVCFR as per ST1/ ST 2/ IEC754Part1 / IEC60332PartI &III/ IEEE-383/ ASTM2843&2863, EIL Specs etc.
9) Armouring shall be G.Sround wire /Flat strip or Aluminium wire/Flat strip over the inner sheath as per IS3975

6.6.8.11 Receipt of material at site

All material loading, unloading, transportation, (shifting and storage, safekeeping)etc., is under the scope of DG vendor.

6.6.8.12 Testing, commissioning, training and approvals

Testing and commissioning shall be carried out based on the specifications, data sheets, BOQ and the latest requirements of the various statutory authorities.

After installation as per the final approved drawing, the site testing shall be carried out by the vendor as specified before commissioning the DG set system. After testing the entire system to the satisfaction of the client and their represents it shall be handed over to the client after completing the testing and commissioning formalities.

A thorough training of the operation and maintenance procedures etc as required or necessary shall be given by the vendor to the Client's representatives with appropriate write-ups and manuals / catalogues as reference for a minimum period of three months after handing over.

The documents / drawings required for obtaining the approval / sanction from the Electrical inspector, State Electricity board, State regulatory authority, Factory inspector, Pollution control board, Regulatory authority, and any other statutory agency appointed for the purpose by the state / central / municipal / local bodies shall be prepared by the DG set supplier.

6.6.8.13 Guarantee

The performance figures specified shall be guaranteed within the tolerance specified or as permitted by relevant standards. In case of failure of equipment to meet the guaranteed performance, the client reserves the right to reject the equipment. However, the Client also reserves the right to use the rejected equipment until new equipment meeting the guaranteed performance requirements is supplied by the vendor at no extra cost. If any equipment supplied by the vendor fails at site during erection, commissioning or service (within guarantee period), the vendor shall repair and put back into successful operation the failed equipment within the time frame and procedure of repair agreed with the client depending on nature of failure at no extra cost to the purchaser. The guarantee period shall be as specified in the commercial terms and conditions.

6.6.8.14 Bar chart / Network

The bidder to indicate following schedules:

- Manufacturing, Inspection &Testing at works
- Shipping
- Pre-commissioning/testing
- Commissioning
- Service kits with all filters and other consumables
- List of recommended spares for three years satisfactory operation.

6.6.8.15 Documentation and drawing requirements:

The following documents, drawings etc shall be submitted along with the offer: Data sheet / Compliance and guaranteed particulars statement.

DG layout plan showing all dimensions, including operation al and maintenance clearances with sections

as required. The plan should also indicate ventilation requirement, civil foundations, loading data, wall openings, etc. & generator earthing requirement

Schematic diagram of control panel with accessories like AVR, AMF, and auxiliary power distribution details etc., along with cable schedule.

Terminal box drawing, literature, write-ups, description of DG set excitation system, voltage regulator, governor, & other auxiliaries, catalogues / brochures etc.

Component list with rating & ranges of all items

Single line diagram for the whole system - control and power

Technical specification sheet with brochures / catalogues and operational details for:

- DG sets
- Acoustic enclosure or Room sound proofing
- Detailed specification sheet for all auxiliary components giving material specifications, make/model, capacity, ratings etc.

6.6.8.16 Testing

The following tests shall be carried out at the manufacturer's works and the test results submitted to the client. The Client reserves the right to inspect the above tests or waive the inspection.

Tests on engine

1) Engine starting time
2) 4hour running at fullload followed by 1hour running at 110% of load
3) Fuel consumption test:
4) One hour running at100%load
5) One hour running at75%load
6) One hour running at50%load

Testing arrangement

1) Arrangement for loading DG by: Vendor
2) Fuel charges for site testing by: Vendor

Shop tests

1) All the tests required by the manufactures practice or by applicable standard during the manufacture stage.
2) Performance tests on the assembled diesel generator set. (With Voltage regulator)
3) Check of fuel consumption at different loads.
4) Measurement of Generator Winding Temperature after stabilized condition at 10% over load.
5) Measurement of cooling water temperature of engine at 10% over load as above
6) Measurement of vibration
7) Measurement of sound level at 1 Meter Level and 10Meter distance
8) Functional tests on fuel transfer pump.
9) Dielectric and insulation tests
10) Routine test on voltage regulator
11) Hydrostatic Pressure test on both fuel tanks (at2Bars)
12) Simulation of all protection
13) Simulation of mains failure and mains return
14) Load tests at 0.8 Power Factor

2Hourat100%ratedload

1Hourat110%ratedload

1Hourat75%ratedload.

1Hourat50%ratedload.

15) Starting tests to show time of starting and load acceptance

6.6.8.17 Inspection, operation, maintenance Manuals

The supplier shall submit along with the delivery and/or on commissioning - as applicable, the Type & Routine test certificates / Guarantee certificates, etc.

6.6.8.18 Make of DG set

DGSet :Preferred makes or equivalent Caterpillar/Cummins

6.6.8.19 Guaranteed technical particulars for DG SET

Sl. No.	Description	Clientsrequiremen	AsofferedParticulars(to be
1	**DG Sets**		
	Rating of sets	Adequate size as required	
	Manufacturer:		
	ModelNo.&Type:		
	Quantity		
	Application:	Stand by power generation- suitable for continuous full / part load operation	
	Anti-vibration mounting	Required	
	Sound proofing	**Acoustic enclosure**	
	Total static weight with enclosure		
	Total Dynamic weight with enclosure		
	Exhaust line with silencer & chimney	Required	
2	**Engine**		
	Make		
	Model no.:		
	Name plate rating:		
	BHP:		
	Engine speed:		
	Method of starting:	Electric	
	Aspiration:	Water cooled Turbo charged	
	Emission:	CPCB norms.	
	Lube oil heater:	Required	

	Lube oil consumption:		
	Cylinder jacket heating (cooling water heating) with thermostat:	Required	
	Lube oil priming facility:	Required	
	Lube oil pump:	Engine driven only	
	Engine noise level	Specify in db	
	Minimum operating time without cooling water at full load	Specify in minutes	
	Combustion air flow	Meter cube/hour:	
	Derating under site conditions:	Specify-if any	
	No.of cylinders:	Specify	
	Turbo charger	Inter/after	
	Maximum time to start from cold & attain rated speed & ready to take load	Specify in seconds	
	Short time over load capacity	110% for 1 hr in 24 hrs of operation	
3	**Cooling system**		
	Method of Jacket cooling:		
	Heat Removal:		
	Radiator fan:	Engine driven	
	Total radiated heat:		
4	**Fuel oil system:**		
	Fuel oil:	High speed Diesel	
	Fuel tank level indication	Required	
	Fuel tank gauge glass	Required	
	Fuel flow meter	Specify	
	Fuel transfer pump drive	If required: Engine driven	
	Fuel consumption at		
	a) Full load:	Specify in Litres/kWh	
	b) 75% load:	Specify in Litres/kWh	
	c)50% load:	Specify in Litres/kWh	
	d) 25% load:	Specify in Litres/kWh	
5	**Exhaust**		
	Exhaust silencer type	Heavy duty Residential/ hospital	
	Exhaust noise level	Confirming to CPCB / TNPCB	

	Heat rejection to exhaust system	Specify in deg C over ambient	
	Max.Permissible back pressure	Specify in exhaust in kg/cmsq:	
	Exhaust gas flow:		
	Exhaust gas temperature:		
	Chimney height	Specify as required, building	
	Emission Limits(g/KW-hr)		
	NOX+HC	Confirming to CPCB / TNPCB	
	CO	Confirming to CPCB / TNPCB	
	IPM	Confirming to CPCB / TNPCB	
	Smoke Limit absorption coefficient, WI (at full load)		
6	**Governor data:**		
	Make:	Specify	
	Model No:	Specify	
	Type:	Electronic only, give details	
	Adjustable droop provided:	Required	
	Speed raise/lower from panel	Required	
7	**Alternator:**		
	Make:		
	Model No:		
	No.of phases:	3phase and neutral	
	Enclosure:	IP 23	
	Terminal voltage & freq.:	415VAC & 50Hz	
	Time permitted to build uprated voltage	3seconds max.	
	Permissible voltage dip	10% for sudden loading of 50%	
	Rating of biggest motor that can be started on DOL with permissible voltage dip of 10% when the generator is		
	a)unloaded:		
	b)80%loaded:		
	c)50%loaded:		
	Power transfer:	Cable adopter box	
	Rating:	adequate size of DG set as required a t0.8P.F	
	Insulation class-Armature:		
	Field:		
	Inertia time constant:	Specify kW-Sec/kVA	
	Bearing type:		

	RFI suppression	Required	
	Short circuit with stand time:	Specify	
	Overload withstand capacity	Min.150%for15Sec.	
	Neutral earthing:	Solidly Earthed	
	Type of Cooling:		
	Efficiency of Alternator		
	a) At100%MCR&ratedp.f.:		
	b) At75%MCR&ratedp.f.:		
	c)At50%MCR&ratedp.f.:		
	Max continuous &momentary unbalanced load capacity:		
	Asymmetrical short circuit withstand capability & duration:	Specify	
	Open circuit transient time constant:	Specify	
	Shortcircuit ratio:	Specify	
8	**Exciter**		
	Type of excitation	Brushless	
	Capacity		
	Operating voltage & current:		
	Duration of field forcing:		
			As offered Particulars (to be
	Class of insulation:		
9	AVR		
	Type of A V R:	Self-regulated	
	Mounting of AVR:		
	Dead band: %		
	Response time:		
	Voltage of operation:		
	Line drop compensator provided to	Required	
	Range of voltage adjustment:	Specify	
	Fine tuning adjustment:	Specify	
10	Set mounted panel		
	The following analogue type		
	Lube oil Temperature indicator:	Required	
	Make:	Specify	
	Type:	Specify	
	Accuracy:	Specify	
	Fuel oil Pressure Indicator:		
	Make:	Required	
	Type:	Specify	
	Accuracy:	Specify	
	Lube oil Pressure Indicator:	Required	
	Make:	Specify	
	Type:	Specify	
	Accuracy:	Specify	
	Engine Speed Indicator:	Required	
	Make:	Specify	
	Type:	Specify	

	Accuracy:	Specify	
	Any other indicator required for the	Specify	
11	Painting:		
	Surface Pre-treatment:	Sand blasting /	
	Primer:	Two coats of primer	
	Final Paint Shade:	Siemens grey as per IS 5 or	
	Minimum Paint Thickness:	100 microns	
12	Acoustic enclosure		
	Make:		
	Model No:		
Sl.			As offered Particulars (to be
	Type:		
	Application	Outdoor / IP54 rating	
	Sound Level	Confirming to CPCB /	
13	Control & power panel		
	Cabinet Construction:	Mounted inside the	
	Degree of protection:	IP54	
	Access:	Front / Back	
	Cable entry:	TOP / BOTTOM and as per	
	Controller:	Integrated Microprocessor:	
	Make:		
	Model No:		
	Type:		
	No. of starting commands in single	3 minimum	
	Time gap between commands:	Specify in seconds	
	Auto stop on resumption of main	Required with inbuilt time	
	Note		
	DG control & On, Off status to be		
14	Miscellaneous		
	Guaranteed output in		
	Alternator to care of 3RD, 5TH, 7TH		

6.6.8.20 General

The metallic body / enclosure of all electrical equipment shall be earthed with a minimum of 2 distinct earth connections of adequate size earth conductors.

Earthing shall be in conformation with IS 3043

6.6.8.21 Earth station

- **Pipe electrode earthing**

Earth electrode shall be of minimum 40 mm dia class "B" GI Pipe 3.0 m long with tapered bottom and with 12 mm dia holes at 75 mm c/c on all sides for bottom 2.0 m with top watering arrangement.

- **Plate electrode**

600 x 600 x 6 mm GI plates with 25 mm dia watering pipe with funnel buried at a depth of 2.5 m forms earth electrode. Earthing strip is directly brought to chamber/disconnecting link in protective pipe.

Earth electrode shall be back filled with alternate layers of charcoal and salt are provided through out height of electrode with overall 300 mm cover

6.6.8.22 Inspection chamber

Brick masonry chamber of size 450 x 450 x 450 mm with heavy-duty cast-iron cover and frame with top at ground level are provided for watering arrangement.

6.6.8.23 Soil treatment

In case of rocky soil or hard murrum, soil resistance is very high. Hence, for getting lower resistivity values, the Concessionaire shall carryout artificial soil treatment to achieve the required level of lower resistance as per IS.

The earth resistance shall not exceed 1.0 ohms in any case. The Concessionaire shall provide additional earth pits to get the desired earth resistance value of 1.0 ohm.

6.6.8.24 Lightning protection

Lightning protection shall be in confirmation with IS/IEC : 62305.

The lightning protection to the buildings shall be effected by use of conventional vertical lightning air termination or horizontal faraday cage or by a combination of both. G.I tapes / strips or aluminium circular conductor shall be laid on all parapet walls and as down conductors.

Conventional spike type lightening arrestor shall be mounted at the highest point of the building and a supporting pole shall be used to achieve the desired height and angle of coverage.

The down conductors shall be brought down from parapet / terrace level to ground level duly ensuring that adequate side flashing distance is maintained between the down conductor and other metallic pipes, if any, running parallel from terrace to ground.

A Test and disconnecting link box shall be provided at a height of 1.0 mtr from G and the down conductor shall be terminated onto this link. Beyond this link 25 x 6 mm GI strip shall be run up to earth station.

Earth station for lightning protection system shall of 600 x 600 x 6 mm GI plate earthing.

6.6.8.25 Inspection and testing

The consultant and the representative of the Owner shall have free access to vendor's works to inspect, expedite and witness shop tests. Any materials or works found to be defective or which does not meet the requirements of this specification will be rejected and shall be replaced at supplier's cost. Purchaser reserves the right to carryout stage wise inspection.

All routine tests shall be carried out on the electrical equipment as per relevant Indian Standard Specifications. The delivery of the electrical equipment / electrical items shall be accompanied with copies of such routine test certificates clearly mentioning reference to the P.O No., Line-item No. of P.O, quantity as per P.O, quantity inspected and passed, Governing IS for testing, test results and details of test equipment with their calibration details.

7 INSTRUMENTATION WORKS

7.1 General

The Concessionaire is required to adopt the latest technology with compatible automation system having fully automatic process control, The "Plant Control Configuration" attached to the Scope of Works gives basic and minimum requirement of Instrumentation and Control Automation with electrical interface. ONLINE to monitor and control the plant from a single location. The plant data collected through online monitoring of water quality and flow shall be made available via the internet to various statutory bodies.

7.2 General requirements

This part covers the general requirements for the design, supply, Installation, inspection and testing of the instrumentation and automation solution proposed for flow measurement, monitoring of water quality and control of plant.

7.3 Reference Standards

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

IEC60381-1:1982Analoguesignalsforprocesscontrolsystems.

7.4 Specification for direct current signals:

- IEC 60947-4-1:2000 Specification for low-voltage switchgear and Control Gear.Contactorsandmotor-starters.Electromechanicalcontactorsandmotor-starters.
- IS 15953:2011
- ISA-5.1-2009
- IEC62443
- IEC61346
- IEC60870-6-allparts
- IEC61131-3industrialcontrolprogrammingstandardadvancements
- IEC61850allpartsrangingfrom1-10
- IEC61850-10:2012-Conformancetesting118
- IECTR61850-90-3:2016 -UsingIEC61850forconditionmonitoring diagnosis and analysis + IEC TR61850-90 all parts
- IEC 60947-4-2:1999 Specification for low-voltage switchgear and Control Gear.Contactors and motor-starters. A.C. semiconductor motor controllers and starters.
- IEC 60947-4-3:1999 Specification for low-voltage switchgear and Control Gear.Contactors and motor-starters. Contactors and motor-starters. AC semiconductor controllers and contactors for non-motor loads.
- IEC 60770-1:1999 Transmitters for use in industrial-process control systems. Methods for performance evaluation.
- BSISO1217:1996 Displacement compressors. Acceptance tests.
- ISO2112:1990 Specification foraminoplastic moulding materials.
- ISO6817:1997Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flowmeters.
- BS EN 837-1:1998 Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing.
- BSEN1057:1996 Copper and copper alloys. Seamless, round copper tubes for water and gas in

sanitary and heating applications.

- BSEN1092-1:2002Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges.
- BSEN1563:1997 Founding. Spheroidal graphite cast iron.
- BSEN60529:1992 Specification for degrees of protection provided by enclosures (IPcode).
- BSEN60534-1:1993Industrial-process control valves. Industrial-process control valves. Control valve terminology and general considerations.
- BSEN60546-1:1993 Controllers with analogue signals for use in industrial-process control systems. Controllers with analogue signals for use in industrial-process control systems.

7.5 Methods for evaluating performance

BSEN60584-2:1993 Thermocouples.

7.6 Tolerances

- BS EN 60654:1998 Operating conditions for industrial-process measurement and control equipment. All relevant parts.
- BS EN 60751:1996 Industrial platinum resistance thermometer sensors.
- BS EN 60873:1993 Methods of evaluating the performance of electrical and pneumatic analogue chart recorders for use in industrial-process control systems.
- BS EN 61000-6:2001 Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments.
- BS 89:1990 Direct acting indicating analogue electrical measuring instruments and their accessories. All parts.
- BS 90:1975 Specification for direct-acting electrical recording instruments and their accessories.
- BS 476 Fire tests on building materials and structures. All parts.
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1041-2.1:1985 Code for temperature measurement. Expansion thermometers. Guide to selection and use of liquid-in-glass thermometers.
- BS 1041-2.2:1989 Code for temperature measurement. Expansion thermometers. Guide to 119 selection and use of dial-type expansion thermometers.
- BS 1041-3:1989 Temperature measurement. Guide to selection and use of industrial resistance thermometers.
- BS 1041-4:1992 Temperature measurement. Guide to the selection and use of thermocouples
- BS 1042-1.4:1992 Measurement of fluid flow in closed conduits. Pressure differential devices. Guide to the use of devices specified in Sections 1.1 and 1.2.
- BS 1123-1:1987 Safety valves, gauges and fusible plugs for compressed air or inert gas

installations. Code of practice for installation.

- BS 1203:2001 Hot-setting phenolic and aminoplastic wood adhesives. Classification and test method.
- BS 1553-1:1977 Specification for graphical symbols for general engineering. Piping systems and plant.
- BS 1571-2:1975 Specification for testing of positive displacement compressors and exhausters. Methods for simplified acceptance testing for air compressors and exhausters.
- BS 1646-1:1979 Symbolic representation for process measurement control functions and instrumentation.

7.7 Basic Requirements

- BS 1646-2:1983 Symbolic representation for process measurement control functions and instrumentation. Specification for additional basic requirements.
- BS 1646-3:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for detailed symbols for instrument interconnection diagrams.
- BS 1646-4:1984 Symbolic representation for process measurement control functions and instrumentation. Specification for basic symbols for process computer, interface and shared display/control functions.
- BS 1794:1952 Specification for chart ranges for temperature recording instruments.
- BS 2765:1969 Specification for dimensions of temperature detecting elements and corresponding pockets.
- BS 3680 Measurement of liquid flow in open channels. All relevant parts.
- BS 3693:1992 Recommendations for design of scales and indexes on analogue indicatinginstruments.
- BS 4675-2:1978 Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity.
- BS 4999-142:1987 General requirements for rotating electrical machines. Specification for mechanical performance: vibration.
- BS 5169:1992 Specification for fusion welded steel air receivers.
- BS 5728-3:1997 Measurement of flow of cold potable water in closed conduits. Methodsfor determining principal characteristics of single mechanical water meters (including test equipment).
- BS 6004:2000 Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.
- BS 6739:1986 Code of practice for instrumentation in process control systems: installation design and practice.
- BS 7671:2001 Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition. Instrument Society of American Standards and Recommended Practices:
- S 5.1 Instrumentation symbols and identification
- S 5.4 Instrument loop diagrams
- S 7.3 Quality standard for instrument air
- RP 16.1 Terminology, dimensions and safety practices for indicating variable 2, 3 areameters
- RP 16.4 Nomenclature and terminology for extension-type variable-area meters(rotameters)
- RP 16.5 Installation, operation, maintenance instructions for glass tube variable area meters (rotameters)
- RP 16.6 Methods and equipment for calibration of variable area meters (rotameters)

- RP 18.1 Specifications and guides for the use of general-purpose enunciators
- S 26 Dynamic response testing of process control instrumentation
- RP 31.1 Specification, installation and calibration of turbine flow meters
- S 37.1 Electrical transducer nomenclature and terminology
- S 37.3 Specifications and tests for strain gauge pressure transducers
- S 50.1 Compatibility of analog signals for electronic industrial process instruments
- S 51.1 Process instrumentation terminology
- RP 60.08 Electrical Guide for Control Centers
- Installation works shall comply with all relevant local Indian Regulations including the Code of Practice for Electrical Wiring Installations – IS 732.
-

7.8 Basic Features

Each instrumentation system shall be designed, manufactured and installed to achieve the following basic requirements:

- To maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance
- To suit the abilities of the staff who will:
    a. Use the systems
    b. Service the systems
- To measure, indicate, process, store and control the relevant parameters, as specified
- To give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of 'operations and maintenance' personnel and that of the plant and to store and collatethe data, as required
- To derive, present and utilize, as required, such additional data to facilitate:
    a. The most efficient operation of the plant
    b. The routine maintenance of the plant

7.9Design Requirements for instrumentation and control systems (I&C)

The instrumentation, control and automation installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification. The instrumentation control and automation systems shall comply with the relevant Indian Standards being practiced as per the industry norms. All consumable items and spare parts shall be readily available within India.

All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years.

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal transmission systems shall be in accordance with IEC 60381-1:1982 or equivalent and shall use a signal of 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the requirements specified in the appropriate part of IEC 60770-1:1999 or equivalent. Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant.

All equipment shall be designed to operate without forced (or fan) cooling.

All measuring instruments shall have zero and span adjustment. Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance. The installation arrangements for meters measuring conductivity, pH, dissolved oxygen, chlorine residual and ionic concentration shall include a sample bench and other facilities for operating portable test meters. Each installation shall incorporate a valve and pipework for obtaining a sample representative of the fluid at the position of the permanent meter, tundish and drain. If the measuring and sampling points are remote from each other, the test and sample facilities shall be provided at both points. Sample transport times shall be minimized by provision of a bypass and drain with control and isolating valves and a local flow meter to enable the correct sample flow to be adjusted. An automatic portable sampler shall be provided for collecting and transporting the samples from the sampling locations to the laboratory.

7.10 Instrument Design Criteria

The design criteria to be applied to instrumentation system shall be as follows:

- Instrumentation & Control (I&C) systems shall be selected, designed, manufactured, installed, tested and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous real time operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect the plant operation. All I&C equipment shall be new, of proven design, reputed make and have data logging facility. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain and shall be suitable for the worst environmental operating conditions. Wherever necessary space heaters, heat dissipaters, dust and weather proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories & safety features.
- No custom-made hybrid type integrated circuits shall be used in any circuit in instrumentation and control equipment.
- Instruments and loggers provided shall be able to carry out continuous real time monitoring and logging of selected water quality parameters.
- All instrumentation shall be suitable for continuous real time operation and be powered through the UPS.
- As far as possible and depending upon the location and availability of wireless services, all transmitting instruments and data loggers shall be of wireless type (GSM / IOT based). In case of non-feasibility, the output of the transmitting instruments shall be 4-20 mA / 0-10V DC linear having two wire system.
- After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.
- Unless otherwise specified, the normal working range of all indicating instruments shall be between 25% and 80% of the full scale range.
- The field instruments i.e. the instruments mounted outside the control panel shall be
- mounted at a convenient height of approximately 1.2 m above grade platform.
- Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65 or better.
- The instruments shall be designed to work at the ambient conditions of temperature, humidity, and contamination that may prevail at site. The instruments shall be given enough protection

against corrosion. All wetted parts of instrument sensors shall be non – corrosive and suitable for use within sewerage environment.

- The performance of all instruments shall be unaffected for the ±10% variation in supply voltage and ±5% variation in frequency simultaneously.
- Unless otherwise specified, double compression glands shall be used for glanding the cable in field instruments and instrument control panel.
- All digital outputs shall be volt free.
- All probe type analyzers should be IP68 rated.
- All displays shall be of the digital type with no moving parts and should utilize back litliquid crystal diode LCD/ LED technology.
- Instrumentation shall utilize solid state electronic technology and avoid the use where practical of any moving parts.
- Minimum maintenance requirements. The instruments selected shall be rugged and not require any consumables / filling solutions. Systems should be able to work with minimum power requirements.
- Lockable enclosure shall be provided for all the field mounted instruments.
- All the instruments and cabinets shall have tag plates / name plates permanently attached to them.
- All instruments to be used or installed within a corrosive sewerage environment shall be explosion proof and intrinsically safe.
- The data obtained from the online quality monitoring system shall be conveyed back via suitable communications protocol, to web servers hosted by a service provider. The service provider shall have the data storage capacity for next 15 years.
- Unless otherwise specified, all continuous online monitoring instruments shall be plug and play type.
- Instrumentation system shall be provided to monitor the following parameters

7.11Online Instruments

The online measurement at Inlet and outlet for continuous monitoring of the raw and treated water characteristics are specified below. However, Concessionaire shall provide additional instruments to support their design. At the Inlet Point and the Outlet Point -

a) Electro-Magnetic Flow Meter
b) Continuous Online pH Measuring System
c) Continuous Online Turbidity Analyzer
d) Chlorine Analyser

Online instrument system shall have the ranges in accordance with CPCB "Guidelines for continuous monitoring for Effluents" and CPHEEO.

7.12Online Instruments Specifications

7.12.1 Flow measuring system

A. Electromagnetic flowmeter: Flow meters shall operate on the electromagnetic induction principle and shall consist of a measuring sensor and measuring transmitter complying with ISO 6817:1997. Measuring sensors shall have a full bore stainless steel metering tube and non-conductive, abrasion-resistant lining to suit the fluid being metered. The lining of material can be of polyurethane. No rubber

lining will be allowed. The flow meter shall have flanged connection. Measuring sensors shall have factory sealed power and signal cables. Unless otherwise specified, the cable lengths shall be sufficient to permit termination external to the chamber, either at a junction box or at the measuring transmitter. Remote flow indicator cum integrator shall be provided on the control panel.

Measuring sensors installed within a chamber shall be suitable for indefinite submersion under a head of water equal to the chamber depth or 3 meters whichever is the greater. Measuring sensors shall be installed on a steel cradle or concrete plinth with upstream and downstream straight pipe lengths not less than those recommended by the manufacturer. When fitted in lined non-metallic or internally-coated pipe work, measuring sensors shall have an earthing electrode or corrosion resistant earthing rings. To ensure full electromagnetic compatibility the flow tube flanges and transmitter housing shall be connected earth.

Measuring sensors shall be bonded by tinned copper braid links at each end to the adjacent pipe work to ensure a good connection between the body and the metered liquid. Measuring sensors installed in a catholic protected pipeline shall have isolation and bonding in accordance with the recommendations of the manufacturer. The measuring transmitter shall provide a precise current input to the field winding of the measuring sensor and shall convert the resultant signal from the electrodes to analogue and pulse outputs in accordance with IEC

60381-1:1982. The signal processing facilities of the converter shall ensure that the output signals are unaffected by interfering voltages, stratified flow, changes in fluid electrical conductivity within the limit stated, non-homogeneity of the fluid and the presence of ferrous

particles. The zero and output signals shall be unaffected by partly-fouled electrodes. The following measuring transmitter features shall be provided as a minimum:

Measuring transmitter features:

Pulsed D.C. field excitation

Scaled pulse output for integration counter drive

Capability of bi-directional measurement with differing forward and reverse ranges and with local and remote indication of flow reversal

Contact operation at a programmable measured value

Integral display of flow and integrated quantity

Galvanic isolation between each output circuit and between the electrode circuit and output circuit

Output circuit isolation from earth within the instrument but suitable for earthing at any point in the external circuit

Key entry for basic parameters

Commissioning and re-scaling to require no special programming knowledge

Adjustable low flow cut-off

Self-diagnosis

Continuously adjustable velocity and flow range settings 128

Terminals accommodated in a compartment separate from electronic components

Outputs including: analogue - 4-20mA

Pulse - two programmable outputs

Alarms - two outputs programmable for high/low

Flow, polarity, forward/reverse, instrument fault, liquid sensing fault condition including partially empty pipe

❖Technical specifications

Measuring Principal: Electromagnetic

Type: Pulsed DC

Corrosive Water Environment

Metering Tube: SS304

Sensor Housing: SS304 fully welded

Connection/ JunctionBox:SS304

Lining Material : PTFE/Polyurethane

Range : As per site requirement

Accuracy : ± 0.3% of flow rate at maximum mean velocity of

1.5 to 3.0 m/sec

Electrode Type : Flush or bullet nose as recommended by the manufacturer

Earthing Ring/Electrode Material: Type 316 stainless steel

Protection Category

Sensor : IP-68

Transmitter / Controller : IP-65

Transmitter / Controller Type : Microprocessor Based

Display : Indicating and totalizing

Indicator : Digital 16-character display

Totalizer : Digital 16-character display

Mounting : Pipe, wall, panel

Diagnostic : Inbuilt

Power Supply : 230 V AC ± 10%, 50 Hz

Analog Output : Isolated 4 – 20mA / 0-10VDC output based on the flow rate

Zero & Span : Field Adjustable

Turndown Ratio : Minimum of 10 to 1 when flow velocity at minimum flow is at least

0.3 metres per second

Zero Stability Feature : Required to eliminate the need to stop flow to check zero alignment

Pressure Loss : Very Low

Removable Electrodes : Required

Flange Material : Carbon steel, Epoxy Coated

Empty Pipe Detection : Inbuilt

Operating Temperature : 0 to 50°C 129

Temperature Compensation: Inbuilt temperature sensors for automatic compensation for changes in air temperature

Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.

7.7.1 Level measuring system

7.7.1.1 Ultrasonic level meters

Ultrasonic level measuring devices applied for liquid level measurement shall comprise of level sensor/transducer, level transmitter, digital level indicator/ remote indicator, control unit and any other items required to complete the level measuring system.

The transducer shall be suitable for flange or bracket mounting as required. To reduce the effect to water turbulence in tanks, averaging facility should be provided in the transmitter unit for providing steady readings.

The design and application of the ultrasonic level measuring system shall take into account the vessel/sump/wet well/channel construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

In case of ultrasonic level sensor, the installation shall avoid any degradation of instrument performance due to spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection. If turbulence exists, shielding, stilling tubes or other measure shall be provided to avoid effects on the measurement.

Technical specifications

- Measuring Principal : Ultrasonic
- Range : As required at site
- Accuracy : ± 0.25% of measured value or better
- Resolution : 2mm or 0.2 percent of range, whichever is greater
- Blanking Distance : As short as 0.3 meters
- Beam Angle : 12 degrees or less
- Temperature compensation : Integral

- Mounting
  a.) Sensor : Flange or bracket

  b.) Transmitter / Controller : Wall, Panel, Pole

- Protection Category
  a.) Sensor : IP-68

  b.) Transmitter / Controller : IP-66 (NEMA 4X)

- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting 130
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 3 SPDT contacts
- Zero & Span : Field Adjustable
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

7.7.1.2 Ultrasonic differential level measurement

The ultrasonic type differential level measuring system shall consist of ultrasonic type level sensors on upstream and downstream of screens, differential level computer / transmitter and indicator. The flow computer / transmitter shall be microprocessor based and shall have facility for programming (i.e. adjustment of set points) while the sensor shall be capable of adjustable datum setting facilities.

The differential level control shall be done by two ultrasonic sensors, one before and one after the screen to sense the differential level through the screen and give a signal to the control to start the screens operation as soon as a preset differential level is reached. After receiving the level signal the control shall start and operate the screen as long as the preset level difference appears.

Technical specifications

- Measuring Principal : Ultrasonic
- Range : As required at site
- Accuracy : ± 0.25% of measured value or better
- Resolution : 2mm or 0.2 percent of range, whichever is greater
- Blanking Distance : As short as 0.3 meters
- Beam Angle : 12 degrees or less
- Temperature compensation : Inbuilt
- Mounting
  a.) Sensor : Flange or bracket

  b.) Transmitter / Controller : W all, Panel, Pole

- Protection Category
  a.) Sensor : IP-68

  b.) Transmitter / Controller : IP-66 (NEMA 4X)

- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 3 SPDT contacts
- Zero & Span : Field Adjustable
- Operating Temperature : 0 to 50°C 131
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

7.7.1.3 Pressure measuring system – pressure transmitter

Pressure measuring system shall measure pressure and transmit signal proportional to pressure. The system shall consist of a combined pressure transducer and transmitter, digital panel indicator, connecting pipe work, diaphragm seal and valves. Pressure measuring system shall be rugged in construction and shall be capable for with standing surge pressures likely to occur in the monitored system. Pressure transmitters shall have over range protection up to 1.5 times the maximum line pressure and shall be capable of withstanding full line pressure on any side with the other side vented to atmosphere without damage or effect on the calibration. No plastic material shall be used in their construction. Internal parts shall be of stainless steel, bronze or approved corrosion-resistant material. Where necessary, a special diaphragm shall be used to segregate the corrosive fluid media. In ammonia applications, the diaphragm shall be in stainless steel. In chlorine applications, the diaphragm shall be in silver or tantalum. In Sulphur dioxide applications, the diaphragm shall be in tantalum.

The zero and span of a pressure transmitter shall not change by more than ±0.1% of the span per °C change in ambient temperature. After application for 10 minutes of pressure at 130% of maximum pressure, the change in zero and span shall not exceed ±0.1% of the span. Pressure transmitters shall be protected to BS EN 60529:1992, IP 65 standard or higher. For transmitters installed in locations liable to flooding or underwater applications, they shall be to IP 68 standard and shall operate up to a maximum submergence of 20 meters of water.

Technical specifications

- Parts : Transmitter and communicator
- Type : Electronic variable capacitance; two-wire transmitter
- Range : As required at site
- Accuracy : ± 0.25% of span or better
- Humidity : 0 to 100% relative humidity
- Damping : Fluid or electronic type with adjustment
- Indicator : LCD with LED backlighting
- Materials : W etted parts including process flanges and drain / vent valves, Type 316
- stainless steel otherwise specified
- Wetted O-Rings : Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise specified
- Fill Fluid : Silicone
- Output : 4 - 20mA DC output proportional to the pressure range

- Mounting : Pipe or wall as specified. Provide stainless steel brackets with stainless steel bolts
- Housing : Modular with separate compartments for electronics and field wiring termination. Epoxy coated aluminium, unless otherwise specified
- Power Supply : 230 V AC ± 10%, 50 Hz
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.

7.7.1.4 Total Suspended Solids Measuring System - TSS Analyzer

❖Technical specifications

- Measuring Principal : Optical
- Application : H2S laden atmosphere and other poisonous gases, Corrosive Waste Water Environment
- Safety : Explosion Proof or Intrinsically Safe
- Range : 0 – 50 mg/l, 0 - 1000 mg/l, 0 – 5000 mg/l
- Accuracy : <5% of reading or better
- Pressure Limit : 6 bar
- Flow Rate : Maximum 3m per second
- Temperature Indication : Inbuilt
- Calibration Method : Single point or two point
- Cleaning : Inbuilt
- Mounting
  a.) Sensor : Inside pipe / channel / tank

  b.) Transmitter / Controller : W all, Panel, Pole

- Protection Category
  a.) Sensor : IP-68 for Sensor

  b.) Transmitter / Controller : IP-66 (NEMA 4X)

- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement
- pH Measuring System - pH Analyzer

7.7.1.5 pH measuring system-pH Analyzer

❖Technical specifications

- Measuring Principal : Combination / Differential Electrode
- Range : 0 - 14 pH
- Accuracy : ±0.02 pH or better
- Repeatability : ±0.05 pH
- Sensitivity : ±0.01 pH
- Pressure Limit : 4 - 6 bar
- Flow Rate : Maximum 3m per second
- Temperature Indication : Inbuilt
- Temperature Compensation : Inbuilt automatic temperature compensation
- Temperature Accuracy : ±0.5 °C
- Calibration Method : Two point automatic, one point automatic, two point manual, one point manual
- Mounting

    a) Sensor : Inside pipe / channel / tank

    b) Transmitter / Controller : W all, Panel, Pole

- Protection Category
- For Transmitter / Controller : IP-66 (NEMA 4X)
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

7.7.1.6 Residual Chlorine Measuring System - Residual Chlorine Analyzer

❖Technical specifications

- Measuring Principal : Amperometric or DPD Colorimetric
- Range : 0 - 10 ppm
- Accuracy : ±3% of the reference test or better
- Resolution : 0.001 ppm
- Repeatability : 30 ppb or 3%, whichever is greater
- pH : Automatic
- Temperature Compensation : Inbuilt temperature sensor
- Temperature Indication : Inbuilt
- Pressure Limit : 0.5 bar
- Flow Rate : Maximum 50 L/hour
- Calibration Method : 1-point or 2-point calibration
- Mounting : W all, Panel 135
- Protection Category

    a.) Sensor : IP-65

    b.) Transmitter / Controller : IP-66 (NEMA 4X)

- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 - 20 mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

7.7.1.7 Conductivity Measurement - Conductivity Analyzer

❖**Technical specifications**

- Range : 0 - 1000 µS/cm
- Accuracy : ±0.5% or better
- Temperature Compensation : Inbuilt
- Temperature Indication : Inbuilt
- Pressure Limit : 6.9 bar
- Flow Rate : Maximum 3m per second
- Mounting

  a.) Sensor : Inside pipe / channel / tank

  b.) Transmitter / Controller : W all, Panel, Pole

- Protection Category
- For Transmitter / Controller : IP-66 (NEMA 4X)o
- Transmitter / Controller Type : Microprocessor Based
- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Communication Protocol : RS 485/Open Protocol like MODBUS, PROFIBUS, etc enable to connect IoT devices for further communication.
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement 136
- Cleaning : Automatic
- Mounting

  a.) Sensor : Inside pipe / channel / tank

  b.) Transmitter / Controller : W all, Panel, Pole

- Protection Category

  a.) Sensor : IP-55 or better

  b.) Transmitter / Controller : IP-55 or better

- Transmitter / Controller Type : Microprocessor Based

- Diagnostic : Inbuilt
- Display : LCD with LED backlighting
- Power Supply : 230 V AC ± 10%, 50 Hz
- Analog Output : Isolated 4 – 20mA
- Relay Contacts : Minimum of 2 SPDT contacts
- Operating Temperature : 0 to 50°C
- Sensor Cable : Integral to sensor
- Cable Length : As per site requirement

7.7.2 Surge Protection Devices

Surge protection devices (SPDs) shall be suitable for withstanding the surge arising out of high energy static discharge / lighting strikes and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPD shall be self resetting to minimize the down time of the measurement loop.

SPDs shall be provided to protect devices transmitting and receiving analogue and digital signals derived from field devices located outdoors.

The surge protection device shall be rated for surge rating of 10kA.

7.7.3 Cabinets for field instruments

Wall mounted cabinets shall be provided for enclosing transducer unit and associated accessories which are mounted outside the main control panel. The cabinet shall be of die-cast aluminium; field provided not less than IP-65 protection and shall be lockable. The cabinet shall have facilities for earthing. A steel plate shall be provided inside the cabinet for mounting instrument and accessories.

7.7.4 Panel Details

7.7.4.1 Cabinet / Enclosure for Instruments

Enclosures shall be any form of board, cabinet, panel, desk, box or case used to protect, contain or group instrumentation, telemetry or control equipment. Cabinets shall be fabricated from cold rolled steel with powder coating sheet of minimum 2 mm thick and shall be suitable for wall mounting or pedestal mounting as required. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories. The cabinet shall be properly painted from inside and outside and shall have built in locking facility. The cabinet shall also be earthed properly. All equipment in or on enclosures shall be arranged logically and, as far as possible, symmetrically, with projections kept to a minimum. Each enclosure shall be designed on ergonomic principles and shall permit in-situ and safe access for any normal adjustment, maintenance and servicing. The tops of plant-mounted enclosures shall be sloped downwards from front to rear.

The minimum degree of protection shall be IP 54 for indoor locations and enclosures for use outside buildings or in places where splashing may occur shall have a minimum rating of protection to BS EN 60529:1992, IP 65 and have tops which project sufficiently to protect the vertical faces of the enclosure and any component mounted thereon from splashing, inclement weather and

direct sunlight. Also, when enclosures for use outside buildings are located where exposure to direct sunlight will give rise to high top-panel surface temperatures such that the internal temperature rises above the manufacturer's recommendation (normally 40°C), the enclosure shall include a sun shield fitted to the top of the enclosure and should have sufficient air ventilation for heat dissipation.

Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for ease of fitting. Wherever necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus. Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

Enclosures for two or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere. Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

7.7.4.2 Panel Design and Construction

Unless otherwise specified, all instrument panels, instrument cubicles, control panels, control consoles and desks, associated equipment and terminal racks, telemetry and electronic equipment racks and the like shall be free-standing, floor-mounted units and shall conform to the requirements of this part and will hereafter be referred to as panels. The design and dimensions of control consoles and desks shall be determined according to their intended function but shall be in accordance with the requirements of the Specification drawings. The height shall not exceed 1400mm above the finished floor level.

Unless otherwise specified as per the approved Design and Drawings, the height of panels shall be not greater than 2130mm overall (excluding lifting devices) above finished floor level. Front of-panel instruments and controls shall be mounted so that the height of their centers above the floor shall be generally between 1800mm and 900mm for indicators, 1400mm and 900mm for recorders and process controllers, 2000mm and 750mm for alarm facias and signal lamps and 1500mm and 750mm for manual controls. Controls, switches and push- buttons shall be positioned below or adjacent to any associated reading instrument. Panels for use in locations such as pumping stations and machinery rooms shall have anti-vibration mountings. The clearance between the extremities of apparatus mounted on the internal walls shall allow safe and unobstructed access to all terminals and to parts requiring maintenance.

Panel layout drawings shall normally include a list of all instruments, accessories and components contained therein. If the drawings have insufficient space for the list, a separate schedule of instruments, accessories and components shall be provided and the panel drawing shall contain a cross reference to the contents list and an indication of the panel location of each item on the list.

7.7.4.3 Panels - major

Panels shall be constructed generally as specified in the preceding clause and as shown in the Specification drawings. Panel material shall be prime-quality, cold-rolled and annealed mild

steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure.

Panel fronts shall be flat and free from bow or ripple. Exterior corners and edges shall be rounded or welded and ground to give a smooth overall appearance. Flanged edges shall be straight and smooth. Materials shall be chosen with due regard to the panel size, number of cut-outs, instrument weight and position of centre of gravity and method of fabrication, with the following:

- minimum thicknesses
- instrument bearing surfaces, gland plates and pneumatic distribution plates:3mm
- internal mounting plates: 3mm
- doors, covers and filler panels: 2mm

No design involving the use of externally-visible assembly or fixing bolts and screws nor any design resulting in dust or water-collecting crevices will be accepted. Stiffeners and supporting frameworks shall be provided where necessary inside panels. Framework shall be hinged or fixed, suitable for the installation of instruments, components and internal equipment for which it is provided and located to give easy access to adjacent equipment.

When a panel is constructed in sections, the sections shall be designed for ease of assembly during installation and, in any case, shall not exceed 2 m in length. All necessary nuts, bolts, washers and the like shall be supplied and included in the same shipment as the relevant sections. Sections exceeding 1 m in length shall be provided with double doors. Unless otherwise shown in the Specification drawings, each panel shall be mounted on a self-draining base frame fabricated from 150 mm deep, steel channel section which shall be drilled or provided with clamps for bolting to the floor. The base frame shall be set back from the panel front face to give a toe space of not less than 25mm. The outside of the base frame shall be covered with an approved kicking strip.

Ceiling and other filler panels shall be fabricated from sheet steel and adequately stiffened. Each section shall have 50 mm returned edges along all four sides and shall be braced to the main steelwork of the panel. A chequered plate floor shall be provided inside and above the level of the base frame, having openings suitable for the bottom entry of cables when applicable. Sufficient removable undrilled gland plates, in sections convenient for handling, shall be fitted close to the appropriate terminal blocks and not less than 230 mm above the panel floor or not less than 230 mm below the panel top. The gland plates shall have removable side covers giving access to both sides of the gland plate and ensuring vermin- proof and dust-proof construction. Gland plates of a surface-mounted enclosure may form a part of the base or top. Panels containing pneumatic or other instruments using a fluid as the transmission medium shall have distribution plates with bulkhead unions for the termination of internal and external pipework.

All doors shall open outwards and all doors in one panel assembly shall use the same lock and key combination. Panel design shall ensure adequate ventilation and air circulation without permitting the entry of vermin or dust. Panels installed in control rooms or other clean condition areas shall have louvres to allow air circulation. Temporary closures shall be provided

to prevent the entry of dust and vermin during transit and installation. After commissioning has been completed, all entries except air-circulation louvres shall be sealed.

No equipment other than front-of-panel items shall be mounted on panel wall surfaces. If electrical and non-electrical instruments are mounted in the same panel, the panel shall be subdivided internally to separate the electrical and non-electrical sections. All connections shall be arranged to ensure that no accidental damage to cabling or electrical components can occur in the event of failure of any non-electrical component or connection. Provision shall be made for safe and easy handling during transit and installation. If lifting eyes are provided, they shall be reversible and panel tops shall be reinforced where necessary.

Where equipment is specified to be installed at a future date, space shall be allocated, and cutouts with removable masking plates, brackets, supports, wiring, terminals and piping and the like shall be provided. Panels shall be finish-coated at the place of manufacture before commencing the installation of apparatus and other fittings.

7.7.4.4 Panels - Minor

Panels for installation on the Plant which contain relatively few items of equipment, or where so specified elsewhere, shall be provided s minor panels and shall be constructed generally as specified in the preceding clause and comply with this Clause. Panels shall be fabricated from sheet steel or other approved material less than 2.5mm thick suitably braced to form a robust and rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance and assembly bolts, screws or rivets shall not be visible on the front face.

The design shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Openings for cables shall be made vermin-proof. Doors shall be hinged and shall be provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Unless otherwise specified, panels shall be suitable for floor mounting and shall not exceed 2130mm in height. Where surface mounted panels are provided, the fixing shall prevent the ingress of moisture and the rear of the enclosure shall be not less than 10mm from the wall.

Lifting eyebolts shall be removed and replaced with bolts after installation. Panels shall be extensible, and symmetrically arranged as far as possible with projections kept to a minimum. Where two or more panels are fitted together, they shall form a flush-fronted continuous panel of uniform height. Front door and top cover dimensions shall match. Instruments, relays, and control devices shall be mounted at a height not more than 2000mm and not less than 300mm from floor level.

The arrangement of equipment within each enclosure shall be such as to permit easy access for installation and maintenance. No instruments, relays or other components shall be mounted on rear access doors or removable covers.

7.7.4.5 Panels - composite

In situations where space limitations preclude the use of separate instrumentation, control and automation (ICA) and switchgear panels and with prior approval of the consultant ICA equipment may be combined within a single enclosure subject to the following conditions:

7.7.4.6 Enclosure

- The observance of all other clauses herein relating to enclosures, mounting boards and

minor panels.

- The written assurance of each supplier of ICA equipment that the proximity of the switchgear will have no detrimental effect on the life or performance of any ICA component
- The total segregation of ICA equipment and switchgear including the glanding and termination facilities.
- The absence of any voltage exceeding 250V ac or 50V dc from any compartment containing ICA equipment.
- The use of the full height of the panel (excluding the busbar chamber and cable space) for any ICA equipment compartment.

Panels - Glass Reinforced Plastic (GRP)

Any panel required to be installed outside buildings shall be manufactured from double-skin, resin-bonded fibreglass, with a totally encapsulated infill of rigid weatherproof and 'boil proof' plywood to BS 1203:2001 between the two skins to provide a rigid and vandal-proof enclosure.

The environmental rating shall be IP 65 or better.

For any application in a non-temperate climate or where so specified elsewhere, the roof section shall be sloping and have a totally-encapsulated infill of end-grain balsa instead of plywood. Box section steel shall be encapsulated into door edges and door frames. Door locks, handles and hinges shall be of a high tensile strength, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel-reinforced surfaces. Threaded studs shall be incorporated into the design of the panel for the mounting of sub frames within the panel. Any panel drilled to provide fixings for internal equipment will not be accepted. Each cubicle shall be provided with a floor or deck with a removable gland plate for cable entry.

The laminate material shall have flame-retardant characteristics in compliance with BS 476

Class 2, and shall retain 'stability, integrity and insulation' for 30 minutes. Colour-impregnated

gel coats backed by coloured resin shall be used to ensure maintenance free and 'colour-fast'

finishes. The internal finish colour shall be white. The fronts of externally-visible instruments and windows shall be of glass. An air-gap of 100mm shall be provided between the top surface of the panel and its protective canopy. All internal equipment shall be mounted on supports built into the fiberglass structure. Fixing bolts through the skin will not be accepted.

7.7.4.7 Panel protection

Adequate facilities for isolation and protection by miniature circuit breaker or fuse for each instrumentation and control circuit and sub-circuit shall be provided and shall be so arranged that any interruption causes minimum disruption of plant, operates the appropriate alarm and cannot result in any unsafe operating condition. All fuses shall be of the cartridge pattern and main fuses shall be of the high rupturing capacity type. Fuse and solid-link carriers and bases shall be of plastic-moulded insulating material as per best industry practices. Ceramic materials will not be accepted. Live connections shall be efficiently shrouded and it shall be possible to

change fuses with power on without danger of contact with live metal. The fuses shall be rated to give maximum protection to the equipment in circuit and the rating shall be permanently inscribed on the fuse label and on the fuse carrier.

Unless necessary for the protection of particular equipment, miniature circuit breakers used for individual circuits in a panel or control desk shall not trip on over-voltage or under-voltage. Bases for solid links shall not be interchangeable with those for fuses. Fuses and links in the same circuit shall be mounted opposite each other in separate adjacent rows and shall not alternate in the same row. At least 10% and not less than two unallocated miniature circuit breakers or fuses and links shall be provided in each panel distribution board. Miniature circuit breakers and fuses of similar size and rating shall be of the same make and type. At least 10%, and not less than two, spare fuses and links of each rating shall be provided and fitted in clips inside the panel.

Each instrument requiring a power supply shall be individually wired and protected so that, in the event of a failure in one circuit, the remainder is unaffected. Power supply circuits shall be of sufficient rating that any protective device may operate without reducing the voltage at the terminals of any other component to an unacceptable level. Remote alarms shall be operated on failure of the electrical supply to a panel or to any internal sub-circuit. Clearly identifiable, switched socket outlets of 15A minimum rating to comply with IS 4615, supplied at the main cabinet operating voltages shall be fitted within the panel at the rate of one for each operating voltage per meter of panel length; for a panel whose length is less than one meter, one switched socket outlet for each main operating voltage shall be provided. Suitable socket outlets for portable tools and hand lamps shall be provided as specified elsewhere.

7.7.4.8 Panel isolation

Clearly-labelled isolating circuit breakers shall be provided for each incoming power supply. Switches shall be of the quick make-and-break type with spring-loaded contacts that close fully without requiring full operation of the handle. The handle and cover shall be interlocked so that the handle cannot be operated when the cover is open and the cover cannot be opened unless the switch is in the ‘off’ position. The ‘on’ and ‘off’ positions of each switch shall be indicated clearly.

Circuit breakers for panel power supplies shall be mounted near an access point and in positions where they may be operated easily from a standing position. Plug-in isolating links or devices of an approved type shall be provided in any circuit that may still be alive when the power supply isolators are in the ‘off’ position, as, for example, in circuits controlling equipment whose power supply is independent of the panel. Such links or devices shall be properly screened and, if not incorporated in or adjacent to their associated outgoing terminals, shall be labelled with suitable warning notices. Any item of panel equipment to which panel internal wiring is connected with a plug and socket instead of terminals shall be wired in flexible cable of adequate rating between the ‘free’ plug and a socket mounted adjacent to the device. The power supply connector shall be a socket.

7.7.4.9 Panel terminal blocks

External wiring for panel power supplies shall be terminated on the appropriate isolator. Signal cables from strain gauges, analyzers, resistance thermometers, re-transmitting slide wires

and thermocouples may be terminated at their appropriate instruments. A terminal block shall be

provided as the interface between the corresponding conductors of each internal and external wire and each internal and external connection except those listed above. The terminal blocks shall be mounted vertically where possible and not nearer than 230mm to the floor or less than 230mm from an incoming cable gland.

Terminal block rows shall be spaced apart by not less than 150mm and arranged to permit convenient access to wires and terminals and to enable ferrule numbers to be read without difficulty. Other circuits shall be grouped on the terminal blocks according to the classification given in the clause for 'Panel internal wiring' which shall be clearly marked along the corresponding section of each terminal board. Groups of different voltages on the same board shall be separated by insulated barriers.

All connections shall be made from the front of terminal blocks and no live metal shall be exposed at the back. All terminal blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw and which permits removal of any terminal without disturbance to adjacent terminals. Pinch-screw type terminal blocks will not be accepted. Terminal mouldings shall be in melamine to ISO 2112:1990, polyamide or equivalent. Terminal rails shall be hot-dip galvanized. Current bars between the two connection points of each terminal block shall be of copper or brass with tin/lead alloy plating. All steel parts shall be zinc-plated and passivated with a yellow chromate layer.

Terminal blocks for input and output analogue signals and for circuits containing volt-free contacts internal or external to the cabinet shall be of the Klippon type SAKC or equivalent which permit the connection of a test millimeter or continuity meter without disconnecting any wiring.

Terminal blocks for power supplies for equipment external to the panel shall permit the isolation of the item of external equipment without affecting the operation of any other circuit within or outside the panel.

No more than one core of external cables or one internal wire shall be connected to any terminal. If terminal blocks are used as common points for two or more circuits, individual terminals with the appropriate number of permanent cross-connections shall be provided. The lengths of exposed cable cores shall be sufficient to reach any terminal in the appropriate row or rows. The cores shall be formed into a neat loom and a separate loom shall be provided for each cable.

Identification ferrules as specified in the clause for 'Panel wiring identification and termination' shall be fitted on each core of all external cables and on each internal wire. The size of the terminals shall be appropriate to the size and rating of the cable cores which will be connected to them but shall not be smaller than Klippon type SAK2.5 or equivalent.

Each row of terminal blocks shall contain at least 25% spare terminals over the number required for terminating all cores of external cables in that row. Unless otherwise specified or shown in the Specification drawings, each external cable shall contain at least 20% spare circuits, with a minimum of one spare circuit. Terminal blocks shall be numbered consecutively in a sequence different from that used for identifying wiring. The terminal numbers, voltage grouping and terminal board layout shall correspond precisely with wiring diagrams so that quick and accurate identification of wiring can be made. All the terminal boards shall be provided with covers of transparent insulating material that does not sustain combustion and shall be sectionalized where possible to give access to groups of terminals without uncovering all boards. Terminals which may be live when the panel is isolated from its main supplies shall be suitably labelled to minimize the risk of accidental contact.

7.7.4.10 Panel internal wiring

Panel circuits shall be segregated into the following categories:

1. Group 1: Power control and very-high-level signal wiring (above 50V):
   AC power supplies

   DC power supplies

   DC current signals above 50mA (such as CT circuits)

   AC voltage and control signals above 50V (such as PT circuits)

2. Group 2: High-level signal wiring (6V to 50V dc):
   Signals from conventional electronic transmitters and controllers (such as 4mA to 20mA)

   Circuits to alarm enunciators and other solid-state devices (excluding those in categories 2.1, 2.5, 3.1, 3.2 and 3.3)

   Digital signals

   Emergency shut-down and tripping circuits

   On / Off control circuits

   Intrinsically safe circuits

   Speech-frequency circuits

3. Group 3: Low-level signal wiring (5V dc and below):
   Signals from thermocouples

   Signals from resistance thermometers and re-transmitting slide-wires

   Signals from analytical equipment and strain gauges

   For Group 3 wiring, internal connections to the instruments shall be made by one of the following methods:

   1. The twisted, screened conductors of the external cable shall be led direct to their appropriate instruments via ducting systems installed for this purpose during construction of the panel.
   2. The conductors of the external cables shall be terminated on terminals segregated from all other categories and the connections to the appropriate instruments shall be made using twisted pairs with individual screening installed for this purpose during construction of the panel.

Internal wiring for all circuits in Group 2 except those sharing a common connection shall be multi-stranded, twisted pair, 0.75mm² minimum copper conductors with HPDE or PVC insulated cable of adequate grade and rating in accordance with BS 6004:2000. Wiring for circuits in other Groups or sharing a common connection shall be run in stranded, 1.0mm² minimum copper conductors with 250V grade, PVC-insulated cable of adequate grade and rating. Wiring sheath colours shall be black for AC circuits, and grey for DC circuits (excluding thermocouple circuits) and blue for Group 2.6 circuits. Circuits supplied at 240V, between 240V and 110V dc shall also be physically segregated from each other and from other circuits. Access to wiring and components of circuits having voltages exceeding 240V shall not be

possible unless and until the circuit has been isolated.

Separate ducts, trunking, cable looms, tray work and the like shall be provided within the panel for each category with at least 150mm between parallel paths of Group 1 and those of any other Group. Intrinsically-safe circuits and their terminals shall be segregated from other circuits and terminals. All wiring shall be neatly and securely fixed by insulated cleats, bunched and secured by approved plastic strapping or run in approved insulated wiring trunking or non- corrodible flexible tubing. Not more than 75% of the capacity of trunking, ducts, looming, or tubing shall be used. Insulated earth wiring shall be so arranged that access to any equipment or connection point or the removal of any item of equipment is unimpeded. Wiring for future equipment shall be secured and terminated on terminal blocks. Lacing for wiring looms shall be of rot-proof cord or plastic strips. Inter-section wiring in multi-section cabinets shall be via a terminal block in each section.

7.7.4.11 Panel wiring identification and termination

Identification ferrules shall be fitted at both ends of each wire. The numbers or letters used shall correspond with the appropriate wiring diagram. The ferrules shall be of plastic insulating material with permanent black characters on a colour-coded background for numbers and on a white background for letters, unaffected by oil or water. They shall be so arranged that they can be read logically from left to right when viewed normally. The system of wire identification shall be such that wires in the same circuit on opposite sides of a terminal shall have the same reference, and this system shall be continued through all external cabling. Terminal ferrules (spade, tongue, crimped connections) shall be provided on each conductor.

7.7.4.12 Panel earthing

Acontinuouscopperearthbarofnotlessthan25mm%6mmcrosssectionshallrun the full A continuous copper earth bar of not less than 25mm % 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. The cable gland-plates and the earth bar shall be provided with suitable brass terminals of not less than 6mm diameter for connecting the metal cladding or armouring of all incoming and outgoing cables to the station earthing system.

A second continuous copper earth bar of not less than 25mm % 6mm cross section, electrically isolated from the steelwork of the panel and metal cladding and armouring of cables, shall be provided for earthing the signal earth connection of each instrumentation and control device and the screen(s) of each instrument cable not earthed elsewhere to the station instrumentation earth plate. The earth bar shall have sufficient brass terminals as specified above for each instrumentation and control device and the screen of every shielded cable plus

25% spare terminals. In multi-section panels, each earth bar shall be electrically bonded to the corresponding bars in the adjacent section(s). Instrumentation and instrument cable screen earthing shall comply with BS 6739: 1986, Section 10, unless otherwise stated in this clause.

Panel Heating

Each panel shall have one or more thermostatically-controlled tubular or ribbed panel heaters to prevent condensation and assist ventilation and which shall be adequate for ambient temperatures down to 5°C. The heater rating shall not exceed 0.2W/Sq.mm and the surface temperature of any part which could be contacted accidentally shall not exceed 60°C. Heaters shall be so situated that no deterioration can be caused to any equipment or wiring in the

panel. The heating circuits shall be switched and fused independently of the instrumentation and control equipment and manually controlled by an enclosed switch mounted in an accessible position within the panel. Thermostats shall be mounted remote from the heaters and other sources of heat and shall be fully adjustable over a range of not less than 0°C to 50°C. Thermostats shall cut out each heater when the internal temperature of the panel exceeds a preset value; differential thermostats shall be used to maintain the panel internal temperature at a pre-set value above the external ambient temperature. If the permanent power supply is not available at the time of installation of the panel and condensation is detected, a temporary power supply shall be connected to the panel of sufficient rating to operate the heaters.

7.7.4.13 Panel lighting

Each panel shall be adequately illuminated internally, as evenly and as free from dazzle as possible, by fixed fluorescent lighting controlled from totally-enclosed light switches and by totally-enclosed door-operated switches positioned so as not to interfere with access. There shall also be one installed inspection lamp per three meters of panel length or part thereof with adequate flexible connection cable to reach any point in the panel. The control switch for an inspection lamp shall form part of the lamp assembly. Lighting circuits shall be fused independently of any instrumentation and control circuit and designed to allow lamps to be replaced safely and shall be fed from a distribution board and circuit breaker connected on the live side of the main panel ac supply circuit breaker.

7.7.4.14 Panel ventilation

Each panel shall be provided with ventilation fans as required to ensure that equipment within the panel is maintained within manufacturer's recommendations, with due regard to the environment in which the panel will be mounted. Fans shall be controlled by a suitably labeled enclosed switch mounted internally in an accessible position. Fans shall be mounted with their axes horizontal and shall be arranged to draw clean air into the panel. Air entries shall have filters which can be renewed from outside the panel and shall be designed to prevent the entry of rain, spray, injurious fluids, sand or dust.

7.7.4.15 Panel piping and tubing

Panels containing equipment using a supply of compressed air shall have a common air pressure reducing station with duplicate pressure-reducing valves and filters. The pressure reducing station shall also include isolating valves upstream and downstream of each filter/reducing-valve set, pressure-relief valve, pressure indicator and low-pressure alarm unit for the low-pressure header and a pressure indicator for the high-pressure pipework. The pressure-reducing station components shall be mounted in a clear space inside the panel, supported on a suitable framework between the lower horizontal row of instruments and the main low-pressure header. All piping, fittings and valves downstream of the pressure-reducing station shall be of brass, copper or plastic. PTFE tape shall not be used downstream of the main filters. The low-pressure header shall be brass and shall be near the panel floor with drain valves and tundishes piped to a drain. Branch air headers shall be of brass (15mm diameter minimum) and shall run vertically from the header to the instrument. The low pressure header and each branch shall have a 6mm minimum, non-ferrous shut-off valve for each instrument requiring an air supply and a compression coupling for each air-purge connection. At least 10% spare connections for possible future instruments shall be provided in each panel

section. Any header dismantled before shipment shall have brass unions or flanges at each panel-section junction. Panel-mounted instruments shall be piped to bulkhead fittings on a gland plate during assembly at the manufacturer's works. Piping shall be colour- coded in accordance with Recommended Practice ISA−RP 7.2 issued by the Instrument. Society of America and shall be segregated from wiring so that any leakage is harmless. Each panel-mounted pressure gauge shall have a stainless steel flush-mounted shut-off and fine- regulating valve mounted vertically below. A drip tray shall be provided below each row of gauges. Exhaust and de-pressurizing pipework shall be routed out of the panel.

7.7.4.16 Panel labels

Labels shall be provided for every panel to describe the duty or otherwise identify the panel and its sections and every instrument, component and item of equipment mounted internally and externally. Where applicable, front-of-panel labels shall be as shown in the Specification drawings. Each label shall be permanently secured to the surface near the item to which it refers.

Externally-fitted labels shall be of perspex or other approved transparent plastic, with letters and numbers rear-engraved and filled with black. The rear surface of each perspex label shall be finished with a coat of paint of the same colour as the panel external finish. Instrument duty labels fitted externally shall be below the item to which they refer. Embossed tape or similar adhesive labels will not be approved.

Laminated materials or rear-engraved and filled plastic shall be used for internally-fitted labels, which shall be white with engraved black letters. Labels conforming to the requirements of the preceding paragraphs or other approved means shall be provided:

1. Labels
    I. To describe or identify circuits or circuit components
    II. To identify DC polarity
    III. To warn or remind about dangerous or potentially-dangerous circumstances
    IV. Wherever elsewhere specified

Unless otherwise specified, all engraving shall be in plain block letters, 4mm high. The minimum practicable number of different sizes shall be used. Manufacturers' nameplates shall not be fitted on panel external surfaces.

7.7.4.17 Panel finish

For control and instrument panels, desks and cubicles a hard, smooth, durable finish, free of blemishes, shall be provided. Before painting, all external welds and any rough areas shall be smoothed, and all surfaces shall be thoroughly cleaned and free from scale, contaminates corrosion or grease. If rust-proof or Zintec steel has not been used in the construction, the panel shall be treated with a passivating agent such as phosphoric acid. All internal surfaces shall have a minimum of three coats of paint of which the first shall be an approved antirusting priming coat and the final coat shall be opaque gloss white enamel. All external surfaces shall have not less than five coats of paint of which the first shall be an approved etch priming coat, and the second and third suitable undercoats, all of which shall be rubbed smooth when dry before application of the next coat. The undercoats shall be easily distinguished in shade or colour from the priming and finishing coats. The two final coats shall be of stove enamel paint,

gloss or semi-matt finish, to a colour and finish. Stoving shall be carried out in accordance with the recommendation of the paint manufacturer. The overall dry film thickness (DFT) shall be between 85 and 120 microns. Nuts, bolts, washers and other fixing devices which may have to be removed for transit or maintenance purposes shall be galvanized or otherwise finished to an approved standard. A 500ml tin of matching touch-up paint shall be provided and packed with each pane.

7.7.4.18 Electrical Indicators and Integrators

Indicators for use with analogue signal-transmission systems shall comply with BS 89:1990 or equivalent and have an accuracy class index of 1.0. Indicator movements shall be critically damped (dead-beat). Indicators for use on more than one circuit shall have rotary switches to select the circuit, with engraved plates to show the circuit selected. Indicators shall have circular scales or shall be of the vertical edgewise type and shall be designed to avoid parallax error.

Scales shall be clearly marked in SI units and shall comply with BS 3693:1992 or equivalent. All instruments mounted on one panel or board, or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering not subject to fading.

The material for scales shall be such that no peeling or discolouration will take place with age under any environmental conditions. Major scale marks and numerals shall be of the same size and thickness and shall be separated by not more than twenty-five minor marks. Pointers shall taper to the width of the scale marks. Integrators shall be of the multi-digit cyclometer type. Integrators operating in conjunction with an electromagnetic or ultrasonic flow meter shall use the pulse output from the flow transmitter. Any integrator operating from a device without a pulse output shall have an integral or separate current-to-pulse converter with sufficient adjustment of the pulse rate to avoid the use of any multiplying factor except in integer power of 10. Each integrator shall incorporate an adjustable limiter whereby any input below a pre-set value is inoperative. Unless otherwise specified, integrators shall have a minimum of eight digits with a decimal point where applicable.

7.7.4.19 Alarm System

Alarms shall be initiated by the opening or closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exit. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple modification after installation requiring no additional parts or special equipment.

Each alarm shall initiate the operation of both visual and audible devices. The sound intensity of each audible device shall be suitable for the maximum sound level of its environment.

Audible devices in the same room or area shall have distinguishable sounds and adjustable sound levels.

7.7.4.20 Matrix Type Alarm Annunciators

The alarm annunciator shall be microprocessor based, modular, split type unit with alarm windows mounted on the front door and electronic modules inside the panel. The weather protection class for alarm annunciator shall be IP-54 of IS 13947, Part-I. Each alarm shall

initiate a visible and audible indication of the specified condition. Unless otherwise specified, alarm indicators shall be grouped together in annunciator units each having at least 20% spare ways. Alarm indicator lamps (Cluster LED type) shall have transparent screens engraved with appropriate legends as approved in the Designs and Drawings. The legend area of each indication shall not exceed 40mm high and 75mm wide. When any alarm condition occurs, a condition device common to an alarm annunciator system shall sound and the appropriate indicator shall flash on an off. The flashing rate shall not be less than 2 Hz and shall notexceed 5 Hz. On pressing an accept pushbutton, the audible device shall be silenced and the flashing light shall become steady. The alarm indicator shall remain illuminated until the alarm condition ceases and a reset pushbutton has been operated.

The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a further alarm condition occurs.

At unmanned locations alarms operated on two or more annunciators shall require acceptance at each annuciator. Alarms shall be accepted automatically and the appropriate audible device silenced after an adjustable period of 1 to 5 minutes.

An integral ‘test’ pushbutton shall be provided to illuminate each lamp in the appropriate group and to operate the audible device but shall not cause a spurious alarm condition on any other annunciator.

Alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds do not initiate any action.

Alarm annunciator / indicator legends or labels shall be arranged with three lines of text as follows:

i. Top Line: Location; example: sludge blanket level
ii. Middle line: parameter; Level
iii. Bottom line: status. High

7.7.4.21 Push-Buttons and Indicator Lights

Push-buttons in control circuits shall have shrouds, guards or other suitable means for preventing inadvertent operation. Status-indicator lights shall be of the high-intensity LED type. Indicator lights shall be of a design which allows easy LED replacement from the front. Indicator lights shall be easily visible above the ambient light level when viewed from within an included angle of 120 degrees. LEDs shall be chosen to ensure clear discrimination between the energized and de-energized states and to ensure an average working life of not less than 3000 hours. A ‘lamp test’ push-button shall be provided for each group of indicator lights. The colours of push-buttons and indicator lights on instrument panels shall be as follows:

i. INDICATOR LIGHTS ON INSTRUMENT PANELS
ii. Start or on (energize) - Green
iii. Stop or off (de-energize) - Red
iv. Open valve - Black*
v. Close valve - Black*
vi. Accept - Black
vii. Lamp test - Black
viii. Reset - Black
ix. Motor running (energized) - Red
x. Motor stopped (de-energized) - Green

xi. Valve open - Red
xii. Valve closed - Green
xiii. Urgent alarm - Red
xiv. Non-urgent alarm - Yellow
xv. Plant healthy or ready for use - White

*Panel-mounted push-buttons for valve operation shall be coloured black, or as per the approved Design and Drawings, with the duty clearly defined by legend on an associated label.

*Panel-mounted push-buttons for valve operation shall be coloured black, or as per the approved Design and Drawings, with the duty clearly defined by legend on an associated label.

7.7.4.22 Analogue Signal Transmission

Unless otherwise specified, analogue signal-transmission systems shall be in accordance with BS EN 60546-1:1993 and shall use a signal of 4mA to 20mA DC. Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter. Transmitters shall be capable of meeting the requirements laid down in the appropriate part of IEC 60770-1:1999.

7.7.4.23 Analogue Process Controllers

Analogue controllers shall use solid-state components and shall have outputs containing three terms with negligible interaction. The controller fascia shall have measured value, set value and output indication, manual set-value and output controls, auto/manual switch for control mode and remote-local transfer switch for set-value control. Manual control stations shall have measured value and set-value indication, local/remote switch and control available lamp indicator. Each controller shall have the means to restrict its output signal to a predetermined, fully adjustable band so that the regulating device is not moved to unsafe positions. The adjustment of these safe operating limits shall be by means of accessible, clearly marked, internal components. A continuously adjustable proportional band of not less than 5 to 500% shall be provided. Integral and derivative action times shall be adjustable over ranges which shall not be narrower than 6 seconds to 25 minutes and 0-to 10 minutes respectively. If the integral or derivative action times' adjustments are in steps, the ratio of successive steps shall not exceed 2. The controls used to set the P, I and D values may be at the front of the instrument or mounted internally in an accessible position.

Each controller shall be designed so that in the event of failure, it shall be possible to plug a portable manual station into the controller case and to control the regulating device manually.

Controller design shall ensure automatic procedure-less, bump less transfer whenever the instrument is switched from "auto" to "manual" or vice versa. Controller action shall be adjustable from direct to reverse and vice versa by the operation of an internal switch. Analogue process controllers shall be capable of meeting the requirements laid down in the appropriate part of BS EN 60546-1:1993.

SCADA (Online Monitoring System)

7.7.4.24 General

One of the key requirements forming part of Operation and Maintenance requirement of WTP, is REAL TIME ONLINE MONITORING of various data & details by authorities & officials in CMWSSB and in other stake holder departments of the project through IOT based solution.

In order to facilitate this requirement, the Concessionaire shall design and implement an SCADA concept based ONLINE MONITORING SYSTEM for real time monitoring of various parameters of the WTP including mechanical equipment (pumps, motors, valves, etc.), process instruments and power network.

The SCADA based REAL TIME ONLINE MONITORING SYSTEM (hereinafter referred to as RTOLMS) should be such that it has feature as per generic requirements to enable transmission of real time data of all the monitored parameters over Internet networks, leased and phone lines, wireless communication etc., or a mix of these as appropriate and as feasible at the respective site(s).

7.7.4.25 Scope of Specification

The purpose of this part of the Specification is to define the basic requirements for microprocessor-based, programmable logic controllers (PLC) integrated into control system and Supervisory Control and Data Acquisition System (SCADA) intended for Water Treatment Plant (WTP) and Raw Water pumping stations.

7.7.4.26 Programmable Logic Controllers

(a) Design and Construction Requirements

WTP PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, simplex input/output (I/O) modules, communication interface modules and man-machine interface (HMI) required to perform the desired functions.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event. PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

PLC shall have the following attributes as a Hot-Standby configuration.

Carry out sequential logic implementation for operations of plant;

Carry out computation and interfacing for data acquisition, data storage and retrieval;

It shall accept downloaded program from a programmer;

It shall have different functional modules to perform the desired functions;

It shall scan the inputs in time cycles and update the status of its outputs.

(b) Dual redundant processors

The master station 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 should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 7 MB. Both the CPU's should have separate backplane and associated hardware for redundancy.

CPU system should have built in WEB server

SCADA connectivity with the CPU will be on dual 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.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided.

PLC CPU and I/O modules, Communication Modules, Converters, Switches etc. shall be of the same logic family.

Failure to do adhere to the above will be treated as a non-responsive bid and lead to technical disqualification. Concessionaire should 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 (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

A. 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.

B. Sufficient plugin 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 wide Central SCADA Monitoring Centre (CSMC) proposed at 2nd Floor, BWSSB Shimsha Bhavan, Jayanagar, Bangalore Adequate references shall be provided to demonstrate similar installations by the manufacturer.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system.

In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').

The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

The PLC shall have a field proven track record and shall be fully compatible with the proposed Central SCADA Monitoring Centre (CSMC) located at 2nd Floor, BWSSB Shimsha Bhavan, Jayanagar, Bangalore SCADA system.

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O, CPU and communication modules, switches and battery backup rates shall be monitored by the PLC and shall be available by report.

During the times of the battery discharge, the PLC shall initiate an orderly self shutdown and automatically restart on the main power restoration without the need for reloading or initiation of any kind.

The PLC shall comply with the specification specified elsewhere in this specification.

Each PLC shall have built in web server capability allowing system information to be stored in a format that allows for easy access and viewing with standard Windows™ based browser. Each unit shall be furnished with built in O & M data associated with its specific site including; as a minimum, basic system information, panel layouts, wiring diagrams, material lists w/part numbers, and operational summary. This information shall be accessible locally or remotely

(c) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications

The following additional features shall be provided.

Redundant system with Hot back up redundancy feature should be built in the CPU.

Software engineered hot backup system will not be not acceptable. CPU should have the memory expansion capability up to 7 MB.

Both the CPU's should have separate backplane and associated hardware for redundancy.

RIO's to have dual redundancy on network level connected to both the CPU. Even on the failure of one CPU backplane the other system should be available on dual network at RIO level.

SCADA connectivity with the CPU will be on dual 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.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity should be provided.

Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus.

On resumption of power following a power failure the PLC shall automatically restart its controlling function.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse.

CPU shall have extensive self diagnostic facilities and watch dog timers to identify faults at card levels

(d) 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 EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery back up. The battery back up provided shall support the memory on loss of power for at least one month. The battery life shall be at least 2 years.

(e) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU., Communication Modules, Converters, Switches etc. 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. I/O Modules should be hot swappable.

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.

I/O modules shall be as follows:

inputs shall be opto isolated.;

filters shall be provided for noise rejection;

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 shall be connected to the PLC by on board Ethernet 10/100 BaseT 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.

(f) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided,cross talk attenuation provision for monitoring of the ADC for overflow detection gain amplifier with high common mode rejection ratio

accuracy for analogue signals shall be 0.5%

(g) Digital Input Modules

The following design features shall be provided contact bounce protection; choice of type of contacts.

(h) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows: contact bounce protection shall be provided relay output shall be provided to operate pump motors and motorised valve actuators fail safe position in case of output module failure and fault indication 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
2. Analog input
3. Analog output
4. Timers
5. Pump Controller
6. Pump Alternation
7. Mathematical Function Blocks
8. Stage Blocks
9. Trending
10. Latch/unlatch relays
11. Counters
12. Comparators
13. Ladder logic
14. Flow Totalization/Integration
15. Intrusion Detection
16. Time of Day Control w/Lockout
17. Ramp Blocks
18. Data Logging

(i) PLC Programming

PLC programming shall be carried using 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 least the following standard operations shall be applicable:

(1) Logic functions (such as AND/OR/AND NOT etc.);

(2) Timer functions (externally adjustable);

(3) Counter functions;

(4) Skip functions;

(5) Comparison functions;

(6) Limit value functions;

(7) Arithmetic functions;

(8) Physical unit functions;

(9) Closed-loop functions such as P/PI/PID/etc.

The Concessionaire shall submit the logic diagrams for review. The Concessionaire shall include the as-built logic in the final submission.

(j) 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 shall be included:

(1) On-line programming

(2) Off-line programming

(3) Flexible corrections during input

(4) Full screen editing functions

(5) Absolute and symbolic programming

(6) Input of comments and title blocks for complete documentation

(7) Complete application software documentation functions. Printouts of application software logic functions shall preferably be in Ladder logic diagrams.

(8) Load and transfer functions

The computer shall be provided complete with proprietary PLC programming and SCADA software complete with plant mimics and documentation software. Communications cables required to interact with the PLC, (Eg: Modbus Cable) would be supplied by the Concessionaire. The software shall provide facilities for: carrying out program revision management; 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; make system backup copies while the system is online; upload and down load programs to the PLC on line; carry out on line maintenance and fault finding on the PLC.

7.7.4.27 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 or HMI console 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.

An alarm shall be generated whenever a communications system failure occurs.

7.7.4.28 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.

1.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 engineering workstations.

It must be possible to install more than one engineering station in a system.

The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from CAD/CAE programs. 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.

Provision of redundant storage media must be possible for the configuration database.

The specs for computer hardware shown are indicative only. The Concessionaire 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:

2. 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.

3. The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC's) over an RS-232/RS-485 serial data link using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Engineer.

4. Data Storage:

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. A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each suitable for backing up the whole system on a weekly basis. Data selected for archive shall be written to removable media which shall be sized to support at least 40 days worth of archive data. Additional storage device to be provided to store the historical data in the Engineering Station.

5. Visual Display Unit (VDU)

1. Visual Display Units (VDU's) shall be colour monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colours, non-interlaced, low radiation, 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 that 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,

2. VDU's shall be 32 inch.

3. VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.

6. Colour LaserJet Multifunction Printer:

Colour LaserJet Multifunction printer shall be used for the production of colour screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the colour printer is operational and comply with the following:

Printer Specification:

All-in-one functions	Print, copy, scan, fax, stand, alone 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	Sheetfed
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

7.7.4.29 System Overview

The SCADA/MMI system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers Terminal (ET), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the MMI shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition.

Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

SCADA/HMI system should be housed in an air-conditioned environment.

7.7.4.30 SCADA software functions

7.7.4.31 General

1. The Concessionaire shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Concessionaire shall make available all standard software functions, even if not specifically detailed in the specification.

2. The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.

3. The Operating System shall be Windows XP, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.

4. The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).OPC should be a in-built feature of the software. The System shall support a fully distributed 64 bit Client/Server architecture. The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA. Object oriented graphics and tools to easily build reusable control strategies. ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.

The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices. Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming.

The SCADA software shall use SQL server as the integral database.

A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports. The Engineering Workstation shall be provided with simulation tools to support off-line testing of the control logics. The Server shall provide the master clock for the SCADA time synchronization. The system software shall be from the SCADA equipment manufacturer. Third party software is not acceptable.

It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database. Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently. Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball. Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer. VDU mimics will display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top

of each operator screen. Each control action will be routed through a series of confirmation routines. The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A4/A3 size, screen dump printer shall be provided for graph and trend prints.

An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.

The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:

- Parameter Displays for signal control
- Control Loop Status Displays
- Real Time and Historical Data Trend Displays
- Event Displays and Log Reports
- Alarm Displays and Log Reports
- Equipment Diagnostic Displays and Reports.

The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:

- ODBC
- OLE
- ActiveX
- COM/DCOM
- DDE and Advance DDE
- C programming language
- Visual Basic
- Microsoft Windows XP or the most current Operating System
- TCP/IP
- OPC
- XML

(b) Display Facilities

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 3 seconds of selection and the displayed data shall be updated from the database .Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database.

The Concessionaire shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.

The initial application software shall provide for the display pages listed below and any pages necessary

for the system to function as a complete entity.

a. Mimic displays.

b. Graphic displays.

c. Trend displays.

d. Alarm summary tables with date and time.

e. Event logs of past 72 hours with date and time.

f. Tabular display of data.

g. Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.

Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.

No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.

7.7.4.32 Monitoring and Alarms

1. The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information on a series of VDU based graphical and tabular displays.

2. In the event of an equipment alarm, the following shall occur at the master station:

a. Alarm message displayed in the alarm message area of the screen.

b. The audible alarm shall sound.

c. The appropriate Section of the display page shall change colour and flash.

d. A full message shall be written on the alarm page.

e. The full alarm message shall be printed on the alarm printer.

f. The full alarm message shall be recorded, stored on disk and automatically archived.

3. The operator should be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and displays. However the display shall remain in the alarm state fixed colour to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.

4. Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.

5. If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.

6. An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.

7. Each signal within the configured system shall be capable of being assigned an alarm based on the

following:

a. Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).

b. Rate of change.

c. Deviation from set point or other control parameter.

8. Alarms shall be time tagged to 1 second resolution at the I/O's.

9. A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.

10. Typical alarm assignments are as follows:

a. critical alarm - an alarm that requires immediate operator action

b. non critical alarm - an alarm that requires operator action but not necessarily immediate action

c. operator guide alarm - an alarm that provides information to the operator

d. event - a low priority condition which is recorded.

Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 75% full.

Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored. The system will provide any combination of the following:

a. Instantaneous value.

b. Average value.

c. Maximum value.

d. Minimum value.

e. Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.

The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

VDU Mimic Displays (SCADA Screens)

The Concessionaire shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is

essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device. The mimic displays shall consist of the following pages:

a. A general diagram covering the whole of the system on a single screen with key data

b. A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data

c. Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.

Login screens, reports screen, security screen, overall WTP screen, etc.. shall be configured.

SCADA screens shall include screens for TSPS under this contract.

Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colours and line texture. Next to the graph, there shall be a key relating each colour to its function. The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user. Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph.

The display of the data shall also be available in tabular form.

(a) Manual Data Entry:

1. The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:

a. Constants which will be changed infrequently. This data may have time and date associated with it.

b. Maintenance related comments.

(b) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

Reports

There shall be a real time spreadsheet facility supplied and installed by the Concessionaire in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports,

either automatically at predetermined intervals, or manually on demand by the Operator. Typical reports on a minimum would be:

a. Flow rates and total.

b. Failures of equipment.

c. Analytical instrumentation parameters.

d. Wet well and tank levels.

e. Discharge pressures.

f. Maintenance schedules.

g. Process alarm conditions.

h. Chlorination equipment

Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW. The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

Data Manipulation

It shall be possible to perform simple mathematical functions on any data, including the following functions:

a. Addition

b.Subtraction

c.Multiplication

d.Division

e.Square root

It shall be possible to log, display or use in a control loop, the resultant data.

Database Query Facilities

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use. Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the DCS and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits. Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

Downloading IO Configuration

It shall be possible to download configuration to the IO's from the Engineer's terminal and the Portable

Programming Unit (Laptop)

Diagnostics

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

Security Access Levels

The functions available on the system shall be fully flexible so as to allow users access levels to be customised by the system operator, to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.

The security/access levels would be divided between engineers, supervisors and operators.

The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. It shall be possible to define a minimum of eight privilege levels.

Passwords entered during the log-on process shall not be printed or displayed.

The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Concessionaire shall provide the following defined user access levels as a minimum and additional levels as instructed by the Engineer:

1. **Default level**:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2.Operator level:

The operator level shall permit authorised users to access default level activities in addition to the

following:

(a) Perform control actions;

(b) Acknowledge alarms;

(c) Enter or modify manually entered data for inclusion into reports.

3. System manager level:

The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

(a) Modify alarm and control set points, dead bands and time delays;

(b) Enter or modify historical data;

(c) Add, delete or modify individual I/O points or point attributes;

(d) Add, delete or modify field device configurations;

(e) Create, delete or modify control algorithms;

(f) Create, delete or modify graphic displays;

(g) Create, delete or modify system reports;

(h) Configure trend displays;

(j) Access the operating system;

(k) Assign access levels and user passwords;

(l) Perform any other system maintenance function

Programming

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

a. All programmes shall be written such that they lend themselves easily to alterations and additions.

b. Good programming practice shall be followed using structured programming techniques. All programmes shall be tidy in format and logical to follow. Programmes should be extensively annotated with comments and be self-documenting.

c. The system shall be supplied with programmes that use a high-level language.

Programme – Documentation

As part of the requirements of this specification full documentation is required as below:

a. Software user manuals

b. Database point allocation table

c. Complete program listing, flow charts for all sequences and control routines

d. Application software source code

e. End user license agreements.

LED Screen

An LED Screen shall provide an elementary full color pictorial flow diagram display of the treatment plant including points at which chemicals are injected. The mimic shall also include displays of process values e.g. Process flows, waste water quality etc. The mimic shall measure not less than 62" LED Screen. The operator interface shall provide facilities to: display status of devices associated with the process area concerned (i.e. running, stopped fault etc.); display analogue values associated with that area of the plant; annunciate alarms associated with the area of the plant concerned; provide facilities for the operator to: silence the alarm (the alarm shall automatically silence after one minute (manually adjustable) if not manually silenced);

I acknowledge alarms
II select the duty drive of duty / standby drive pairs;
III adjust process set points;
IV prompt process actions.

PABX system

Private Automatic Branch Exchange (PABX) System for Connection to Public Switched Telephone Network (PSTN)

General:

The PABX system described in this specification shall have the following minimum features and facilities integrated into the system and ancillary equipment:

Scope:

This technical specification describes requirement of Private Automatic Branch Exchange (PABX) system connected to Public Switched Telephone Network (PSTN) and PABX to Exchange Telephone systems of Sub Treatment plant areas for WTP.

Operating loop limits:

The system shall provide the following loop features:

The extension line maximum loop resistance, including the resistance of the telephone shall not be less than 600 ohm.

The trunk and tie line shall be capable of detecting a signalling current from the distant end, with the supply at a minimum of 45 volt.

Following Technical details along with Datasheets shall be submitted during Detailed Engineering.

(a) Whether the system can be equipped with duplicated controls and processor unit.

(b) What type of main processor/s will be supplied?

(c) Which components are duplicated, e.g. main memories, clock generator, switching network, multibus, signal unit, conference equipment, and voice mail?

(d) What the size of the main system memory is.

(e) What the dynamic traffic value is as specified in Busy Hour Call Attempts (BHCA).

(f) Whether the main processor can be upgraded to allow for a greater number of BHCA.

Features:

- DDI and DDO: The PABX system offered shall have Direct Dialling In (DDI) and Direct Dialling Out (DDO) facilities to be utilized to full advantage by the user to and from all extensions.
- The system will make provision for internal dialling.
- The baring of individual telephone extensions for WTP at least 24 levels.
- Individual code baring will be possible (e.g. the baring of code 010) .
- The system will allow for conference.
- The system will make provision for call transfer.
- The system will make provision for Individual Speed Call.
- The system will have Inbuilt battery charger.
- The system will make provision for Code Looking of extensions.
- The system will make provision for Last Number Redial.
- The system will make provision for Call Hold.
- The system will support dial impulses analogue telephones.
- The system will support two (2) wire telephone systems.
- The system will have Fully Hybrid Ports.
- The system will have 32 party Conferencing and call budgeting features.
- The system will have Digital Architecture.
- The system will have scalability to 27 trunks and 72 Extensions.
- The system will have Automatic call distribution – (**ACD)** feature.
- The system will have Global and personal memory banks.
- The system will have a feature of Auto redial multiple numbers.
- The system will have account code feature.
- The system will have Listen in.
- The system will have STD Compatibility.
- The system will have a feature of Flexible station numbering.
- The system will be having a Key Telephone Instrument / Console.
- The Features of Key Telephone Instrument / Console as follows.
  - KTS features include
  - Hands free answering
  - Full lit line key
  - 06 programmable keys
  - 2 line display
  - 10 one touch keys

Earthing:

PABX system shall be installed at Central Control Room / Administrator Room, the Concessionaire has to provide Earthing for PABX system from control room of Instrumentation control panel.

(i) Telephone Instruments:

The Concessionaire shall supply, install, test and commission telephone instruments in- tended for use with the PABX installation for all indoor extensions, as well as those outdoor extensions which are included in the telephone schedule included else- where in the specification

The Concessionaire shall functionally check each telephone jack point, using a standard telephone

instrument, for successful operation.

The PABX system must offer a choice of telephone instruments to meet the various requirements of the users. The telephone instruments should include:

(1) Basic analogue 2 wire connections.

(2) The system shall have the capability of handling telephone instruments with 16 digit keypads.

The tenderer shall define clearly in his tender every type of telephone instrument which may be used in conjunction with the system offered, as well as the type of analogue will be supplied, the facilities which each type of telephone offers and the cost of these instruments.

All telephone instruments shall be provided with a standard three-(3) metre connecting cable with a plug.

The tenderer must take note that the quantities of telephone instruments may be increased or decreased during the construction phase of this contract. The final contract sum will be adjusted accordingly.

Note:-

1) The Concessionaire has to provide Trunk line protections for each line.

2) 2-Pair Cat-5 Cables along with Junction boxes shall be provided by the Concessionaire for Connection to PABX system to each Extension Telephone Instrument systems.

3) If any items are required for PABX and PSTN, Concessionaire has to provide those Items as a Turnkey basis.

4) Concessionaire has to provide Telephone Land line Service for PABX system at WTP.

8 ERECTION, TESTING AND COMMISSIONING

8.1 Equipment Installation, Testing and Commissioning

8.1.1 Installation of equipment

a) In accordance with the specific installation instructions as shown in the Concessionaire's drawings or as directed by the Executing Agency, the Concessionaire shall unload, erect, install, wire, test and place into use of all electrical equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented.

b) The Concessionaire shall furnish all supervision, labor, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.

c) Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.

d) The Concessionaire shall erect and commission the equipment as per the instructions of the Executing Agency and shall extend all co-operation to him.

e) In case of any doubt / query as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Executing Agency. The Concessionaire shall be held responsible for any damage to the equipment consequent to not following instructions correctly.

f) The Concessionaire shall move all equipment into the respective buildings through regular doors or floors openings provided specifically for the equipment. The Concessionaire shall make his own arrangement for lifting of equipment.

g) Where assemblies are supplied in more than one section, the Concessionaire shall make all necessary mechanical and electrical connections between sections including the connections between bus bars / wires. The Concessionaire shall also carry out the adjustments/alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or business chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Concessionaire at his own expenses.

h) The Concessionaire shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Executing Agency.

i) Care shall be taken during handling on insulating oil to prevent ingress of moisture or foreign matter. In the testing, circulation, filtering, or otherwise handling of oil, rubber hose shall not be used. Circulation and filtering of oil, the heating of oil by regulated short-circuit current during drying runs and sampling and testing of oil shall be in accordance with the latest Code of Practice IS:10028 (Part II) shall be carried out.

j) Inspection, storage, installation, testing and commissioning of transformers shall be in accordance

with the latest Indian Standard Code of Practice IS:10028. All commissioning tests as applicable, vide Appendix B of IS:10028 (Part II) shall be carried out.

k) Switchgear, relay and control panels shall be installed in accordance with the latest Indian Standard Code of Practice IS:10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Concessionaire shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in approved manner to prevent ingress of moisture.

l) After installation of all power and control wiring, the Concessionaire shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal AC or DC voltage to the circuits and operating the equipment. Megger tests for insulation, polarity installation tests shall be carried out by the Concessionaire who shall also make all necessary for proper functioning of the equipment.

m) Installation and testing of the battery and battery chargers shall be done in strict compliance with the applicable standards. Each cell shall be inspected for breakage and condition of cover seals as soon as received at site. The battery shall be set up on racks as soon as possible after receipt, utilizing lifting devices. The cells shall not be lifted by terminals. Contact surface of the battery terminals and inter cell connectors shall be cleaned, coated with protective grease and assembled. Each connection shall be properly tightened. Each cell shall be tested with an hydrometer and thermometer and the results logged. A freshening charge, if required, shall be added. When handed over to the Executing Agency, the battery shall be fully charged and the electrolyte shall be at the full level of the specified specific gravity.

n) Equipment furnished with finished coats of paint shall be touched up by the Concessionaire if their surface is spoiled or marred while handling.

o) Foundation work and grouting-in of fixing bolts or channels for all transformer, switchgear, motors and control panels will be carried out by the Concessionaire.

Installation work for earthing and lightning protection system.

- the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/coating, drilling, brazing/soldering/welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Concessionaire's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washing, bituminous.
- The quantities, sizes, materials of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be as shown on the project drawings.
- The work of embedment of earthing conductor in RCC floors / walls along with provision of earth plate inserts / pads / earth risers shall be done by the Concessionaire when the floors are cast or during construction of walls.The Concessionaire's scope of installation shall include laying the conductors in position with 50 mm concrete cover, making welded connections to inserts/pad/risers above the floor near the equipment. The embedded conductors shall be connected to reinforcing rods wherever necessary.
- If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Concessionaire where required, together with associated civil work such as excavation/ chasing, concreting and

surfacing, if not already done in the civil work. The concrete cover over the conductor shall not be less than 50 mm.

- Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth upto 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing / welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfiring material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch and tampered utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for suitable material from outside.
- Installation of earth connection leads to equipment and risers on steel structures / walls shall include laying the conductors, welding / cleating at specified intervals, welding / brazing to the main earth grid risers, bolting at equipment terminals and coating welded/ brazed joints by bitumen paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment / structure.
- Electrodes shall be installed (a) directly in earth, or (b) in constructed earth pits and connected to main buried earth grid. The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe / rod / plate electrodes in test pits and connecting to main earth conductors.
- Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening / cleating / welding of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level
- Installation of the test links shall include mounting of the same at specified height on wall/ column by suitable brackets and connections of the test link to the earth electrode.
- Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- Suitable earth risers shall be provided above finished floor/ground level. If the equipment is not available at the time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided will be marked in project drawings.
- Earth leads and risers between equipment earthing terminal and the earthing grid shall follow as direct and short a path as possible.
- Wherever earthing conductors passes through walls galvanized iron sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Concessionaire by suitable water proof compound.

8.1.1.1 Earthing connections

- All connections in the main earth conductors buried in earth/concrete and connection between main earthing conductor and earth leads shall be of welded type.
- Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
- All bimetallic connections shall be treated with suitable compound to prevent moisture ingression.
- Metallic conduits and pipes shall be connected to the earthing system.
- Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrestor and transformer earthing leads which shall be directly connected to plate electrode.

8.1.1.2 Earth electrodes

- Electrodes shall as far practicable, be embedded below permanent moisture level.
- Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of plate electrodes in test pits shall be suitable for watering. The necessary materials required for installation work shall also include civil work such as excavation and connection to main earth grid.
- Earth pits shall be treated with salt and charcoal.
- Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Concessionaire shall arrange for a suitable soil from outside.

8.1.1.3 Lightning protection system

- The lightning protection of air termination rods and/or horizontal air termination conductors shall be fixed in such a way that they remain in their installed position even during severe weather conditions. The necessary accessories such as cleats, clamps, welding materials, bolts, nuts shall be supplied by the Concessionaire.
- Air termination system shall be connected to earthing system by down conductors. The down conductors shall follow a direct path to earth. There shall not be any sharp bends, turns and kinks in the down conductors.
- All joints in the down conductors shall be of welded type. All metallic structures within 2 metres of down conductors shall be bonded to lightening protection system.
- Every down conductor shall be provided with a 'test link' at about 1000 mm above ground level housed in a suitable G.I. enclosure made of adequate thickness steel sheet andhot-dip galvanized. The test joint shall be directly connected to the earthing system electrode.
- The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However, all metal projections, railings, vents, tanks, etc. above the roof shall be bonded together to form a part of roof grid.

8.1.2 Installation of cable racks and trays

a) Lines and grade for trays may be measured from building steel and finished floor elevations. Changes in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.

b) Where embedded steel inserts in concrete floors/walls for welding the supports for cable racks/trays are not available, Concessionaire shall provide suitable anchor fasteners at no extra cost.

c) Cable shall be clamped to the cable trays at regular intervals.

d) Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

8.1.3 Installation of cables

a) The Concessionaire shall install, test and commission the cables specified in the specification in accordance with drawings & instructions issued by the Executing agency representative. Cables shall

be laid directly buried in earth, on cable racks, in built-up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings. Concessionaire's scope of work includes unloading, laying, fixing, jointing, bending and termination of the cables. The Concessionaire shall also supply the necessary materials and equipment required for jointing and termination of the cables.

b) All apparatus, connections and cable work shall be designed and arranged to minimise risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Concessionaire.

c) Standard cable grips and reels shall be utilised for cable pulling. If unduly difficult pulling occurs, the Concessionaire shall check the pull required and suspend pulling until further procedure has been approved by the Executing Agency. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.

d) After pulling the cable, the Concessionaire shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at intervals on long runs of cables on cable trays and in pull boxes. Cables and joint markers and RCC warning covers shall be provided wherever required. All cables shall be allocated a unique number which shall be fixed to each end of the cable using corrosion resistant label. Cable 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
- Telecommunication T_

e) Sharp bending and kinking of cables shall be avoided. The bending radii for various types of cables shall not be less than those specified below :

11 KV XLPE multicore armoured cables: 15 times the overall dia of the cable

650 / 1100 V PVC insulated armoured cables: 12 times the overall dia of the cable

If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Executing Agency.

f) Power, control and instrumentation cables shall be laid in separate cable racks / rays. g)Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.

h) 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 gives the distances in

mm that shall be maintained between the different categories / voltage grade of cable.

Cablecategory	HV Power	LV Power	C&I Protection	Telecommunication/ datanetwork
HVPower	-	275	550	550
LVPower	275	-	275	275
C&IProtection	550	275	-	275
Telecommunication	550	275	275	-

i) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at not less than one metre depth.

j) Cables laid in ground shall be laid on a 50 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench.

k) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a latter date.

l) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directly into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in tray shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.

m) Cable splices will not be permitted except where permitted by the Executing Agency.

Splices shall be made by Concessionaire for each type of wire or cable in accordance.

with the instructions issued by cable manufacturer's and the Executing Agency. Before splicing, insulated cables shall have conductor insulation stepped and bound or pencilled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

n) Jointing of cables shall be in accordance with relevant Indian Standard Code of Practice. Materials and tools required for cable jointing work, including c old setting bituminous compound shall be supplied by the Concessionaire. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.

o) At cable terminal points where the conductor and cable insulation will be terminated, termination shall be made in neat, workmanlike and approved manner by men specialised in this class of work.

p) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Executing Agency for the various control circuit, by code marked wiring diagram.

q) When control cables are to be fanned out and cabled together with cord, the Concessionaire shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Concessionaire shall make a temporary connection with sufficient length of cables so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.

r) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Executing Agency. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

s) After installation and alignment of motors, the Concessionaire shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/tray. The Concessionaire shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings, if any.

t) For directly buried underground cables, Concessionaire shall install galvanised cast iron cable markers over ground, at all bends, loops, joints, crossing points and at every 25 meters interval on straight runs. The cable markers shall be anchored in the ground to a depth of minimum 500 mm. The cable markers for L.T. cables & HT cables shall be distinctly different in shape and marked as L.T. Cables and HT Cables as the case may be by 30 mm size letters.

8.1.4 Lighting system installation

This covers the requirements of installation of the following:-

a) Lighting fixtures complete with lamps and accessories

b) Main Lighting distribution board

c) Lighting panels

d) Receptacles and lighting control switches e) Point wiring

f) Street lighting poles and flood light towers

g) Multicore cables for street and boundary lighting

h) Maintaining equipment/materials during storage and being responsible for the equipment/material until they are handed over to the Executing Agency.

i) Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

8.1.4.1 Applicable standards

Electrical wiring installations :

(system voltage exceeding 650 V)

Code of practice for interior illumination (Part-1)	:	IS:3646/BS:8206
Code of practice for street lighting installation	:	IS:1944
Code of practice for industrial lighting	:	IS:6666
Code of practice for fire safety of building	:	IS:1646
Boxes for enclosure of electrical accessories	:	IS:5133 (Part I)

Guide for safety procedures and practices in :IS:5216 electrical work

Ceiling roses : IS:371

8.1.4.2 Lighting fixtures

a) The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings enclosed. Installation shall include all materials required to mount the fixtures in the manner as shown in the drawings. Installation of lighting fixtures shall include installation of control gear box wherever applicable.

b) Installation of receptacles and switches shall be carried out suitably as per the lighting layout drawings prepared by Concessionaire and approved by Executing Agency. Switch shall be mounted in flush with the front cover plate. Supply and installation of necessary hardware shall be included in the scope for installation of receptacles/switches.

c) Lighting distribution boards shall be installed at the location indicated in the layout drawings prepared by Concessionaire and approved by Executing Agency. Installation rates quoted for installation of lighting distribution boards shall include supply and installation of base channels, foundation bolts, etc.

d) Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 100 mm (min.) above the ground level. Construction of concrete plinth shall be included in the installation of outdoor lighting distribution board. Installation cost of lighting distribution board shall include installation of earthing conductor from LDB to the nearest earthing grid.

Point wiring

Supply and installation of conduit point wiring

a) The point wiring shall include supply of necessary materials for the conduit wiring such as galvanised rigid steel conduit, galvanised M.S. fixing saddles with spacer plates, nylon/fibre plugs, galvanised M.S. fixing screws, 12 SWG galvanised steel earthing wire, PVC insulated copper or aluminium conductor wires, control switches and pulling, termination of the earthing/PVC insulated wires as required, installation of control switches, drilling holes in brick walls/RCC roof slabs for taking the wiring conduits and refinishing any other works/material necessary for

making point wiring complete in all respects.

b) Wires used for conduit point wiring of lighting fixtures/ceiling fans and receptacles shall be 1100 V grade, PVC insulated, single core, stranded copper conductor wires of sizes not less than 1.5 sq.mm and 2.5 sq.mm respectively. Wires shall conform to IS:694 and shall bear the ISI mark.
c) Bidder shall take into consideration necessary galvanised MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

Point wiring shall also include/hold good for the following:

a) Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
b) Drilling holes in brick/RCC wall & roof for taking cable or conduit, sealing and refinishing with cement plaster.
c) Testing, commissioning and handing over the lighting system in commercial working condition.

Outdoor Lighting (Street and Flood Lighting)

The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

a) Installation of multicore/single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.
b) Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination and testing and commissioning of cables.
c) Concessionaire's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of HDPE pipes for road crossing shall also be included.
d) Supply and installation of necessary cleating arrangement for cabling on flood light poles.
e) Concessionaire shall provide necessary foundation for erecting street light pole/flood light tower and install the same. Concessionaire shall prepare foundation drawings with necessary details to Executing Agency for approval.
f) Concessionaire shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Concessionaire and joint marker shall also be provided at no extra cost.

Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation. Concessionaire shall earth street light pole/flood light poles and junction box with 25 x 3 mm G.S. flat tap off from the 25 x3 mm M.S. flat earthing grid along the street lighting included in the scope. The Concessionaire shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate pole.

Installation of lighting poles & towers for outdoor lighting (Street and flood lighting)

a) Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
b) All street light poles and towers shall be painted with two coats of red oxide oil primer followed by two coats of aluminium alkyd paint.

Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 240 V, AC 1- Phase Distribution Boards

Installation of above items shall include necessary foundation channels, bolts/nuts, etc. for grouting

lighting distribution boards, iron brackets/grouting brackets, bolts/nuts for wall/column mounted panels and associated civil works.

C17.5 Point wiring

8.1.4.3 Wiring

a) conduit wiring shall have provision for easy inspection. Exposed wiring when run along wall shall be as near the ceiling as possible. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.

b) Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.

c) Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires, the following colour wires shall be used.

(i) R - Phase - Red

(ii) Y - Phase - Yellow

(iii) B - Phase - Blue

(iv) Neutral - Black

d) There shall be a circuit breaker or a linked switch on each live conductor of supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in neutral wire in the form of switch or fuse unit.

e) Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.

f) Receptacles and lighting fittings in general shall be fed from different circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.

g) Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.

h) For long conduit wiring runs, inspection/pull boxes shall be provided at intervals not exceeding 10 m. Such facilities shall also be provided at conduit bends.

8.1.4.4 General practices

a) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.

b) Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding

250 volts, a ceiling rose or any similar attachment shall not be used.

c) A socket outlet shall not embody fuse terminals as an integral part of it. The switch controlling the socket outlet shall be on the live side of the line.

d) All exposed metal parts of the plug, when the plug is in complete engagement with the socket

outlet, shall be in effective electrical connection with the earthing pin.

8.1.4.5 Earthing

a) Exposed conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints. In case of concealed wiring 1.5 / 2.5 sq.mm PVC insulated wire inside the conduit shall be used for earthing.

b) Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.

c) For outdoor lighting poles the earthing conductor shall be terminated upto the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting.

Pre-Commissioning checks and commissioning

All checks and tests shall be as per the Manufacturer's drawing manuals, relevant codes of

installation and commissioning check lists as given below:-

a) Among other commissioning tests, the following shall be carried out at site after completion of installation. Concessionaire shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards / International Standards. All tests to be carried out in the presence of Executing Agency.

(i) For Transformers

Dielectric strength of transformer oil. Operation of all protective equipment, voltage/turns ratio at all taps, winding resistance at all taps, vector group test, phase sequence test, buchholz relay operation (alarm and trip), OLTC control indicating and alarm circuits, lightning arrestor installation, test the bushing oil for dielectric strength.

(ii) For Switchgear

Power frequency high voltage test, operation tests.

(iii) For Relays

Check internal wiring, relay settings.

Satisfactory operation over their whole operating range by secondary injection. Check the minimum pick up voltage of D.C. coils, megger all terminals to body and AC to DC terminals.

(iv) Relay and Control Panel

Switch development, check on relays, check on metres, functional checking of all control circuit, e.g. closing, tripping, control, interlock, supervision, and alarm circuits including proper functioning of the component equipment.

(v) Circuit breakers

Manual operation of breakers, power closing/opening operation manually and electrically, breaker closing and tripping time, trip free and antipumping operation, control wiring for correctness of connections, continuity and IR value, electrical and mechanical interlocks, all functional checks on CTS, checks on spring charging motor.

(vi) Battery

Special gravity test, cell voltage check, capacity test as per IS, Initial charging cycle.

(vii) Battery charger & D.C. Distribution Board

Functional check of auxiliary devices such as alarms, indicating etc., measurement of voltage regulation.

(viii) Voltage transformers

Polarity test, ratio test on all cores, oil level and leakages, 'Insulation resistance

test', earthing connection.

(ix) Current Transformer

Megger between windings and winding terminal to body, polarity test, capacitance and tan delta test.

(x) Cables

All new cables shall be tested for its insulation strength before terminating / jointing. After terminating / jointing is completed of all L.V. (i.e. 650/1100V) cable shall be tested by 1000V megger. All H.T. Cables (i.e. 11 KV) shall be tested by 2500 V motor operated megger.

Cable core shall be tested for

- Continuity
- Absence of cross phasing
- Insulation resistance to earth
- Insulation resistance between conductors

(xi) Earthing and Lightning Protection System

The Concessionaire shall ensure the continuity of all conductors and joints. The Executing Agency may ask for earth continuity tests earth resistance measurements and other tests which in his opinion are necessary to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth resistance value should be not greater than one (1) ohm,

(xii) Lighting System

Before putting complete system into service, commissioning tests stipulated in applicable standards and code of practice shall be carried out by the Concessionaire in the presence of the Executing Agency covering all lighting system equipment.

(xiii) The Concessionaire shall carry out insulation resistance tests by megger of following rating:

Control circuits upto 220 V : 500 V megger

Power circuits upto 1.1 KV : 1000 V megger

8.1.4.6 Safety procedure and practice

Following safety procedure and practice should be provided by Concessionaire in switchgear room/sub-station as per latest edition of I.S. 5216.

a) Rubber matting

(i) In front of 11 KV switchgear.

(ii) In front of 415 V switchgear and other panel in switchgear room.

b) Shock treatment charts

(i) One chart near 11 KV switchgear room

(ii) One chart near 415 V switchgear room

c) Caution/Danger Board

(i) 11 KV switchgear

(ii) 11 KV capacitor panel

(iii) 415 V switchgear

(iv) Transformer near H.T. cable box

(v) All power Distribution Board

d) Fire Safety

The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per the statutory norms.

SCHEDULE E: APPLICABLE PERMITS

Indicative list of approval is mentioned below, Concessionaire shall have to make assessment of applicable permits, approvals, clearances:

Applicable Permits

Concessionaire will be responsible for obtaining various permits, authorizations and consents to enable them to carry out their duties. These will include, but not be limited to the following:

b) Licenses to store and use chemicals
c) Licenses to use machinery
d) Waste management licenses
e) Health and Safety certificates
f) Fire certificate
g) Approval from Labour Inspector
h) Approval from District Health Officer
i) Insurance as appropriate
j) Licenses to carryout water operations
k) Right to use Electrical power
l) Abstraction licences from various departments
m) Disposal licenses for sludge

Apart from the licenses and approvals stated above the Concessionaire shall be responsible to procure and maintain all such licenses as may be required from time to time during the execution of the works under this Agreement.

SCHEDULE F:1. CONSTRUCTION PERIOD PERFORMANCE SECURITY

WHEREAS:

A. …… (the "**Concessionaire**") and …… (the "**Authority**") have entered into a Concession Agreement dated ……. (the "**Agreement**") whereby the Authority has agreed to the Concessionaire undertaking the development of……basis (the "**Project**"), subject to and in accordance with the provisions of the Agreement.

B. The Agreement requires the Concessionaire to furnish a Performance Security to the Authority in a sum of Rs……. (Rupees …… crore) (the "**Guarantee Amount**") as security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period (as defined in the Agreement).

C. We,……..through our Branch at.....(the "**Bank**") have agreed to furnish this Bank 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 performance of the concessionaire's obligations during the Construction period, under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon occurrence of any failure or default in due and faithful performance of all or any of the Concessionaire's obligations, under and in accordance with the provisions of the Agreement, on its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Concessionaire, such sum or sums upto 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 Executive Director in the Authority, that the Concessionaire 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 Concessionaire is in default in due and faithful performance of its obligations during the Construction Period under the Agreement and its decision that the Concessionaire is in default shall be final, and binding on the Bank, notwithstanding any differences between the Authority and the Concessionaire, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Concessionaire for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the BankwerethepprincipaldebtorandanychangeintheconstitutionoftheConcessionaireand/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 Concessionaire 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, fulfilment and/or performance of all or any of the obligations of the Concessionaire 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 Concessionaire, 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 Concessionaire 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 fulfilment, compliance and/or performance of all or any of the obligations of the Concessionaire under the Agreement.

7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain inforce in accordance with Article 9 of the Agreement.

8. 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.

9. 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 authorised 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.

10. This guarantee shall also be operational at our branch at _____, from whom, confirmation regarding the issue of this guarantee or extension/renewal thereof shall be made available on demand. In the contingency of this guarantee being invoked and payment thereunder claimed, the said branch shall accept such invocation letter and make payment of amounts so demanded under the said invocation.

11. This Guarantee shall come into force with immediate effect and shall remain in force and

effect for a period of two years from the date hereof 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,SEALEDAND 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 F: 2. OPERATION PERIOD PERFORMANCE SECURITY

WHEREAS:

A. …… (the "**Concessionaire**") and …… (the "**Authority**") have entered into a Concession Agreement dated ……. (the "**Agreement**") whereby the AuthorityhasagreedtotheConcessionaireundertakingthedevelopmentof ……basis(the"**Project**"),subjecttoandinaccordancewiththeprovisionsof the Agreement.

B. The Agreement requires the Concessionaire to furnish a Performance Security to the Authority in a sum of Rs……. (Rupees …… crore) (the "**Guarantee Amount**") as security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period (as defined in the Agreement).

C. We,……..through our Branch at.....(the "**Bank**") have agreed to furnish this Bank Guarantee by way of Performance Security.

NOW,THEREFORE,theBankhereby,unconditionallyandirrevocably,guaranteesand affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due performance of the concessionaire's obligations during the Initial Operation period/Operation Period, under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon occurrence of any failure or default in due and faithful performance of all or any of the Concessionaire's obligations, under and in accordance with the provisions of the Agreement, on its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Concessionaire, 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 Executive Director in the Authority, that the Concessionaire 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 Concessionaire is in default in due and faithful performance of its obligations during the Construction Period under the Agreement and its decision that the Concessionaire is in default shall be final, and binding on the Bank, notwithstanding any differences between the Authority and the Concessionaire, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Concessionaire for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the BankweretheprincipaldebtorandanychangeintheconstitutionoftheConcessionaire 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 Concessionaire 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, fulfilment and/or performance of all or any of the obligations of the Concessionaire contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powersexercisablebytheAuthorityagainsttheConcessionaireandeithertoenforceor 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 Concessionaire 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 fulfilment, compliance and/or performance of all or any of the obligations of the Concessionaire under the Agreement.

7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain inforce in accordance with Article 9 of the Agreement.

8. 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.

9. 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 authorised 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.

10. This guarantee shall also be operational at our branch at _____, from whom, confirmation regarding the issue of this guarantee or extension/renewal thereof shall be made available on demand. In the contingency of this guarantee being invoked and payment thereunder claimed, the said branch shall accept such invocation letter and make payment of amounts so demanded under the said invocation.

11. This Guarantee shall come into force with immediate effect and shall remain in force and

effect for a period of two years from the date hereof 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,SEALEDAND 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 G: deleted

SCHEDULE H: DRAWINGS

1. **Drawings**
   In compliance of the obligations set forth in Article 12.2 of this Agreement, the Concessionaire shall furnish to the Independent Engineer, free of cost, all Drawings listed in this Schedule-H.

2. **Additional drawings**
   If the Independent Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in Para, it may by notice require the Concessionaire to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Concessionaire shall promptly prepare and furnish such drawings to the Independent Engineer, as if such drawings formed of this Schedule-H.

3. **List of Drawings**

   a. Project Area Map

(Schedule-H)

ANNEXURE 1: TABLE OF CONTENTS FOR DETAILED PROJECT REPORT (DPR)

ANNEXURES / APPENDICES:

VOLUME – I - FINAL DETAILED PROJECT REPORT

1. PROJECT BACKGROUND
2. APPROACH AND METHODOLOGY
3. EXISTING SCENARIO
4. SITE INVESTIGATIONS
5. PROPOSED REHABILITAITON MEASURES
6. PROPOSAL SUMMARY
7. CONSTRUCTION METHODOLOGY

VOLUME – II – DRAWINGS

VOLUME – III – FINAL DETAILED PROJECT REPORT ANNEXURE

1. DESIGN
2. INVESTIGATION
3. CONSTRUCTION SCHEDULE

SCHEDULE I: TESTS

1. Schedule of Tests

1.1. The Concessionaire shall, no later than 30 (thirty) days prior to the likely completion of the Project, notify the Independent Engineer and the Authority of its intent to subject the Project to Tests, and no later than 7 (seven) days prior to the actual date of Tests, furnish to the Independent Engineer and the Authority detailed inventory and particulars of all works and equipment forming part of the Project.

1.2. The Concessionaire shall notify the Independent Engineer of its readiness to subject the Project to Tests at any time after 7 (seven) days from the date of such notice, and upon receipt of such notice, the Independent Engineer shall, in consultation with the Concessionaire, 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 Independent Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 14 and this Schedule-I.

2. Tests

2.1. In pursuance of the provisions of Article 14.1.2 of this Agreement, the Independent Engineer shall conduct, or cause to be conducted, the Tests specified in this Paragraph 2.

2.2. Visual and physical Test: The Independent Engineer shall conduct a visual and physical check of the Project to determine that all works and equipment forming part thereof conform to the provisions of this Agreement.

2.3. Asset or Equipment Specific Tests: The Independent Engineer may require the Concessionaire to carry out or cause to be carried additional Tests, in accordance with Good Industry Practice, for determining the compliance of the Project with Specifications and Standards.

3. Agency for conducting Tests

All Tests set forth in this Schedule-I shall be conducted by the Independent Engineer or such other agency or person as it may specify in consultation with the Authority.

4. Completion/Provisional Certificate

Upon successful completion of Tests, the Independent Engineer shall issue the Completion Certificate or the Provisional Certificate, as the case may be, in accordance with the provisions of Article 14.

5. Tests during construction

Without prejudice to the provisions of this Schedule-I, tests during construction shall be conducted In accordance with the provisions of Article 13.3.1.

SCHEDULE J: COMPLETION CERTIFICATE

FORMAT OF COMPLETION CERTIFICATE

1 I/We,…….. (Name of the Independent Engineer), acting as Independent Engineer, under and in accordance with the Concession Agreement dated ……..(the "Agreement"), for _____ on Hybrid Annuity Model Project (the "Project") on design, build, operate and transfer (the "DBFOT Annuity or Hybrid Annuity") basis, through……(Name of Concessionaire), hereby certify that the Tests specified in Article 14 and Schedule of the Agreement have been successfully undertaken to determine compliance of the Project with the provisions of the Agreement, and I/We am/are satisfied that the Project can be safely and reliably placed in commercial service of the Users thereof.

2 It is certified that, in terms of the aforesaid Agreement, all works forming part of the Project have been completed, and the Project is hereby declared fit for entry into commercial operation on this the day of _____

SIGNED, SEALED AND DELIVERED
For and on behalf of
INDEPENDENT ENGINEER by:

(Signature)
(Name)
(Designation)
(Address)

FORMAT OF PROVISIONAL CERTIFICATE

1 I/We,…… (Name of the Independent Engineer), acting as Independent Engineer, under and in accordance with the Concession Agreement Dated…… (the "Agreement"), for development and operation of the _____ on Hybrid Annuity Mode(the "Project") on design, build, operate and transfer (the "DBFOT Annuity or Hybrid Annuity") basis through……(Name of Concessionaire), hereby certify that the Tests specified in Article 14 and Schedule-I of the Agreement have been undertaken for the Project/section…….. of the Project to determine compliance thereof with the provisions of the Agreement.

2 Construction Works forming part of the Project/section of the Project that were found to be incomplete and/or deficient have been specified in the Punch List appended hereto, and the Concessionaire has agreed and accepted that it shall complete and/or rectify all such works in the time and manner set forth in the Agreement. Some of the incomplete works have been delayed as a result of reasons attributable to the Authority or due to Force Majeure and the Provisional Certificate cannot be withheld on this account. Though the remaining incomplete works have been delayed as a result of reasons attributable to the Concessionaire,[1] I/We am/are satisfied that having regard to the nature and extent of such incomplete works, it would not be prudent to withhold commercial operation of the Project/section…….. of the Project, pending completion thereof.

3 In view of the foregoing, I/We am/are satisfied that the Project/section of the Project can be safely and reliably placed in commercial service of the Users thereof, and in terms of the Agreement, the Project/section of the Project is hereby provisionally declared fit for entry into commercial operation on this the …… day of…… 20

ACCEPTED, SIGNED, SEALED
FOR AND ON BEHALF OF
CONCESSIONAIRE by:
(Signature)
(Name and Designation)
(Address)

SIGHNED, SEALED AND DELIVERED DELIVERED
FOR AND ON BEHALF OF
INDEPENDENT ENGINEER by:
(Signature)
(Name and Signature)
(Address)

[1]May be struck out if not applicable. Also strike out other parts which are not applicable.

SCHEDULE K: MAINTENANCE REQUIREMENTS

The Concessionaire shall perform all the obligations under the Agreement with utmost care, effective and efficient and adapt the best practices in all operations and maintenance activities in accordance to the industry standards and in confirmation to the guidelines provided in the Manual on Water Supply and Treatment and the Manual on Operations and Maintenance of Water Supply Schemes published and amended from time to time by CPHEEO, Government of India.

Schedule of Preventive maintenance works to be done during O&M to be furnished as following table: Applicable to the motors, pumps, reduction gears at in individual units such as Alum Plan, Chlorination Plant etc.

Item No.	Description of works	Frequency					
		Daily	Weekly	4 Weekly	8 Weekly	26 Weekly	52 Weekly
1.0	**Check Pump is Operational**						
1.1	Change Over Pumps						
1.2	Pumpout Well						
1.3	Record Hours Run						
1.4	While pump operating check						
1.4.1	Pipe work for leak or vibration						
1.4.2	Oil or Fluid leaks						
1.4.3	Bearing Temperature						
1.5	Check Glands / Seals and Adjust/Repack as required						
1.6.1	Check operation of Air Release Pipes						
1.6.2	Clean cut Air Release Pipes						
1.7	Check lubrication points and Lubricate as required						
1.8	Check non return valves for operation						
1.9	Check Units Security, Fixing Bolts						
1.10	Check all Guards and Operational						

2.0	**While Pump operating check**						
2.0.1	Motor for Noise or Vibration						
2.0.2	Brush Sparking						
2.0.3	Security of Cooling Fan						
2.0.4	Security of Terminal Box						
2.0.5	Security of Computing Guards						
2.1	Stop Motor & Switch Off Isolator						
2.1.1	Suck out Dust and Dirt						
2.1.2	Apply Oil						
2.2	Check Condition of Cabling Conduit and Earth Bonding						
2.3	Check geared motor condition and oil levels						
2.4	Check Belt Pulley and Alignment						
2.5	Check Mechanical Alignment and Clean Dust and Dirt						
3.0	**Inspect and Check the Following**						
3.0.1	All Auxiliary Equipment						
3.0.2	All Terminals						
3.0.3	Panel Enclosures and Installations						
3.1	Carryout all required Tests						
3.1.1	To Earthing / Loops						
3.1.2	Control Transformers						
3.1.3	Power Indicators						
3.1.4	Power Supply Protective Devices						
4.0	**Starters**						

4.1	Check Contacts						
4.2	Check Security of connections						
4.3	Check for Overheating / Deterioration						
4.4	Check Contracts and ArcShields						
4.5	Check operation of Emergency Stopsand Safety Devices						
5.0	**Structureand Exterior Works**						
5.1	Clean ScumFormation						
5.2	Clean Pump Pit, Valve Chambers Available						
5.3	Operate Stop Logs &Grease Equipments						
5.4	Operate Penstocks Fully& Grease						
5.5	Clean out Pump House						
5.6	Clean Windows						
5.7	Operate allvertically Hung Door and Lubricate						
5.8	Sweet and Tidy Upgrounds roofs weed asrequired						

Other Specific maintenance tasks generally to be taken by the Concessionaire in O&M:

WEEKLY:

i) Checking pipeline leakages
ii) Tightening of all electrical connections
iii) Tightening of all cable connections
iv) Temperature difference due to loose connections
v) Watering of earth stations
vi) Operation of all sluice & butterfly valves, scour and pressure relief valves, gates and air valves.
vii) Measurement of current and voltages in all electrical equipments.

MONTHLY:

i) Changing of gland packing
ii) Checking indicators for wearing of parts
iii) Functioning of chlorine equipment
iv) Adoption of energy conservation methods

v) Checking of electrical contacts
vi) Checking of motors with motor checker
vii) Meggering of electrical equipments.

QUARTERLY:

i) Relay testing and calibration of meters, gauges, instruments
ii) Calibration of motor speed
iii) Level gauges and flow

METERS YEARLY:

i) Checking for overhauling of equipment wherever required.
ii) Improvements if required for operation of motors
iii) Testing of all equipments and instruments

Preliminary Treatment area wise:

Preliminary treatment is considered to be the inlet area, the feed channel to the Clariflocculators, prechlorination, Alum dosing and MOL feed. The function of preliminary treatment is to collect the raw water, remove any matter that might be harmful to subsequent treatment processes and passes on to the clariflocculators.

INLET AREA & DISTRIBUTION CHANNELS TASKS:

Tasks	Frequency
Remove trapped floating material & scour	1 time per day
Check dosing lines and dosing points of Cl_2, Alum	1 time / shift
Check Raw Water sampling system and collection and testing	1 time / shift
Check instrumentation	1 time / shift
Check that the distribution to the clarifiers is not impeded 1 time / hour	1 time / shift
Check condition of inlet sluice gates bye-pass stop logs	1 time / shift
Check and record PH turbidity at Raw Water inlet Chamber	1 time / shift
GENERAL	
Check that operation of plant is satisfactory	1 time / shift
Take reading of inflow raw water turbidity, pH level and to be recorded	1 time / shift
Clean all necessary channels, chambers, etc. as not previously specified	1 time / shift
Remove sag from valves, gates stop logs and flow splitting devices, etc.	1 time / day

CLARIFIERS:

In which coagulation takes place to settle down the dissolved solids and suspended solids

Check orifice flow of clarified water and lavender channels	1 time / shift
Clean scour in flocculator zone	1 time / day
Check & clean settled sludge	1 time / shift

SLUDGE BALANCING TANKS:

Remove scour, solids off tank surface	1 time / shift
Clean and flush sludge line	1 time / day

GENERAL:

Check that operation of flocculators scrappers are satisfactorily	1 time / day
Check & fill gear box oil	1 time / day
Grease points (small amount	1 time / month
Clean bridges and hand rail and walkways	1 time / month
Check that operation of agitators are satisfactorily	1 time / hour
Check protective devices, timers & controlling panels	1 time / week
Check M.O.L feed system and points	1 time / day
Check and collect samples for test	1 time / day
Clean and flush MOL fed lines before shifting next to stand by feed line	1 time / day
Take readings of clarified water turbidity PH, RC and record	1 time / hour

Take readings gross run / record	1 time /day
Clean all necessary channels, chambers etc. as not previously specified	1 time / week
Major clean of tank (dropping out)	1 time / year

Note : Emptying of tanks for inspection must be done in conjunction with maintenance staff. It is likely that infrequent tasks of this nature will cause problems remaining action.

Alum Plant : To prepare day to day required strength of Alum solution and the same has to be dated to the Raw water flow in the inlet bay.

TASKS:

Check the required no. of saturators are filled with sufficient water 1 time / shift

Check according to requirement Alum blocks are loaded in the saturator 1 time / shift

Check the performance of Duty Air blower and solution transfer pump 1 time / hour

Check the Alum solution duty Agitator performance 1 time / hour Check the required strength of Alum solution is dosed in the raw water 1 time / hour

Remove foams in the solutions if necessary 1 time / hour

Cleaning of saturators each in 1 cycle and flushing 1 time / week

Cleaning of dilution tanks 1 time / week

Cleaning of constant head tank 1 time / week

GENERAL:

Check / Change of Air Blowers	1 time / shift
Check / Change of Saturators	1 time / shift
Check / Change of Alum Dilution tank	1 time / shift
Check / Change of constant head tank	1 time / shift
Check the operation of plant	1 time / hour
Record the readings of Raw Water inflow	1 time / hour
Turbidity, pH and record	1 time / hour
Check the performance of Instruments	1 time / hour
Check and fill gear box oil	1 time / week
Grease points (small amount	1 time / month
Check condition of valves	1 time / shift
Clean all chambers, pump pit etc. as not previous specified	1 time / week

MILK OF LIME PLANT: To prepare day to day required strength of quick lime solution and the same to be dosed for pH conditioning. The system comprises mechanical transfer of quick like from the store to the crusher by using belt conveyor and Bucket elevator, crushing to size appropriate to the equipment, storing crushed lime, slaking of lime using hot and cold water, de-gritting the milk of lime with dilution and dosing milk of lime through pumps.

TASKS:

Check mechanical transfer system	1 time / hour
Check crushing and storing crushed lime	1 time / hour
Check hot water system	1time/hour
Check slacking system	1 time / hour
Check clarifier and dilution system	1 time / hour
Check dosing MOL system	1 time / hour
Clean stock tank and dosing tanks	1 time / week

Remove grit released from slacker clarifier Hydro clones by 1 time / shift Manual process next of the plant

GENERAL:

Check / Change of duty pumps	1 time / shift
Check the operation of plant	1 time / hour
Check performance of Instruments	1 time / hour
Take readings and record	1 time / hour
Check all fill gear box oil	1 time / week
Grease points (small amount)	1 time / month

Clean all necessary walkways, handrails, pits etc. as not Previously specified 1 time / week

TASK:

Check acid is drawn and pumped with required strength with dilution at the point of application 1 / hour

Check levels and performance of vessels, dosing lines1/ Shift

GENERAL:

Check / Change of duty pumps check and clean the drains, pit etc. as not previously specified 1 / week

SCHEDULE L: Performance standards of treated water

The treated water should meet the performance standards for drinking water standard norms IS 10500:2012 as described below:

S. No.	Parameters	Acceptable limit	Permissible limit
1	Color Hazen units, Max	5	15
2	Odour	Agreeable	Agreeable
3	Taste	Agreeable	Agreeable
4	Turbidity (NTU), Max	1	5
5	pH @25° C	6.5-8.5	6.5 -8.5
6	Total dissolved solids mg/l, Max	500	2000
7	Total hardness (as CaCo3) mg/l, Max	200	600
8	Calcium (as Ca) mg/l, Max	75	200
9	Magnesium (as Mg) mg/l, Max	30	100
10	Chlorides (as Cl) mg/l, Max	250	1000
11	Residual Chlorine (mg/l), Min	0.2	1
12	Ammonia as N (mg/l), Max	0.5	No Relaxation
13	Nitrate as NO3 (mg/l), Max	45	No Relaxation
14	Fluorides (as F) mg/l, Max	1	1.5
15	Sulphate (as SO4) mg/l, Max	200	400
16	Iron (as Fe) mg/l, Max	0.3	No Relaxation
17	Copper (as cu) mg/l, Max	0.05	1.5
18	Manganese (as Mn) mg/l, Max	0.1	0.3
19	Mercury (as Hg)mg/l, Max	0.001	No Relaxation
20	Cadmium (as Cd), mg/l, Max	0.003	No Relaxation
21	Selenium (as Se), mg/l, Max	0.01	No Relaxation
22	Total Arsenic (as As)mg/l, Max	0.01	0.05
23	Cyanide (as CN), mg/1, Max	0.05	No Relaxation
24	Lead (as pb) mg/l, Max	0.01	No Relaxation
25	Zinc (as Zn) mg/l Max	5	15
26	Anionic detergents (as MBAS mg/l, Max	0.2	1
27	Total Chromium (as Cr_{d}+) mg/l, Max	0.05	No Relaxation
28	Polynuclear aromatic hydrocarbons (as PAH) mg/l, Max	0.0001	No Relaxation
29	Aluminum (as Al), mg/l, Max	0.03	0.2
30	Bacteriological Quality (Total Coliforms MPN)	Shall not be detectable in any 100ml of sample	

SCHEDULE M: LIST OF MAKES OF EQUIPMENT

S. No.	Equipment	Makes or Equivalent	ShortForm
1	Pumps	Mather & Platt (I) Ltd Jyoti Ltd BeconWier Ltd WorthingtonIndiaLtd KSB Pumps, Kirloskar Oranyother approvedvendorsby CMWSSB	KBL MP JYOTI BEACON WORTHIN KSB
2	Motors	Kirloskar Electric Co. Ltd New Government Electric Factory Ltd Siemens India Limited Jyoti Ltd Crompton Greaves Ltd Or any other approved vendors by CMWSSB	KEC NGEF SIEMENS JYOTI CGL
3	GateValves	Kirloskar Brothers Ltd Indian Valve Company Upathyaya Valves Manufacturers P Ltd Or any other approved vendors by CMWSSB	KBL IVC UVML
4	Non-returnValves	Kirloskar Brothers Ltd Indian Valve Company Upathyaya Valves Manufacturers Pvt ltd	KBL IVC UVML
5	Sluice Gates	JashEngineering P Ltd The Indian Valve Co. Oriental Castings Bharat Industrial Corporation Hydraulic& General Engineers Or any other approved vendors by CMWSSB	JASH IVC OC BIC SIWL HEG
6	Butterfly Valve	Audco, Kirloskar, IVI, IVC	
7	C I Sluice Valves	Kirloskar, IVI, Fouress,	

8	Differential float control valves	Bermad, Doret, VAG Or any other approved vendors by CMWSSB	
9	Altitude pilot control valves	Bermad, Doret, VAG	
10	Actuator	Marsh L&T Rotork Auma Or any other approved vendors by CMWSSB	MARSH L&T ROTORK AUMA
11	G I Pipes	Tata, Jindal	
12	Ductile Iron Pipe & Fittings and DismantlingJoints	The Indian Iron & Steel Company Ltd Bharat Industrial Corporation Oriental Castings Upadhayay Castings,Calcutta Electric Steel Castings TataIron & SteelCo. Or any other approved vendors by CMWSSB	IISCO BIC OC UCL ESC TISCO
13	Crane	W H Brady & Co. Ltd Hercules Hoists Ltd Delta Engineering Works Sharps Engineering Pvt Ltd Reva Engineering Electrotechnics Avon Cranes Or any other approved vendors by CMWSSB	BRADY INDEF DELTA SHARPS REVA ELECTRO AVON
14	ChainPulley Block	Reva Engineering Hercules Hoists Ltd WHBrady &Co.Ltd Or any other approved vendors by CMWSSB	REVA INDEF BRADY
15	SumpPumpSet	Kirloskar Brothers Ltd SU Motors Pvt Ltd Jyoti Ltd Flight Or any other approved vendors by CMWSSB	KBL SU JYOTI

16	DewateringPump Set	KirloskarBrothers Ltd ModiIndustries(FC)PvtLtd SU Motors Pvt Ltd KishorePumps KSB Pumps Or any other approved vendors by CMWSSB	KBL MIPL SU KPL KSB
17	415 V Switchgear Control Gear components / Bus Duct	Larsen & Toubro Ltd Siemens India Limited Voltas Ltd English Electric Ltd Jyoti Ltd Control and Switchgear Bhartia Cutler Hammer Electrical Control Gear Ltd ASPL Or any other approved vendors by CMWSSB	L&T SIEMENSVOLTS EEL JYOTI C&S BCH ELCON ASPL
18	Power Transformer	Bharat Bijlee Ltd New Government Electric Factory Ltd Kirloskar Electric Co.Ltd VOLTAMP Or any other approved vendors by by CMWSSB	BBL NGEF KEC VOLTAMP
19	Motors contactors	Bhartia CutlerHammer Larsen &Tubro Ltd Siemens GEPower Or any other approved vendors by CMWSSB	BCH L&T SIEMENS GE
20	11 KV/ 3.3 KV Switchgear	JyotiLtd New Government Electric Factory Ltd Siemens India Limited Asian Brown Boveri ALSTOM Kirloskar Electric Ltd Bharat Heavy Electricals Ltd Crompton Greaves VOLTAS Ltd Or any other approved vendors by CMWSSB	JYOTI NGEF SIEMENS ABB ALSTOM KIRLOSKAR BHEL CGL VOLTAS

21	Cables	IndianCables Ltd FortGlosterIndustriesLtd Cable Corpn. Of India Universal Cables IndianCableCo. AsianCablesCorporationLtd Gemscab FinolerxCablesLtd Delton Cables Polycab Oranyother approvedvendorsby CMWSSB	ICL FGI CCI UNISTAR ICCASIAN GEMSCAB FCL DELTON
22	Instruments & Control Cables	Asian Cable Corporation Delton Cables LAPP Finolex Thermopads Udey Pyro Cables TCL cables, Elkay telelinks,	
23	OpticFibre Cables	Delink Cords RRCale Icon Akash Oranyother approvedvendorsby CMWSSB	DELINK CORDS RR ICON AKSH
24	Level Transmitters	M/s EMERSON M/s ABB, M/s Siemens M/s Endress+Hauser M/s Yokogawa	EMERSON ABB, Siemens Endress+Hauser Yokogawa
25	Flow meters/Flow Indicator/ Transmitter (Electromagnetic flow meter	M/s ABB M/s Siemens M/s Yokogawa M/s Endress+Hauser M/s Krohne Marshall	
26	Level/Float Switches	M/s EMERSON M/s ABB M/s SBEM M/s Endress+Hauser M/s Pune Techtrol	
27	Pressure Switches	M/S Warree M/S ABB, M/s Wika M/s Gen Inst Co	Warree ABB, Wika Gen Inst Co

		M/s Switzer M/s Danfoss	Switzer Danfoss
28	Pressure Gauges	WAREE, WIKA, AN Instruments, Guru, Hitek, Electronet	
29	Pressure Indicator Transmitter	M/s EMERSON M/s ABB, M/s Siemens M/s Endress+Hauser M/s Wika	
30	pH/Turbidity/Online Residual Chlorine Analyzer	M/s Hach Company M/s Yokogawa M/s EMERSON M/s WTW	
31	Ultrasonic Type Level Measurement Device	Endress+Hauser / Krohne Marshall / Hycontrol UK, Electronet/ EIP Enviro Level Controls Pvt. Ltd./ SBEM Pvt.Ltd.	
32	Surge Protection Devices / Lightning Protection Units	M/s Hensel M/s Phoenix M/s Crompton Greaves M/s MTL Instruments M/s Pepper & Fuchs M/s Cirprotec M/s MH Instruments	
33	Flow Indicator and Totalizer, Alarm Annunciators	M/s Masibus M/s Alan M/s Omron M/s NISHKO	
34	Workstations, Servers	Dell, HP, Lenovo	
35	Programmable Logic Controllers	Siemens, Phoenix contact, Honywell, Schneider,	

		confirming to IP-20 with ambient operational temperature 55oC.	
36	Analog Signal Multiplier	MASIBUS, Sai Tech, MTL INSTS, NISHKO	
37	SCADA Programming Software	Siemens, Phoenix contact, Honywell, Schneider, confirming to IP-20 with ambient operational temperature 55oC	
38	Control Panels / Enclosures	Rittal, Pyrotech, Hoffmann	
39	VFD	Siemens, L&T, ABB, Schneider, Danfoss	
40	Mechanical Water Meter with pulse out put	Siemens Building Technologies DWYER INSTRUMENTS EnviroTechAlrams Ltd.	
41	AMR Water Meter	Xylem india IXOM Water care Zenner Water Meters · Toshniwal Water Meters Baylon DEIHL	
42	Billing Software	Xylem india Webnox Technologies PYRUMAS	
43	Diesel Generators	Kohler, caterpillar, Cumins, Jackson,	

SCHEDULE N:

DELETED

SCHEDULE O: ENVIRONMENTAL & SOCIAL SCREENING

DELETED

SCHEDULE P: ENVIRONMENT SOCIAL HEALTH & SAFETY (ESHS) REQUIREMENTS

DELETED

SCHEDULE Q: SAFETY REQUIREMENTS

1. Guiding principles

1.1. Safety Requirements aim at reduction in injuries, loss of life and damage to the properties resulting from accidents on the Project, irrespective of the person(s) at fault.

1.2. Safety Requirements apply to all phases of construction, operation and maintenance with emphasis on identification of factors associated with accidents, consideration of the same, and implementation of appropriate remedial measures.

2. Obligations of the Concessionaire

The Concessionaire shall abide by the following as they relate to safety of the Users:

a) Applicable Laws and Applicable Permits;

b) Manual for Water Supply and Treatment, issued by CPHEEO;

c) relevant Technical Specification;

d) provisions of this Agreement; and

e) Good Industry Practice.

f) Appoint a safety officer to ensure all the safety measures are implemented by the concessionaire.

SCHEDULE R: INDEPENDENT ENGINEER

1. Selection of Independent Engineer

1.1. The Authority shall appoint a consulting engineering firm substantially in accordance with the selection criteria set forth in the Tamil Nadu Transparency in Tenders Act, 1998 and read with the Tamil Nadu Transparency in Tenders (Public Private Partnership Procurement) Rules, 2012 and any amendments thereof to be the independent consultant under this Agreement (the "Independent Engineer"). The appointment shall be made no later than 60 (sixty) days from the Effective Date and shall initially be for a period until the end of the Defects Liability Period.

1.2. In the event of termination of an Independent Engineer appointed in accordance with the provisions of Paragraph 1.1, the Authority shall appoint another firm of Technical Consultants forthwith or may engage a government-owned entity in accordance with the provisions of Paragraph 5 of this Schedule-R.

1.3. The Concessionaire may, in its discretion, nominate a representative to participate in the process of selection to be undertaken by the Authority under this Schedule-R.

2. Terms of Reference

The Terms of Reference for the Independent Engineer shall substantially conform to Schedule-S.

3. Fee and expenses

3.1. In determining the nature and quantum of duties and services to be performed by the Independent Engineer during the Development Period and Construction Period, the Authority shall endeavour that payments to the Independent Engineer on account of fee and expenses do not exceed 1% (three per cent) of the Bid Project Cost. Payments not exceeding such 1% (one cent) shall be borne equally by the Authority and the Concessionaire in accordance with the provisions of this Agreement and any payments in excess thereof shall be borne entirely by the Authority.

3.2. The nature and quantum of duties and services to be performed by the Independent Engineer during the Operation Period shall be determined by the Authority in conformity with the provisions of this Agreement and with due regard for economy in expenditure. All payments made to the Independent Engineer on account of fee and expenses during the Operation Period shall be borne equally by the Authority and the Concessionaire.

4. Deleted

5. Appointment of government entity as Independent Engineer

Notwithstanding anything to the contrary contained in this Schedule, the Authority may in its discretion appoint a government-owned entity as the Independent Engineer; provided that such entity shall be a body corporate having as one of its primary function 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 Authority shall not be eligible for appointment as Independent Engineer.

SCHEDULE S: TERMS OF REFERENCE FOR INDEPENDENT ENGINEER

1. Scope

These Terms of Reference for the Independent Engineer (the "TOR") are being specified pursuant to the Concession Agreement dated (the "Agreement"), which has been entered into between the Authority and the "Concessionaire") for _____on HAM mode in the state of Tamil Nadu on design, build, operate and transfer (the "DBFOT Annuity or Hybrid Annuity") basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

2. Definitions and interpretation

1.1 The words and expressions beginning with or in capital letters used in this TOR 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.

1.2 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.

1.1. 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. Role and functions of Independent Engineer

3.1. The role and functions of the Independent Engineer shall include the following:

i. review of the detailed Drawings, DPR and other documents as set forth in Paragraph 4;

ii. Review, inspection and monitoring of Construction Works as set forth in Paragraph 5; conducting Tests on completion of construction and issuing Completion/ Provisional Certificate as set forth in Paragraph 5

iii. Deleted;

iv. Deleted;

v. determining, as required under the Agreement, the costs of any works or services and/or their reasonableness during and until the end of Defects Liability Period;

vi. determining, as required under the Agreement, the period or any extension thereof, for performing any duty or obligation until the end of Defects Liability Period;

vii. Assisting the Parties in resolution of Disputes as set forth in Paragraph 9; and

viii. Undertaking all other duties and functions in accordance with the Agreement.

4. Development Period

4.1. During the Development Period, the Independent Engineer shall undertake a detailed review of the detailed Drawings and DPR to be furnished by the Concessionaire along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials

from borrow areas and quarry sites, topographical surveys and traffic surveys. The Independent Engineer shall complete such review and send its comments/ observations to the Authority and the Concessionaire within 15 (fifteen) days of receipt of such Drawings and DPR. In particular, such comments shall specify the conformity or otherwise of such Drawings and DPR with the Scope of the Project and Specifications and Standards.

4.2. The Independent Engineer shall review any modified Drawings and DPR or supporting Documents sent to it by the Concessionaire and furnish its comments within 7 (seven) days of receiving such Drawings or DPR.

4.3. The Independent Engineer shall review the detailed Drawings and DPR comprising construction methodology, quality assurance procedures and the procurement, engineering and construction time schedule sent to it by the Concessionaire and furnish its comments within 15 (fifteen) days of receipt thereof.

4.4. Upon reference by the Authority, the Independent Engineer shall review and; comment on the EPC Contract or any other contract for construction, operation and maintenance of the Project, and furnish its comments within 7 (seven) days from receipt of such reference from the Authority.

5. Construction Period

5.1. In respect of the detailed Drawings and DPR received by the Independent Engineer for its review and comments during the Construction Period, the provisions of Paragraph 4 shall apply, mutatis mutandis.

5.2. The Independent Engineer shall review the monthly progress report furnished by the Concessionaire and send its comments thereon to the Authority and the Concessionaire within 7 (seven) days of receipt of such report

5.3. The Independent Engineer shall inspect the Construction Works and the Project once every month, preferably after receipt of the monthly progress report from the Concessionaire, but before the 20th (twentieth) day of each month in any case, and make out a report of such inspection (the "Inspection Report") setting forth an overview of the status, progress, quality and safety of construction, including the work methodology adopted, the materials used and their sources, and conformity of Construction Works with the Scope of the Project and the Specifications and Standards. In a separate section of the Inspection Report, the Independent Engineer shall describe in reasonable detail the lapses, defects or deficiencies observed by it in the construction of the Project. The Inspection Report shall also contain a review of the maintenance of the existing lanes in conformity with the provisions of the Agreement. The Independent Engineer shall send a copy of its Inspection Report to the Authority and the Concessionaire within 7 (seven) days of the inspection.

5.4. The Independent Engineer may inspect the Project more than once in a month if any lapses, defects or deficiencies require such inspections.

5.5. For determining that the Construction Works conform to Specifications and Standards, the Independent Engineer shall require the Concessionaire to carry out, or cause to be carried out, tests on a sample basis, to be specified by the Independent Engineer in accordance with Good

Industry Practice for quality assurance. The Independent Engineer shall issue necessary directions to the Concessionaire for ensuring that the tests are conducted in a fair and efficient manner, and shall monitor and review the results thereof.

5.6. The sample size of the tests, to be specified by the Independent Engineer under Paragraph 5.5, shall comprise 10% (ten per cent) of the quantity or number of tests prescribed for each category or type of tests in the Quality Control Manuals; provided that the Independent Engineer may, for reasons to be recorded in writing, increase the aforesaid sample size by up to 10% (ten per cent) for certain categories or types of tests.

5.7. The timing of tests referred to in Paragraph 5.5, and the criteria for acceptance/ rejection of their results shall be determined by the Independent Engineer in accordance with the Quality Control Manuals. 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 Concessionaire for its own quality assurance in accordance with Good Industry Practice.

5.8. In the event that the Concessionaire carries out any remedial works for removal or rectification of any defects or deficiencies, the Independent Engineer shall require the Concessionaire to carry out, or cause to be carried out, tests to determine that such remedial works have brought the Construction Works into conformity with the Specifications and Standards, and the provisions of this Paragraph 5 shall apply to such tests

5.9. In the event that the Concessionaire fails to achieve any of the Project Milestones, the Independent Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the Independent Engineer shall determine that completion of the Project is not feasible within the time specified in the Agreement, it shall require the Concessionaire to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which COD shall be achieved. Upon receipt of a report from the Concessionaire, the Independent Engineer shall review the same and send its comments to the Authority and the Concessionaire forthwith.

5.10. If at any time during the Construction Period, the Independent Engineer determines that the Concessionaire has not made adequate arrangements for the safety of workers and Users in the zone of construction or that any work is being carried out in a manner that threatens the safety of the workers and the Users, it shall make a recommendation to the Authority forthwith, identifying the whole or part of the Construction Works that should be suspended for ensuring safety in respect thereof .

5.11. In the event that the Concessionaire carries out any remedial measures to secure the safety of suspended works and Users, it may, by notice in writing, require the Independent Engineer to inspect such works, and within 3 (three) days of receiving such notice, the Independent Engineer shall inspect the suspended works and make a report to the Authority forthwith, recommending whether or not such suspension may be revoked by the Authority.

5.12. If suspension of Construction Works is for reasons not attributable to the Concessionaire, the Independent Engineer shall determine the extension of dates set forth in the Project Completion Schedule, to which the Concessionaire is reasonably entitled, and shall notify the Authority and the Concessionaire of the same.

5.13. The Independent Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-I and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 5.13 and all matters incidental thereto, the Independent Engineer shall act under and in accordance with the provisions of Article 14 and Schedule-I.

5.14. Upon reference from the Authority, the Independent Engineer shall make a fair and reasonable assessment of the costs of providing information, works and services as set forth in Article 16 and certify the reasonableness of such costs for payment by the Authority to the Concessionaire

5.15. The Independent Engineer shall aid and advise the Concessionaire in preparing the Operation and Maintenance Manual

5.16. Upon reference from the Authority, the Independent Engineer shall undertake the assessment of cost of civil works, as per applicable schedule of rates, for the reduction of Scope of work as provided in Article 16.6.1 of the Concession Agreement.

6. Deleted

7. Termination

7.1. At any time during the tenure of Independent Engineer (until Defects Liability Period), not earlier than 90 (ninety) days prior to Termination but not later than 15 (fifteen) days prior to such Termination, the Independent Engineer shall, in the presence of a representative of the Concessionaire, inspect the Project for determining compliance by the Concessionaire with the Divestment Requirements set forth in Article32.1 and, if required, cause tests to be carried out at the Concessionaire's cost for determining such compliance. If the Independent Engineer determines that the status of the Project is such that its repair and rectification would require a larger amount than the sum set forth in Article 33.2, it shall recommend retention of the required amount in the Escrow Account and the period of retention thereof.

7.2. The Independent Engineer shall inspect the Project once in every 15 (fifteen) days during a period of 90 (ninety) days after Termination (in the event of Termination of the Agreement prior to end of Defects Liability Period) for determining the liability of the Concessionaire under Article 33, in respect of the defects or deficiencies specified therein. If any such defect or deficiency is found by the Independent Engineer, it shall make a report in reasonable detail and send it forthwith to the Authority and the Concessionaire.

8. Determination of costs and time

8.1. The Independent Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.

8.2. The Independent Engineer shall determine the period, or any extension thereof, that is required to be determined by it under the Agreement.

9. Assistance in Dispute resolution

9.1. When called upon by either Party in the event of any Dispute, the Independent Engineer shall mediate and assist the Parties in arriving at an amicable settlement.

9.2. 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 Independent Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

10. Other duties and functions

The Independent Engineer shall perform all other duties and functions specified in the Agreement.

11. Miscellaneous

11.1. The Independent Engineer shall notify its programmer of inspection to the Authority and to the Concessionaire, who may, in their discretion, depute their respective representatives to be present during the inspection.

11.2. A copy of all communications, comments, instructions, Drawings or Documents sent by the Independent Engineer to the Concessionaire pursuant to this TOR, and a copy of all the test results with comments of the Independent Engineer thereon shall be furnished by the Independent Engineer to the Authority forthwith.

11.3. The Independent Engineer shall obtain, and the Concessionaire shall furnish in 2 (two) ……. Copies thereof, all communications and reports required to be submitted, under this Agreement, by the Concessionaire to the Independent Engineer, whereupon the Independent Engineer shall send 1 (one) of the copies to the Authority along with its comments thereon.

11.4. The Independent 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

11.5. Upon completion of its assignment hereunder, the Independent Engineer shall duly classify and list all Drawings, Documents, results of tests and other relevant records, and hand them over to the Authority or such other person as the Authority may specify, and obtain written receipt thereof. Two copies of the said documents shall also be furnished in their editable digital format or in such other medium or manner as may be acceptable to the Authority.

11.6. Wherever no period has been specified for delivery of services by the Independent Engineer, the Independent Engineer shall act with the efficiency and urgency necessary for discharging its functions in accordance with Good Industry Practice.

SCHEDULE T: ESCROW AGREEMENT

THIS ESCROW AGREEMENT is entered into on this the day of 20__ AMONGST

1. ……..Limited, a company incorporated under the provisions of the Companies Act, 2013 and having its registered office at…….. (hereinafter referred to as the "Concessionaire" which expression shall, unless repugnant to the context or meaning thereof, include its successors, permitted assigns and substitutes);

2. ……(insert name and particulars of Lenders' Representative) and having its registered office at…… acting for and on behalf of the Senior Lenders as their duly authorized agent with regard to matters arising out of or in relation to this Agreement (hereinafter referred to as the "Lenders' Representative" which expression shall, unless repugnant to the context or meaning thereof, include its successors and substitutes);

3. ……..(insert name and particulars of the Escrow Bank) and having its registered office at…….. (hereinafter referred to as the "Escrow Bank" which expression shall, unless repugnant to the context or meaning thereof, include its successors and substitutes); and

4. The _____, established under the _____, represented by its _____ and having its principal offices at _____ (hereinafter referred to as the "Authority" which expression shall, unless repugnant to the context or meaning thereof, include its administrators, successors and assigns).

WHEREAS:

A. The Authority has entered into a Concession Agreement dated_____ with the Concessionaire (the "Concession Agreement") for the _____ on HAM mode in the state of Tamil Nadu. Project (the "Project") on design, build, operate and transfer (the "DBFOT Annuity or Hybrid Annuity") basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this Agreement.

B. Senior Lenders have agreed to finance the Project in accordance with the terms and conditions set forth in the Financing Agreements.

C. The Concession Agreement requires the Concessionaire to establish an Escrow Account, inter alia, on the terms and conditions stated therein.

NOW, THEREFORE, in consideration of the foregoing and the respective covenants and agreements set forth in this Agreement, the receipt and sufficiency of which is hereby acknowledged, and intending to be legally bound hereby, the Parties agree as follows:

1. DEFINITIONS AND INTERPRETATION

1.1. Definitions

In this Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"Agreement" means this Escrow Agreement and any amendment thereto made in accordance with the provisions contained herein;

"Concession Agreement" means the Concession Agreement referred to in Recital (A) above and annexed hereto as Annex-A, and shall include all of its Recitals and Schedules and any amendments made thereto in accordance with the provisions contained in this behalf therein;

"Cure Period" means the period specified in this Agreement for curing any breach or default of any provision of this Agreement by the Concessionaire, and shall commence from the date on which a notice is delivered by the Authority or the Lenders' Representative, as the case may be, to the Concessionaire asking the latter to cure the breach or default specified in such notice;

"Escrow Account" means an escrow account established in terms of and under this Agreement, and shall include the Sub-Accounts;

"Escrow Default" shall have the meaning ascribed thereto in Article 31.1.1;

"Lenders' Representative" means the person referred to as the Lenders' Representative in the foregoing Recitals;

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the Parties to this Agreement individually;

"Payment Date" means, in relation to any payment specified in Clause 4.1, the date(s) specified for such payment; and

"Sub-Accounts" means the respective sub-accounts of the Escrow Account, into which the monies specified in Clause 4.1 would be credited every month and paid out if due, and if not due in a month then appropriated proportionately in such month and retained in the respective sub-accounts and paid out therefrom on the Payment Date(s).

1.2. Interpretation

1.2.1. References to Lenders' Representative shall, unless repugnant to the context or meaning thereof, mean references to the Lenders' Representative, acting for and on behalf of Senior Lenders.

1.2.2. The words and expressions beginning with capital letters and defined in this Agreement shall have the meaning ascribed thereto herein, and the words and expressions used in this Agreement and not defined herein but defined in the Concession Agreement shall, unless repugnant to the context, have the meaning ascribed thereto in the Concession Agreement.

1.2.3. References to Clauses are, unless stated otherwise, references to Clauses of this Agreement.

1.2.4. The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Concession Agreement shall apply, mutatis mutandis, to this Agreement.

2. ESCROW ACCOUNT

2.1. Escrow Bank to act as trustee

2.1.1. The Concessionaire hereby appoints the Escrow Bank to act as trustee for the Authority, the Lenders' Representative and the Concessionaire in connection herewith and authorizes the Escrow Bank to exercise such rights, powers, authorities and discretion as are specifically delegated to the Escrow Bank by the terms hereof together with all such rights, powers,

authorities and discretion as are reasonably incidental hereto, and the Escrow Bank accepts such appointment pursuant to the terms hereof.

2.1.2. The Concessionaire hereby declares that all rights, title and interest in and to the Escrow Account shall be vested in the Escrow Bank and held in trust for the Authority, the Lenders' Representative and the Concessionaire, and applied in accordance with the terms of this Agreement. No person other than the Authority, the Lenders' Representative and the Concessionaire shall have any rights hereunder as the beneficiaries of or as third party beneficiaries under this Agreement.

2.2. Acceptance of Escrow Bank

The Escrow Bank hereby agrees to act as such and to accept all payments and other amounts to be delivered to and held by the Escrow Bank pursuant to the provisions of this Agreement. The Escrow Bank shall hold and safeguard the Escrow Account during the term of this Agreement and shall treat the amount in the Escrow Account as monies deposited by the Concessionaire, Senior Lenders or the Authority with the Escrow Bank. In performing its functions and duties under this Agreement, the Escrow Bank shall act in trust for the benefit of, and as agent for, the Authority, the Lenders' Representative and the Concessionaire or their nominees, successors or assigns, in accordance with the provisions of this Agreement.

2.3. Establishment and operation of Escrow Account

2.3.1. Within 30 (thirty) days from the date of this Agreement, and in any case prior to the Appointed Date, the Concessionaire shall open and establish the Escrow Account with the (name of Branch) Branch of the Escrow Bank. The Escrow Account shall be denominated in Rupees.

2.3.2. The Escrow Bank shall maintain the Escrow Account in accordance with the terms of this Agreement and its usual practices and applicable regulations, and pay the maximum rate of interest payable to similar customers on the balance in the said account from time to time.

2.3.3. The Escrow Bank and the Concessionaire shall, after consultation with the Lenders' Representative, agree on the detailed mandates, terms and conditions, and operating procedures for the Escrow Account, but in the event of any conflict or inconsistency between this Agreement and such mandates, terms and conditions, or procedures, this Agreement shall prevail.

2.4. Escrow Bank's fee The Escrow Bank shall be entitled to receive its fee and expenses in an amount, and at such times, as may be agreed between the Escrow Bank and the Concessionaire. For the avoidance of doubt, such fee and expenses shall form part of the O&M Expenses and shall be appropriated from the Escrow Account in accordance with Clause 4.1.

2.5. Rights of the Parties Save and except as otherwise provided in the Concession Agreement, the rights of the Authority, the Lenders' Representative and the Concessionaire in the monies held in the Escrow Account are set forth in their entirety in this Agreement and the Authority, the Lenders' Representative and the Concessionaire shall have no other rights against or to the monies in the Escrow Account.

2.6. Substitution of the Concessionaire The Parties hereto acknowledge and agree that upon substitution of the Concessionaire with the Nominated Company, pursuant to the Substitution

Agreement, it shall be deemed for the purposes of this Agreement that the Nominated Company is a Party hereto and the Nominated Company shall accordingly be deemed to have succeeded to the rights and obligations of the Concessionaire under this Agreement on and with effect from the date of substitution of the Concessionaire with the Nominated Company.

3. DEPOSITS INTO ESCROW ACCOUNT

3.1. Deposits by the Concessionaire

3.1.1. The Concessionaire agrees and undertakes that it shall deposit into and/or credit the Escrow Account with:

a. All monies received in relation to the Project from any source, including the Senior Lenders, lenders of Subordinated Debt and the Authority;

b. All funds received by the Concessionaire from its shareholders, in any manner or form;

c. Any other revenues; rentals, deposits or capital receipts, as the case may be, from or in respect of the Project; and

d. All proceeds received pursuant to any insurance claims

3.1.2. The Concessionaire may at any time make deposits of its other funds into the Escrow Account, provided that the provisions of this Agreement shall apply to such deposits.

3.2. Deposits by the Authority

3.2.1. The Authority agrees and undertakes that, as and when due and payable, it shall deposit into and/or credit the Escrow Account with:

a. Grant and any other monies disbursed by the Authority to the Concessionaire;

b. All revenues collected by the Authority in exercise of its rights under the Concession Agreement; and

c. Termination Payments

Provided that, notwithstanding the provisions of Clause 4.1.1, the Authority shall be entitled to appropriate from the aforesaid amounts, any amounts due and payable to it by the Concessionaire, and the balance remaining shall be deposited into the Escrow Account.

3.3. Deposits by Senior Lenders

The Lenders' Representative agrees, confirms and undertakes that the Senior Lenders shall deposit into and/or credit the Escrow Account with all disbursements made by them in relation to or in respect of the Project; provided that notwithstanding anything to the contrary contained in this Agreement, the Senior Lenders shall be entitled to make direct payments to the EPC Concessionaire under and in accordance with the express provisions contained in this behalf in the Financing Agreements.

3.4. Interest on deposits

The Escrow Bank agrees and undertakes that all interest accruing on the balances of the Escrow Account shall be credited to the Escrow Account; provided that the Escrow Bank shall be

entitled to appropriate therefrom the fee and expenses due to it from the Concessionaire in relation to the Escrow Account and credit the balance remaining to the Escrow Account.

4. WITHDRAWALS FROM ESCROW ACCOUNT

4.1. Withdrawals during Concession Period

4.1.1. At the beginning of every month, or at such shorter intervals as the Lenders' Representative and the Concessionaire may by written instructions determine, the Escrow Bank shall withdraw amounts from the Escrow Account and appropriate them in the following order by depositing such amounts in the relevant Sub-Accounts for making due payments, and if such payments are not due in any month, then retain such monies in such Sub-Accounts and pay out therefrom on the Payment Date(s):

a. All taxes due and payable by the Concessionaire for and in respect of the Project;

b. Deleted;

c. All payments relating to construction of Additional Project Facilities, subject to and in accordance with the conditions, if any, set forth in the Financing Agreements;

d. O&M Expenses, subject to the ceiling, if any, set forth in the Financing Agreements;

e. O&M Expenses and other costs and expenses incurred by the Authority in accordance with the provisions of the Concession Agreement, and certified by the Authority as due and payable to it;

f. Any amounts due and payable to the Authority;

g. Monthly proportionate provision of Debt Service due in an Accounting Year;

h. all payments and Damages certified by the Authority as due and payable to it by the Concessionaire pursuant to the Concession Agreement;

i. Monthly proportionate provision of debt service payments due in an Accounting Year in respect of Subordinated Debt;

j. any reserve requirements set forth in the Financing Agreements; and

k. Balance, if any, in accordance with the instructions of the Concessionaire and the Authority.

4.1.2. No later than 60 (sixty) days prior to the commencement of each Accounting Year, the Concessionaire shall provide to the Escrow Bank, with prior written approval of the Lenders' Representative, details of the amounts likely to be required for each of the payment obligations set forth in this Clause 4.1; provided that such amounts may be subsequently modified, with prior written approval of the Lenders' Representative, if fresh information received during the course of the year makes such modification necessary.

4.2. Withdrawals upon Termination upon Termination of the Concession Agreement, all amounts standing to the credit of the Escrow Account shall, notwithstanding anything in this Agreement, be appropriated and dealt with in the following order:

a. All taxes due and payable by the Concessionaire for and in respect of the Project;

b. Deleted;

c. amount of the Debt Due approved by the Authority as part of the Termination Payment, excluding Subordinated Debt;

d. all payments and Damages certified by the Authority as due and payable to it by the Concessionaire pursuant to the Concession Agreement, including any claims in connection with or arising out of Termination;

e. Retention and payments arising out of, or in relation to, liability for defects and deficiencies set forth in Article 33 of the Concession Agreement;

f. Outstanding Debt Service including the balance of Debt Due;

g. Outstanding Subordinated Debt;

h. Incurred or accrued O&M Expenses;

i. Any other payments required to be made under the Concession Agreement; and

j. Balance, if any, in accordance with the instructions of the Concessionaire and the Authority:

Provided that the disbursements specified in Sub-clause (i) of this Clause 4.2 shall be undertaken only after the Vesting Certificate has been issued by the Authority.

4.3. Application of insufficient funds:

Funds in the Escrow Account shall be applied in the serial order of priority set forth in Clauses 4.1 and 4.2, as the case may be. If the funds available are not sufficient to meet all the requirements, the Escrow Bank shall apply such funds in the serial order of priority until exhaustion thereof.

4.4. Application of insurance proceeds

Notwithstanding anything in this Agreement, the proceeds from all insurance claims, except life and injury, shall be deposited into and/or credited to the Escrow Account and utilized for any necessary repair, reconstruction, reinstatement, replacement, improvement, delivery or installation of the Project, and the balance remaining, if any, shall be applied in accordance with the provisions contained in this behalf in the Financing Agreements.

4.5. Withdrawals during Suspension

Notwithstanding anything to the contrary contained in this Agreement, the Authority may exercise all or any of the rights of the Concessionaire during the period of Suspension under Article 30 of the Concession Agreement. Any instructions given by the Authority to the Escrow Bank during such period shall be complied with as if such instructions were given by the Concessionaire under this Agreement and all actions of the Authority hereunder shall be deemed to have been taken for and on behalf of the Concessionaire.

5. OBLIGATIONSOF THE ESCROW BANK

5.1. Segregation of funds

Monies and other property received by the Escrow Bank under this Agreement shall, until used or applied in accordance with this Agreement, be held by the Escrow Bank in trust for the purposes for which they were received, and shall be segregated from other funds and property of the Escrow Bank.

5.2. Notification of balances

7 (Seven) business days prior to each Payment Date (and for this purpose the Escrow Bank shall be entitled to rely on an affirmation by the Concessionaire and/or the Lenders' Representative as to the relevant Payment Dates), the Escrow Bank shall notify the Lenders' Representative of the balances in the Escrow Account and Sub-Accounts as at the close of business on the immediately preceding business day.

5.3. Communications and notices

In discharge of its duties and obligations hereunder, the Escrow Bank:

a. May, in the absence of bad faith or gross negligence on its part, rely as to any matters of fact which might reasonably be expected to be within the knowledge of the Concessionaire upon a certificate signed by or on behalf of the Concessionaire;

b. may, in the absence of bad faith or gross negligence on its part, rely upon the authenticity of any communication or document believed by it to be authentic;

c. shall, within 5 (five) business days after receipt, deliver a copy to the Lenders' Representative of any notice or document received by it in its capacity as the Escrow Bank from the Concessionaire or any other person hereunder or in connection herewith; and

d. shall, within 5 (five) business days after receipt, deliver a copy to the Concessionaire of any notice or document received by it from the Lenders' Representative in connection herewith.

5.4. No set off

The Escrow Bank agrees not to claim or exercise any right of set off, banker's lien or other right or remedy with respect to amounts standing to the credit of the Escrow Account. For the avoidance of doubt, it is hereby acknowledged and agreed by the Escrow Bank that the monies and properties held by the Escrow Bank in the Escrow Account shall not be considered as part of the assets of the Escrow Bank and being trust property, shall in the case of bankruptcy or liquidation of the Escrow Bank, be wholly excluded from the assets of the Escrow Bank in such bankruptcy or liquidation.

5.5. Regulatory approvals

The Escrow Bank shall use its best efforts to procure, and thereafter maintain and comply with, all regulatory approvals required for it to establish and operate the Escrow Account. The Escrow Bank represents and warrants that it is not aware of any reason why such regulatory approvals

will not ordinarily be granted to the Escrow Bank.

6. ESCROW DEFAULT

6.1. Escrow Default

6.1.1. Following events shall constitute an event of default by the Concessionaire (an "Escrow Default") unless such event of default has occurred as a result of Force Majeure or any act or omission of the Authority or the Lenders' Representative:

a. the Concessionaire commits breach of this Agreement by failing to deposit any receipts into the Escrow Account as provided herein and fails to cure such breach by depositing the same into the Escrow Account within a Cure Period of 5 (five) business days;

b. the Concessionaire causes the Escrow Bank to transfer funds to any account of the Concessionaire in breach of the terms of this Agreement and fails to cure such breach by depositing the relevant funds into the Escrow Account or any SubAccount in which such transfer should have been made, within a Cure Period of 5 (five) business days; or

c. the Concessionaire commits or causes any other breach of the provisions of this Agreement and fails to cure the same within a Cure Period of 5 (five) business days.

6.1.2. Upon occurrence of an Escrow Default, the consequences thereof shall be dealt with under and in accordance with the provisions of the Concession Agreement**.**

7. Termination of Escrow Agreement

7.1. Duration of Escrow Agreement

This Agreement shall remain in full force and effect so long as any sum remains to be advanced or is outstanding from the Concessionaire in respect of the debt, guarantee or financial assistance received by it from the Senior Lenders, or any of its obligations to the Authority remain to be discharged, unless terminated earlier by consent of all the Parties or otherwise in accordance with the provisions of this Agreement.

7.2. Substitution of Escrow Bank

The Concessionaire may, by not less than 45 (forty five) days prior notice to the Escrow Bank, the Authority and the Lenders' Representative, terminate this Agreement and appoint a new Escrow Bank, provided that the new Escrow Bank is acceptable to the Lenders' Representative and arrangements are made satisfactory to the Lenders' Representative for transfer of amounts deposited in the Escrow Account to a new Escrow Account established with the successor Escrow Bank.

The termination of this Agreement shall take effect only upon coming into force of an Escrow Agreement with the substitute Escrow Bank.

7.3. Closure of Escrow Account

The Escrow Bank shall, at the request of the Concessionaire and the Lenders' Representative made on or after the payment by the Concessionaire of all outstanding amounts under the Concession Agreement and the Financing Agreements including the payments specified in

Clause 4.2, and upon confirmation of receipt of such payments, close the Escrow Account and Sub- Accounts and pay any amount standing to the credit thereof to the Concessionaire. Upon closure of the Escrow Account hereunder, the Escrow Agreement shall be deemed to be terminated.

8. SUPPLEMENTARY ESCROW AGREEMENT

8.1. Supplementary escrow agreement

The Lenders' Representative and the Concessionaire shall be entitled to enter into a supplementary escrow agreement with the Escrow Bank providing, inter alia, for detailed procedures and documentation for withdrawals from Sub- Accounts pursuant to Clause 4.1.1 and for matters not covered under this Agreement such as the rights and obligations of Senior Lenders and lenders of Subordinated Debt, investment of surplus funds, restrictions on withdrawals by the Concessionaire in the event of breach of this Agreement or upon occurrence of an Escrow Default, procedures relating to operation of the Escrow Account and withdrawal therefrom, reporting requirements and any matters incidental thereto; provided that such supplementary escrow agreement shall not contain any provision which is inconsistent with this Agreement and in the event of any conflict or inconsistency between provisions of this Agreement and such supplementary escrow agreement, the provisions of this Agreement shall prevail.

9. INDEMNITIES

9.1. General indemnity

9.1.1. The Concessionaire will indemnify, defend and hold the Authority, Escrow Bank and the Senior Lenders, acting through the Lenders' Representative, harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of any breach by the Concessionaire of any of its obligations under this Agreement or on account of failure of the Concessionaire to comply with Applicable Laws and Applicable Permits.

9.1.2. The Authority will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Authority to fulfil any of its obligations under this Agreement materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement or this Agreement other than any loss, damage, cost and expense arising out of acts done in discharge of their lawful functions by the Authority, its officers, servants and agents.

9.1.3. The Escrow Bank will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Escrow Bank to fulfil its obligations under this Agreement materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Escrow Bank, its officers, servants and agents.

9.2. Notice and contest of claims

In the event that any Party hereto receives a claim from a third party in respect of which it is

entitled to the benefit of an indemnity under Clause 9.1 or in respect of which it is entitled to reimbursement (the "Indemnified Party"), it shall notify the other Party responsible for indemnifying such claim hereunder (the "Indemnifying Party") within 15 (fifteen) days of receipt of the claim and shall not settle or pay the claim without the prior approval of the Indemnifying Party, which approval shall not be unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim, it may conduct the proceedings in the name of the Indemnified Party and shall bear all costs involved in contesting the same. The Indemnified Party shall provide all cooperation and assistance in contesting any claim and shall sign all such writings and documents as the Indemnifying Party may reasonably require.

10. DISPUTE RESOLUTION

10.1. Dispute resolution

10.1.1. Any dispute, difference or claim arising out of or in connection with this Agreement, which is not resolved amicably, shall be decided finally by reference to arbitration to a Board of Arbitrators comprising one nominee of each Party to the dispute, and where the number of such nominees is an even number, the nominees shall elect another person to such Board. Such arbitration shall be held in accordance with the Rules of Arbitration of the International Centre for Alternative Dispute Resolution, New Delhi (the "Rules") or such other rules as may be mutually agreed by the Parties, and shall be subject to the provisions of the Arbitration and Conciliation Act, 1996.

10.1.2. The Arbitrators shall issue a reasoned award and such award shall be final and binding on the Parties. The place of arbitration shall be the capital of the State and the language of arbitration shall be English.

11. MISCELLANEOUS PROVISIONS

11.1. Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the courts in Chennai shall have jurisdiction over all matters arising out of or relating to this Agreement.

11.2. Waiver of sovereign immunity The Authority unconditionally and irrevocably:

a. agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

b. agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Authority with respect to its assets;

c. waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

d. consents generally in respect of the enforcement of any judgment or award against it in

any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgment that may be made or given in connection therewith).

11.3. Priority of agreements

In the event of any conflict between the Concession Agreement and this Agreement, the provisions contained in the Concession Agreement shall prevail over this Agreement.

11.4. Alteration of term

All additions, amendments, modifications and variations to this Agreement shall be effectual and binding only if in writing and signed by the duly authorized representatives of the Parties.

11.5. Waiver

11.5.1. Waiver by any Party of a default by another Party in the observance and performance of any provision of or obligations under this Agreement:

- **a.** Shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions of or obligations under this Agreement;
- **b.** shall not be effective unless it is in writing and executed by a duly authorized representative of the Party; and
- **c.** shall not affect the validity or enforceability of this Agreement in any manner

11.5.2. Neither the failure by any Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation thereunder nor time or other indulgence granted by any Party to another Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

11.6. No third party beneficiaries This Agreement is solely for the benefit of the Parties and no other person or entity shall have any rights hereunder.

11.7. Survival

11.7.1. **Termination of this Agreement**

- **a.** shall not relieve the Parties of any obligations hereunder which expressly or by implication survive termination hereof; and
- **b.** except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, shall not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of, or caused by, acts or omissions of such Party prior to the effectiveness of such termination or arising out of such termination.

11.7.2. All obligations surviving the cancellation, expiration or termination of this Agreement shall only survive for a period of 3 (three) years following the date of such termination or expiry of this Agreement.

11.8. Severability

If for any reason whatever any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid, unenforceable or illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to dispute resolution under Clause 10.1 of this Agreement or otherwise.

11.9. Successors and assigns

This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and permitted assigns.

11.10. Notices

All notices or other communications to be given or made under this Agreement shall be in writing and shall either be delivered personally or sent by courier or registered post with an additional copy to be sent by facsimile or e-mail. The address for service of each Party, its facsimile number and e-mail are set out under its name on the signing pages hereto. A notice shall be effective upon actual receipt thereof, save that where it is received after 5.30 (five thirty) p.m. on a business day, or on a day that is not a business day, the notice shall be deemed to be received on the first business day following the date of actual receipt. Without prejudice to the foregoing, a Party giving or making a notice or communication by facsimile or e-mail shall promptly deliver a copy thereof personally, or send it by courier or registered post to the addressee of such notice or communication. It is hereby agreed and acknowledged that any Party may by notice change the address to which such notices and communications to it are to be delivered or mailed. Such change shall be effective when all the Parties have notice of it.

11.11. Language

All notices, certificates, correspondence and proceedings under or in connection with this Agreement shall be in English.

11.12. Authorized representatives

Each of the Parties shall, by notice in writing, designate their respective authorized representatives through whom only all communications shall be made. A Party hereto shall be entitled to remove and/or substitute or make fresh appointment of such authorized representative by similar notice.

11.13. Original Document

This Agreement may be executed in four counterparts, each of which when executed and delivered shall constitute an original of this Agreement.

IN WITNESS WHEREOF THE PARTIES HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DATE FIRST ABOVE WRITTEN.

THE COMMON SEAL OF CONCESSIONAIRE has been affixed pursuant to the resolution passed by the Board of Directors of the Concessionaire at its meeting held on the day of 20 hereunto affixed in the presence of , Director, who has signed these presents in token thereof and Company Secretary / Authorized Officer who has countersigned the same in token thereof[2].

SIGNED SEALED AND DELIVERED

For and on behalf of SENIOR LENDERS by the Lender's representative:

(Signature)

(Name)

(Designation)

(Address)

(Fax No.)

(E-mail address)

(Signature)

(Name)

(Designation)

(Address)

(Fax No.)

(E-mail address)

SIGNED, SEALED AND DELIVERED

SIGNED, SEALED AND DELIVERED

[2] To be affixed in accordance with the articles of association of the Concessionaire and the resolution passed by its Board of Directors

For and on behalf of	for and on behalf of
THE ESCROW BANK by	THE AUTHORITY by:
(Signature)	(Signature)
(Name)	(Name)
(Designation)	(Designation)
(Address)	(Address)
(Fax No.)	(Fax No.)
(E-mail address)	(E-mail address)

SIGNED, SEALED In the presence of:

SCHEDULE U: PANEL OF CHARTERED ACCOUNTANTS

1 Panel of Chartered Accountants

Pursuant to the provisions of Article 27.2.1 of the Agreement, the Authority and the Concessionaire shall prepare a mutually agreed panel of 5 (five) reputable firms of Chartered Accountants having their registered offices in India (the "Panel of Chartered Accountants"). The criteria for preparing such Panel and the procedure to be adopted in this behalf shall be as set forth in this Schedule-P.

2 Invitation for empanelment

2.1 The Authority shall invite offers from all reputed firms of Chartered Accountants who fulfil the following eligibility criteria, namely:

a) the firm should have conducted statutory audit of the annual accounts of at least fifty companies registered under the Companies Act, 1956, including any re-enactment or amendment thereof, of which at least ten should have been public sector undertakings;

b) The firm should have at least 5 (five) practicing Chartered Accountants on its rolls, each with a minimum experience of ten years in the profession;

c) The firm or any of its partners should not have been disqualified or black-listed by the Comptroller and Auditor General of India or the Authority; and

d) The firm should have an office in the State or in an adjacent State with at least 2 (two) practicing Chartered Accountants on its rolls in such State.

2.2 Interested firms meeting the eligibility criteria shall be required to submit a statement of their capability including the bio-data of all the practicing Chartered Accountants on its rolls. In particular, each firm shall be required to furnish year-wise information relating to the names of all the companies with an annual turnover exceeding Rs. 25,00,00,000 (Rs. twenty five crore) whose annual accounts were audited by such firm in any of the preceding 5 (five) Accounting Years

3 Evaluation and selection

3.1 The information furnished by each firm shall be scrutinized and evaluated by the Authority and 1 (one) point shall be awarded for each annual audit of the companies specified in Paragraph 2.2 above. (For the avoidance of doubt and by way of illustration, a firm which has conducted audit of the annual accounts of any such company for 5 (five) years shall be awarded 5 (five) points).

3.2 The Authority shall prepare a list of all the eligible firms along with the points scored by each such firm and 5 (five) firms scoring the highest points shall be identified and included in the draft Panel of Chartered Accountants.

4 Consultation with the Concessionaire

The Authority shall convey the aforesaid panel of firms to the Concessionaire for scrutiny and comments, if any. The Concessionaire shall be entitled to scrutinize the relevant records of the

Authority to ascertain whether the selection of firms has been undertaken in accordance with the prescribed procedure and it shall send its comments, if any, to the Authority within 15 (fifteen) days of receiving the aforesaid panel.

5 Mutually agreed panel

5.1 The Authority shall, after considering all relevant factors including the comments, if any, of the Concessionaire, finalize and constitute a panel of 5 (five) firms which shall be deemed to be the mutually agreed Panel of Chartered Accountants.

5.2 After completion of every 5 (five) years from the date of preparing the mutually agreed Panel of Chartered Accountants, or such earlier period as may be agreed between the Authority and the Concessionaire, a new panel shall be prepared in accordance with the provisions of this Schedule-J.

SCHEDULE V: VESTING CERTIFICATE

1. The _____, _____ (the "Authority") refers to the Concession Agreement dated …….. (the "Agreement") entered into between the Authority and …….. (the "Concessionaire") for _____on HAM mode in the state of Tamil Nadu. (the "Project") on design, build, operate and transfer ("DBFOT Annuity or Hybrid Annuity") basis.

2. The Authority hereby acknowledges compliance and fulfilment by the Concessionaire of the Divestment Requirements set forth in Article 32.1 of the Agreement on the basis that upon issue of this Vesting Certificate, the Authority shall be deemed to have acquired, and all title and interest of the Concessionaire in or about the Project shall be deemed to have vested unto the Authority, free from any encumbrances, charges and liens whatsoever.

3. Notwithstanding anything to the contrary contained hereinabove, it shall be a condition of this Vesting Certificate that nothing contained herein shall be construed or interpreted as waiving the obligation of the Concessionaire to rectify and remedy any defect or deficiency in any of the Divestment Requirements and/or relieving the Concessionaire in any manner of the same.

Signed this…… day of……., 20……. At……..

AGREED, ACCEPTED AND SIGNED For and on behalf of for and on behalf of CONCESSIONAIRE by: (Signature) (Name) (Designation) (Address)	AGREED, ACCEPTED AND SIGNED For and on behalf of for and on behalf of AUTHORITY by: (Signature) (Name) (Designation) (Address)

In the presence of:

1.

2

SCHEDULE W: SUBSTITUTION AGREEMENT

THIS SUBSTITUTION AGREEMENT is entered into on this the……day of……..20…….
AMONGST

1 The _____, established under the _____ Act _____, represented by its _____ and having its principal offices at _____ (Hereinafter referred to as the "Authority" which expression shall unless repugnant to the context or meaning thereof include its administrators, successors and assigns);

2 ……Limited, a company incorporated under the provisions of the Companies Act, 2013 and having its registered office at ……. (Hereinafter referred to as the "Concessionaire" which expression shall unless repugnant to the context or meaning thereof include its successors and permitted assigns and substitutes);

3 …….. (insert name and particulars of Lenders' Representative) and having its registered office at……., acting for and on behalf of the Senior Lenders as their duly authorized agent with regard to matters arising out of or in relation to this Agreement (hereinafter referred to as the "Lenders' Representative", which expression shall unless repugnant to the context or meaning thereof include its successors and substitutes);

WHEREAS:

A. The Authority has entered into a Concession Agreement dated……. With the Concessionaire (the "Concession Agreement") for _____ on HAM mode in the state of Tamilnadu. (the "Project") on design, build, operate and transfer basis (the "DBFOT Annuity or Hybrid Annuity"), and a copy of which is annexed hereto and marked as Annex-A to form part of this Agreement.

B. Senior Lenders have agreed to finance the Project in accordance with the terms and conditions set forth in the Financing Agreements.

C. Senior Lenders have requested the Authority to enter into this Substitution Agreement for securing their interests through assignment, transfer and substitution of the Concession to a Nominated Company in accordance with the provisions of this Agreement and the Concession Agreement.

D. In order to enable implementation of the Project including its financing, construction, operation and maintenance, the Authority has agreed and undertaken to transfer and assign the Concession to a Nominated Company in accordance with the terms and conditions set forth in this Agreement and the Concession Agreement.

NOW, THEREFORE, in consideration of the foregoing and the respective covenants and agreements set forth in this Agreement, the receipt and sufficiency of which is hereby acknowledged, and intending to be legally bound hereby, the Parties agree as follows:

1. DEFINITIONS AND INTERPRETATION

1.1. Definitions

In this Substitution Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"Agreement" means this Substitution Agreement and any amendment thereto made in accordance with the provisions contained in this Agreement;

"Financial Default" means occurrence of a material breach of the terms and conditions of the Financing Agreements or a continuous default in Debt Service by the Concessionaire for a minimum period of 3 (three) months;

"Lenders' Representative" means the person referred to as the Lenders' Representative in the foregoing Recitals;

"Nominated Company" means a company, incorporated under the provisions of the Companies Act, 1956, including any re-enactment or amendment thereof, selected by the Lenders' Representative, on behalf of Senior Lenders, and proposed to the Authority for assignment/transfer of the Concession as provided in this Agreement;

"Notice of Financial Default" shall have the meaning ascribed thereto in Clause 3.2.1; and

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the Parties to this Agreement individually.

1.2. Interpretation

1.2.1. References to Lenders' Representative shall, unless repugnant to the context or meaning thereof, mean references to the Lenders' Representative, acting for and on behalf of Senior Lenders.

1.2.2. References to Clauses are, unless stated otherwise, references to Clauses of this Agreement.

1.2.3. The words and expressions beginning with capital letters and defined in this Agreement shall have the meaning ascribed thereto herein, and the words and expressions used in this Agreement and not defined herein but defined in .the Concession Agreement shall, unless repugnant to the context, have the meaning ascribed thereto in the Concession Agreement.

1.2.4. The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Concession Agreement shall apply, mutatis mutandis, to this Agreement.

2. ASSIGNMENT

2.1. Assignment of rights and title

The Concessionaire hereby agrees to assign the rights, title and interest in the Concession to, and in favor of, the Lenders' Representative pursuant to and in accordance with the provisions of this Agreement and the Concession Agreement by way of security in respect of financing by the Senior Lenders under the Financing Agreements.

3. SUBSTITUTION OF THE CONCESSIONAIRE

3.1. Rights of substitution

3.1.1. Pursuant to the rights, title and interest assigned under Clause 2.1, the Lenders' Representative shall be entitled to substitute the Concessionaire by a Nominated Company under and in

accordance with the provisions of this Agreement and the Concession Agreement.

3.1.2. The Authority hereby agrees to substitute the Concessionaire by endorsement on the Concession Agreement in favor of the Nominated Company selected by the Lenders' Representative in accordance with this Agreement. For the avoidance of doubt, the Senior Lenders or the Lenders' Representative shall not be entitled to operate and maintain the Project as Concessionaire either individually or collectively.

3.2. Substitution upon occurrence of Financial Default

3.2.1. Upon occurrence of a Financial Default, the Lenders' Representative may issue a notice to the Concessionaire (the "Notice of Financial Default") along with particulars thereof, and send a copy to the Authority for its information and record. A Notice of Financial Default under this Clause 3 shall be conclusive evidence of such Financial Default and it shall be final and binding upon the Concessionaire for the purposes of this Agreement.

3.2.2. Upon issue of a Notice of Financial Default hereunder, the Lenders' Representative may, without prejudice to any of its rights or remedies under this Agreement or the Financing Agreements, substitute the Concessionaire by a Nominated Company in accordance with the provisions of this Agreement.

3.2.3. At any time after the Lenders' Representative has issued a Notice of Financial Default, it may by notice require the Authority to suspend all the rights of the Concessionaire and undertake the operation and maintenance of the Project in accordance with the provisions of Article 30 of the Concession Agreement, and upon receipt of such notice, the Authority shall undertake Suspension under and in accordance with the provisions of the Concession Agreement. The aforesaid Suspension shall be revoked upon substitution of the Concessionaire by a Nominated Company, and in the event such substitution is not completed within 180 (one hundred and eighty) days from the date of such Suspension, the Authority may terminate the Concession Agreement forthwith by issuing a Termination Notice in accordance with the provisions of the Concession Agreement; provided that upon written request from the Lenders' Representative and the Concessionaire, the Authority may extend the aforesaid period of 180 (one hundred and eighty) days by a period not exceeding 90 (ninety) days. For the avoidance of doubt, the Authority expressly agrees and undertakes to terminate the Concession Agreement forthwith, upon receipt of a written request from the Lenders' Representative at any time after 240 (two hundred and forty) days from the date of Suspension hereunder.

3.3. Substitution upon occurrence of Concessionaire Default

3.3.1. Upon occurrence of a Concessionaire Default, the Authority shall by a notice inform the Lenders' Representative of its intention to issue a Termination Notice and grant 15 (fifteen) days' time to the Lenders' Representative to make a representation, stating the intention to substitute the Concessionaire by a Nominated Company.

3.3.2. In the event that the Lenders' Representative makes a representation to the Authority within the period of 15 (fifteen) days specified in Clause 3.3.1, stating that it intends to substitute the Concessionaire by a Nominated Company, the Lenders' Representative shall be entitled to undertake and complete the substitution of the Concessionaire by a Nominated Company in

accordance with the provisions of this Agreement within a period of 180 (one hundred and eighty) days from the date of such representation, and the Authority shall either withhold Termination or undertake Suspension for the aforesaid period of 180 (one hundred and eighty) days; provided that upon written request from the Lenders' Representative and the Concessionaire, the Authority shall extend the aforesaid period of 180 (one hundred and eighty) days by a period not exceeding 90 (ninety) days; provided further that the Lenders' Representative may at any time withdraw its representation hereunder and upon such withdrawal, the Authority may terminate this Agreement in accordance with the provisions hereof.

3.4. Procedure for substitution

3.4.1. The Authority and the Concessionaire hereby agree that on or after the date of Notice of Financial Default or the date of representation to the Authority under Clause 3.3.2, as the case may be, the Lenders' Representative may, without prejudice to any of the other rights or remedies of the Senior Lenders, invite, negotiate and procure offers, either by private negotiations or public auction or tenders for the take over and transfer of the Project including the Concession to the Nominated Company upon such Nominated Company's assumption of the liabilities and obligations of the Concessionaire towards the Authority under the Concession Agreement and towards the Senior Lenders under the Financing Agreements.

3.4.2. To be eligible for substitution in place of the Concessionaire, the Nominated Company shall be required to fulfil the eligibility criteria that were laid down by the Authority for short listing the bidders for award of the Concession; provided that the Lenders' Representative may represent to the Authority that all or any of such criteria may be waived in the interest of the Project, and if the Authority determines that such waiver shall not have any material adverse effect on the Project, it may waive all or any of such eligibility criteria.

3.4.3. Upon selection of a Nominated Company, the Lenders' Representative shall request the Authority to:

a. Accede to transfer to the Nominated Company the right to construct, operate and maintain the Project in accordance with the provisions of the Concession Agreement;

b. Endorse and transfer the Concession to the Nominated Company, on the same terms and conditions, for the residual Concession Period; and

c. Enter into a Substitution Agreement with the Lenders' Representative and the Nominated Company on the same terms as are contained in this Agreement.

3.4.4. If the Authority has any objection to the transfer of Concession in favor of the Nominated Company in accordance with this Agreement, it shall within 15 (fifteen) days from the date of proposal made by the Lenders' Representative, give a reasoned order after hearing the Lenders' Representative. If no such objection is raised by the Authority, the Nominated Company shall be deemed to have been accepted. The Authority shall thereupon transfer and endorse the Concession within 15 (fifteen) days of its acceptance/deemed acceptance of the Nominated Company; provided that in the event of such objection by the Authority, the Lenders' Representative may propose another Nominated Company whereupon the procedure set forth

in this Clause 3.4 shall be followed for substitution of such Nominated Company in place of the Concessionaire.

3.4.5. The transfer of Concession hereunder to a Nominated Company may, notwithstanding anything to the contrary in this Agreement and the Concession Agreement, be undertaken by transfer of no less than 75% (seventy five per cent) of the equity of the Concessionaire to the Nominated Company, and upon such transfer hereunder, the Concessionaire shall be deemed to be the Nominated Company under and in accordance with the provisions of this Agreement and the Concession Agreement.

3.5. Selection to be binding

The decision of the Lenders' Representative and the Authority in selection of the Nominated Company shall be final and binding on the Concessionaire. The Concessionaire irrevocably agrees and waives any right to challenge the actions of the Lenders' Representative or the Senior Lenders or the Authority taken pursuant to this Agreement including the transfer/assignment of the Concession in favor of the Nominated Company. The Concessionaire agrees and confirms that it shall not have any right to seek revaluation of assets of the Project or the Concessionaire's shares. It is hereby acknowledged by the Parties that the rights of the Lenders' Representative are irrevocable and shall not be contested in any proceedings before any court or Authority and the Concessionaire shall have no right or remedy to prevent, obstruct or restrain the Authority or the Lenders' Representative from effecting or causing the transfer by substitution and endorsement of the Concession as requested by the Lenders' Representative.

4. PROJECT AGREEMENTS

4.1. Substitution of Nominated Company in Project Agreements

The Concessionaire shall ensure and procure that each Project Agreement contains provisions that entitle the Nominated Company to step into such Project Agreement, in its discretion, in place and substitution of the Concessionaire in the event of such Nominated Company's assumption of the liabilities and obligations of the Concessionaire under the Concession Agreement.

5. TERMINATION OF CONCESSION AGREEMENT

5.1. Termination upon occurrence of Financial Default

At any time after issue of a Notice of Financial Default, the Lenders' Representative may by a notice in writing require the Authority to terminate the Concession Agreement forthwith, and upon receipt of such notice, the Authority shall undertake Termination under and in accordance with the provisions of Article 31 of the Concession Agreement.

5.2. Termination when no Nominated Company is selected

In the event that no Nominated Company acceptable to the Authority is selected and recommended by the Lenders' Representative within the period of 180 (one hundred and eighty) days or any extension thereof as set forth in Clause 3.3.2, the Authority may terminate the Concession Agreement forthwith in accordance with the provisions thereof.

5.3. Realization of Debt Due

The Authority and the Concessionaire hereby acknowledge and agree that, without prejudice to their any other right or remedy, the Lenders' Representative is entitled to receive from the Concessionaire, without any further reference to or consent of the Concessionaire, the Debt Due upon Termination of the Concession Agreement. For realization of the Debt Due, the Lenders' Representative shall be entitled to make its claim from the Escrow Account in accordance with the provisions of the Concession Agreement and the Escrow Agreement.

6. DURATION OF THE AGREEMENT

6.1. Duration of the Agreement

This Agreement shall come into force from the date hereof and shall expire at the earliest to occur of the following events:

A. Termination of the Agreement; or

B. No sum remains to be advanced and no sum are outstanding to the Senior Lenders, under the Financing Agreements.

7. INDEMNITY

7.1. General indemnity

7.1.1. The Concessionaire will indemnify, defend and hold the Authority and the Lenders' Representative harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense of whatever kind and nature arising out of any breach by the Concessionaire of any of its obligations under this Agreement or on account of failure of the Concessionaire to comply with Applicable Laws and Applicable Permits.

7.1.2. The Authority will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Authority to fulfil any of its obligations under this Agreement, materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement or this Agreement, other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Authority, its officers, servants and agents.

7.1.3. The Lenders' Representative will indemnify, defend and hold the Concessionaire harmless against any and all proceedings, actions and third party claims for any loss, damage, cost and expense arising out of failure of the Lenders' Representative to fulfil its obligations under this Agreement, materially and adversely affecting the performance of the Concessionaire's obligations under the Concession Agreement, other than any loss, damage, cost and expense, arising out of acts done in discharge of their lawful functions by the Lenders' Representative, its officers, servants and agents.

7.2. Notice and contest of claims

In the event that any Party hereto receives a claim from a third party in respect of which it is entitled to the benefit of an indemnity under Clause 7.1 or in respect of which it is entitled to reimbursement (the "Indemnified Party"), it shall notify the other Party responsible for indemnifying such claim hereunder (the "Indemnifying Party") within 15 (fifteen) days of receipt

of the claim and shall not settle or pay the claim without the prior approval of the Indemnifying Party, such approval not to be unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim, it may conduct the proceedings in the name of the Indemnified Party and shall bear all costs involved in contesting the same. The Indemnified Party shall provide all cooperation and assistance in contesting any claim and shall sign all such writings and documents as the Indemnifying Party may reasonably require.

8. DISPUTE RESOLUTION

8.1. Dispute resolution

8.1.1. Any dispute, difference or claim arising out of or in connection with this Agreement which is not resolved amicably shall be decided by reference to arbitration to a Board of Arbitrators comprising one nominee each of the Authority, Concessionaire and the Lenders' Representative. Such arbitration shall be held in accordance with the Rules of Arbitration of the International Centre for Alternative Dispute Resolution, New Delhi (the "Rules") or such other rules as may be mutually agreed by the Parties, and shall be subject to provisions of the Arbitration and Conciliation Act, 1996.

8.1.2. The Arbitrators shall issue a reasoned award and such award shall be final and binding on the Parties. The place of arbitration shall be the capital of the State and the language of arbitration shall be English.

9. MISCELLANEOUS PROVISIONS

9.1. Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of India, and the courts in the New Delhi shall have jurisdiction over all matters arising out of or relating to this Agreement.

9.2. Waiver of sovereign immunity

The Authority unconditionally and irrevocably:

a) agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

b) agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Authority with respect to its assets;

c) waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

d) consents generally in respect of the enforcement of any judgment or award against it in any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgment that may be made or given in connection therewith).

9.3. Priority of agreements

In the event of any conflict between the Concession Agreement and this Agreement, the provisions contained in the Concession Agreement shall prevail over this Agreement.

9.4. Alteration of terms

All additions, amendments, modifications and variations to this Agreement shall be effectual and binding only if in writing and signed by the duly authorized representatives of the Parties.

9.5. Waiver

9.5.1. Waiver by any Party of a default by another Party in the observance and performance of any provision of or obligations under this Agreement:

a) Shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions of or obligations under this Agreement;

b) Shall not be effective unless it is in writing and executed by a duly authorized representative of the Party; and

c) Shall not affect the validity or enforceability of this Agreement in any manner.

9.5.2. Neither the failure by either Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation thereunder nor time or other indulgence granted by a Party to another Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

9.6. No third party beneficiaries

This Agreement is solely for the benefit of the Parties and no other person or entity shall have any rights hereunder.

9.7. Survival

9.7.1. Termination of this Agreement:

a) Shall not relieve the Parties of any obligations hereunder which expressly or by implication survive termination hereof; and

b) except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, shall not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of or caused by acts or omissions of such Party prior to the effectiveness of such termination or arising out of such termination.

9.7.2. All obligations surviving the cancellation, expiration or termination of this Agreement shall only survive for a period of 3 (three) years following the date of such termination or expiry of this Agreement.

9.8. Severability

If for any reason whatever any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid,

unenforceable or illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to dispute resolution under Clause 8 of this Agreement or otherwise.

9.9. Successors and assigns

This Agreement shall be binding on and shall inure to the benefit of the Parties and their respective successors and permitted assigns.

9.10. Notices

All notices or other communications to be given or made under this Agreement shall be in writing, shall either be delivered personally or sent by courier or registered post with an additional copy to be sent by facsimile or e-mail. The address for service of each Party, its facsimile number and e-mail address are set out under its name on the signing pages hereto. A notice shall be effective upon actual receipt thereof, save that where it is received after 5.30 (five thirty) p.m. on any day, or on a day that is a public holiday, the notice shall be deemed to be received on the first working day following the date of actual receipt. Without prejudice to the foregoing, a Party giving or making a notice or communication by facsimile or e-mail shall promptly deliver a copy thereof personally, or send it by courier or registered post to the addressee of such notice or communication. It is hereby agreed and acknowledged that any Party may by notice change the address to which such notices and communications to it are to be delivered or mailed. Such change shall be effective when all the Parties have notice of it.

9.11. Language

All notices, certificates, correspondence and proceedings under or in connection with this Agreement shall be in English.

9.12. Authorized representatives

Each of the Parties shall by notice in writing designate their respective authorized representatives through whom only all communications shall be made. A Party hereto shall be entitled to remove and/or substitute or make fresh appointment of such authorized representative by similar notice.

9.13. Original Document

This Agreement may be executed in three counterparts, each of which when executed and delivered shall constitute an original of this Agreement.

IN WITNESS WHEREOF THE PARTIES HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DATE FIRST ABOVE WRITTEN

THE COMMON SEAL OF CONCESSIONAIRE has been affixed pursuant to the resolution passed by the Board of Directors of the Concessionaire at its meeting held on the……..day of the ……..20……..here unto affixed in to the presence of……the Director, who has signed these presents in token	SIGNED, SEALED AND DELIVERED For and behalf of THE AUTHORITY by:

thereof, ……Company Secretary /Authorized Officer who has countersigned the same in token thereof	
(Signature) (Name) (Designation) (Address) (Fax No.) (e-mail address)	(Signature) (Name) (Designation) (Address) (Fax No.) (e-mail address)

SIGNED, SEALED AND DELIVERED
For and on behalf of
SENIOR LENDERS by the
Lenders' Representative:
(Signature)
(Name)
(Designation)
(Address)
(Fax No.)
(E-mail address)
In the presence of:
1.
2.

ANNEXURE–I

LISTOF EXISTING ASSETSTOBEHANDEDOVERTOCONCESSIONAIRE

I.	INLETBAY			
	1.	Raw water sampling pumps	-	2 Nos.
	2.	Inlet chamber drain sluice gate	-	1No.
	3.	Feed channel drain arrangement	-	5 Nos.
II.	CLARIFLOCCULATORS			
	1.	Clariflocculators 53.83m dia. with M.S. Bridge Manually operated C.I. Gate, Scrapper arms bridge driving unit etc. with necessary accessories	-	5Nos.
	2.	Sludge chamber with valves & accessories	-	5 Nos.
	3.	Electro mechanical actuators	-	5Nos.
	4.	Clarifloculator outlet sampling pumpsets	-	10Sets
III.	SLUDGEBALANCETANKANDCONTROLROOM			
	1.	Sludge balancing tank	-	2 Nos.
	2.	Sluicegates	-	2 Nos.
	3.	Agitator	-	2 Nos.
	4.	Sludge transfer pump sets	-	2 Nos.
	5.	Submersible pumpsets	-	1No.
	6.	Motor control panel, PDB, LDB,Instrument ControlPanel, Annunciator with Electronic Hotter	-	1Set
	7.	Air Compressors 90lit.10.5Kg/sq.m.	-	2 Nos.
	8.	Underflow pumpsets	-	2Nos.
IV.	ALUMPLANT			
	1.	Alum saturators with level switches	-	4 Nos.
	2.	Alum transfer pumpsets with B.P. and Accessories	-	4 Nos.
	3.	Air blower units with all accessories	-	2 Nos.
	4.	Mono-rail pulley block (1.5T)	-	2 Nos.

8.	Submersible pumpsets (portable) with 50m long Hose	-	1No.
9.	Dilution tank with agitator, level switches, gauge level indicator, sensor, transmitter etc.	-	3 Nos.
10.	Constant head tank with Rotameter and Accessories	-	2 Nos.
11.	Main instrument control panel annunciator PDB, LDB etc.	-	1Set
12.	Motor control center panel for controlling air Blowers alum transfer pumpsets, agitators etc.	-	1Set.
13.	2Ton capacity Voltas make Fork Lift	-	1No.
14.	Alumstoringcrates2mx1.2m	-	384Nos.

V. MILK OF LIME PLANT(32T/DAY)

1.	Belt Conveyor	-	1No.
2.	Grizzly Screen	-	1No.
3.	Jaw crusher	-	1No.
4.	Bucket elevator	-	1No.
5.	Table feeder	-	1No.
6.	Lime bin	-	1No.
7.	Drum Slacker	-	1No.
8.	Door Classifier	-	1No.
9.	RCC Milk of lime tank 1.75mx1.75m with agitator, motor etc.	-	1No.
10.	Slurry pumpsets	-	2 Nos.
11.	Motor control center panel for controlling lime transfer pumpsets, dosing pumpsets agitator set	-	1 Set.
12.	RCCMilkoflimetank2.5mx2.5mwith sensor, level indicators	-	2 Nos.
13.	Dosingpumpsetswithreductiongears15:1	-	2 Nos.
14.	Mono-railpulleyblock2TCapacity	-	2 Nos.
16.	Mono-railpulleyblock1Tcapacity	-	1No.
17.	Exhaust fans	-	2 Nos.
18.	Limestorewithnecessarylightfittings exhaust fan etc.	-	1No.

19.	Instrument control panel	-	1No.

VI. CHLORINATIONPLANT

1.	Vacuum operated chlorinator with vacuum line, chlorine extraction line, necessary suitable valves, motorized systems filters, rotameters and automatic changeover Panel controlling all the five chlorinators	-	5 Nos.
2.	Electrically operated traversing crane 2 T capacity with pulley block motor, bridge grinders etc.	-	2 Nos.
3.	Submersible pumpsets with hose and electrical connections	-	1Set
4.	Low ventilating system comprising of air, exhaust fans, chute motors and push button starter	-	9 Sets
5.	Instrumentation control panel consisting of Annunciators indicators etc.	-	1Set
6.	Motor control center consisting of control switches for controlling incoming and outgoing system motivator pumps and service water pumps	-	1Set
7.	Booster water pumpsets with pushbutton	-	5 Sets
8.	Service water pump sets with push button	-	2 Sets
9.	Electromechanical actuators	-	1No.

VII. FILTERHOUSE

1.	Filter bed outlet sampling Pumpsets	-	48Nos.
2.	Stop logs with lifting wooden frames	-	4 Nos.
3.	Filter feed inlet sluice gate pneumatically operated Withmanualoverride650x650mm	-	24Nos.
4.	Filter under drain lateral piping system for each Bed consisting of PVC perforated piping network	-	24Nos.

5.	Pneumatically operated backwash outlet sluice gate With manual override 700x700mm	-	24Nos.
6.	Back wash motor pumpsets	-	3Sets
7.	100mm dia pipeline for providing water supply to Backwash pumpsets	-	11.75m
8.	Backwash motor suction valve	-	3Nos.
9.	Backwash motor non-return valve	-	3Nos.
10.	Squire edge orifice with flange tapping	-	1No.
11.	Backwash air blower with push buttons	-	3Sets
12.	Air blower sluice valve	-	3 Nos.
13.	Squire edge orifice with flanged tapings (air blower)	-	1No.
14.	Pneumatically operated butterfly valve with Manual override	-	24Nos.
15.	Pressure switch at blower delivery	-	1No.
16.	Air Compressor for pneumatic operation of Butterfly valves & sluice valves	-	2 Sets
17.	Solenoid valves panels for operating pneumatically Filter inlet, sluice gate and back wash outlet gate	-	24Nos.
18.	Solenoid valves panels for operating pneumatically butterfly valves for air inlet backwash water inlet To filter & filtered water outlet	-	24Nos.
19.	Filter control consoles for operating backwash Orifice and filter beds comprising of	-	24Nos.
	i. Filter head loss indicator	-	1No.
	ii. Scour air pressure indicator	-	1No.
	iii. Backwash water head indicator	-	1No.
	iv. Valve position indicator	-	1No.
	v. Pneumatic system pressure indicator	-	1No.

	vi. Open/Close/Off switches indicating lamps pushbuttons, with their connections	-	1Set
20.	Programmable logic control system for automatic Operation of filter beds consisting of one P.L.C. for each bed with digital input analogue input and Output without centralized control	-	24Nos.
21.	Loss of head indicating transmitter	-	24Nos.
22.	Filtered water outlet isolation valve pneumatically operated	-	24Nos.
23.	Filtered water outlet restrict or valve manually Worm gear operated	-	24Nos.
24.	1800mmdia. Filtered water conduit having feed connections from each filter bedwith2Nos.of 1800mm.manuallyoperatedbutterflyvalves	-	237.3m
25.	Motor control centre panel for controlling air blowers backwash pumpsets, pneumatic Compressors, etc.	-	2Sets
26.	Submersible pumpsets with cable connections And hoses	-	1Set
27.	Mono-rail systems		
	i) Filtercontrolblock2T	-	1Set
	ii) Backwashpumpblock2T	-	1Set
	iii) Filtercontrolblock2T(air blower section	-	3 Sets
	iv) Pipegaller1T	-	1Set
28.	Instrument control panel consisting of indicators, annunciators etc. for controlling filter beds	-	1Set
29.	Indicator Panel	-	1No.

VIII. SUBSTATION

1. Two pole structure for receiving TNEB supply

	With necessary accessories	-	1Set
2.	500KVA,11KV/433Volts,50Cycles Power transformer	-	2 Nos.
3.	H.T. minimum oil circuit breakers for controlling transformers	-	2 Nos.
4.	L.T. controlling panel consisting of bus couplers controlling switches to each plant etc.	-	1Set
5.	Power factor improving capacitors with control panel etc.	-	1Set
6.	Battery charger with batteries for operating H.T. Switch Gears	-	1Set
7.	500MVA cubical3panelRMGunit2incomer and 1 outgoing panel	-	1Set
8.	500MVA cubical 6panel consisting of 1incomer and 5 outgoing panel	-	1Set

IX. HT CLEAR WATER PUMP HOUSE

1.	400KW/3.3.KVPumpsets	-	6 Nos.
2.	10HP Vacuum Pumpsets	-	2 Nos.
3.	3HPDrain Pump Sets	-	2Nos.
4.	HT/11KV/7Panel	-	1Set
5.	HT/3.3.KV14Panel	-	1Set
6.	ATS PANEL with Auto Transformer for 3.3KV/400KWPumpset	-	6 Sets
7.	1525KVA/11KV Diesel Generator set with NGR, PANEL, Synchronizing panel and outgoing breaker etc.	-	2 Sets
8.	Fuel pump, Water cooling pump oil	-	2Sets in
	Circulating pump–Air compressor set, Soft water pump set	-	Each item
9.	3250KVA Transformer	-	2 Nos.
10.	200KVA Transformer	-	1No.

11.	Electro-mechanical Actuator	-	6 Nos.
12.	750mmdia Sluice valve	-	12Nos.
13.	1200mmdia Sluice valve	-	2 Nos.
14.	Treated water online Residual chlorine meter	-	1 Set.
15.	Ultra-sonic level transmitter	-	1Set

XI CLEAR WATER PUMP HOUSE

1.	1250KVA11KV/433Volts50CyclesPower Transformer	-	2Nos
2.	H.T.3PanelVCB	-	1 Set.
3.	L.T.controlling panel including Busduct control switches, starter panel etc. including capacitor controls	-	1 Set.
4.	250HP horizontal split casing pump with 180KW motors	-	3Sets.
5.	Vacuum pumpsets	-	2Sets.
6.	625KVA415Volts50c/s Diesel engine driven genset with control panel, day tank, diesel Storage tanker etc.	-	1 Set.
7.	Diesel pump set	-	2Sets.
8.	Ultra sonic level transmitter	-	1Set
9.	Electromechanical Actuators	-	6Nos

XII MECHANICALSLUDGEDEWATERINGPLANTREDHILLS

1.	Agitator type sludge balancing tank	-	2Nos.
2.	Solid bowl centrifuge	-	5 Nos.
3.	Polymer dosing system	-	1Lot
4.	Belt Conveyor	-	1No.
5.	11KV Transformer 11KV/440Volt, 250KVA	-	1No.
6.	HT MOCB load break isolator	-	1No.
7.	LTPanel, power control center	-	1No.
8.	Motor Control Center Panel Board	-	1No.
8.	Instrumentation Panel Board	-	1Lot
9.	Sludge feed pumps HP7.5,RPM 1440	-	5 Nos.

10.	Interconnecting Pipes valves	-	1Lot
11.	Level Switch, Lighting system	-	1Lot

RAWWATERPUMPHOUSEREDHILLSMACHINERYDETAILSH.V. INSTALLATION

12.	11 KV Double pole structure comprising of AB switches, D.D. Fuse, lighting arrestors, pin insulators, Disc insulators etc.		1Set
13.	M.V.Transformer		2 Nos.
	(a) Capacity2500KVA11KV/3.3KV	-	2 Nos.
	(b) Capacity250KVA11KV/433Volt	-	1No.
14.	500MVA Cubical 6panel consist of 2 incomers and 4 outgoing panel		1Set
15.	3.3 KV 8 (Eight Panel Each panel consist of MDCB Make ABB Amps 1250 with all indicating & protective instruments		1Set
16.	3.3KV350HPsquirrelCageinductionmotor Amps 58 Volt 3300	-	Make GEC 6 Nos.
17.	Pump make: Mather and Platt Discharge 5500 lps Head27mts.	-	6 Nos.
18.	MotorStarterPanel3.3KV Each Panel having Auto Transformer make RMH	-	6 Nos.
19.	VacuumpumpmakeKirloskar5HP	-	4 Nos.
20.	Sump Pump	-	2 Nos.
21.	Electromechanical actuators	-	6Nos.
22.	LT Distribution Board Incomer800A Volt 414 Make L&T	-	1No.
23.	Lighting points	-	50Nos

XIV. RAW WATER PUMP HOUSE REDHILLS D.G.SET ROOM DETAILS

1.	Diesel Generator Set Capacity1000KVAwithAlternator 11 KV 50 c/s / 1450 rpm Make Jakson alternator Jothi	-	2 Sets
2.	11 KV Panel 3 Panel consisting of Synchronising Panel AVR relays and other instruments neutral grounding panel etc.	-	1Set
4.	DGSet1000KVA/Cooling tower with circulating pump	-	2 Sets
5.	D.G.Set water circulating pumpsets	-	2 Sets
6.	Electrical Driven oil pumpset	-	2 Sets
7.	LT Panel Board	-	1Set

XV JONESTOWER

1. Pair of bell mouth valve with operating mechanism	-	3 Sets
2. Pair of Scour valve with operating mechanism	-	1Set
3. Level Transmitter	-	1No.
4. Dead storage pump house panel, conduit chambers	-	1Set
5. Roughing filter and allied civil structure inside the Raw water pump house campus	-	1Set