CHENNAI METROPOLITAN WATER SUPPLY AND SEWERAGE BOARD

CHENNAI- 600 002

NATIONAL COMPETITIVE BIDDING

BID DOCUMENT
FOR

PERFORMANCE BASED CONTRACT FOR OPERATION AND MAINTENANCE OF WATER DISTRIBUTION STATIONS, PIPELINE NETWORKS (PUMPING MAINS & DISTRIBUTION MAINS), HOUSE SERVICE CONNECTIONS AND ALLIED WORKS AT RAMAKRISHNA NAGAR HEAD WORKS & MAJESTIC COLONY, VALASARAVAKKAM FOR 5 YEARS IN AREA XI (PACKAGE - I)

CONTRACT NO: CNT/WSS/NCB/MWB/3692/2025-26

BID DOCUMENT

VOLUME - II

SPECIFICATIONS

SUPERINTENDING ENGINEER (CONTRACTS & MONITORING)
CHENNAI METROPOLITAN WATER SUPPLY & SEWERAGE BOARD

No.1, Pumping Station Road, Chintadripet, Chennai-02

Telephone: 044 –29520299, 044- 28451300

E-mail : secandm@gmail.com

INTERPRETATION

In this contract the following words shall be understood as having the meanings herein assigned to them.

a. "The Board" means the Chennai Metropolitan Water supply and Sewerage Board, a Statutory Body constituted under Madras Metropolitan Water Supply and Sewerage Act 1978 having its Office at No.1, Pumping Station Road, Chintadripet, Chennai-02 and any officer duly authorized by this Board to act on its behalf.

b. `Contractor' means the person or persons or firm or company contracting for the work specified, including his or their executors or administrators of legal representatives or successors:

c. `Engineer' means Chief Engineer (or) his representative or any other Engineer appointed from time to time by the Board to act as such in connection with these Works. Whenever any Work is specified to be done or material supplied to the satisfaction of the Engineer, it shall be taken as including his properly authorised assistants and duly authorised representatives.

d. `Works' means works to be constructed, completed and maintained in accordance with contract.

e. TNBP - Tamil Nadu Building Practice.

f. IS - Indian Standards

g. ISS - Indian Standard Specifications

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WATER SUPPLY DETAILS

Water Distribution Area:

Area: Area XI

Sl. No	Description	Area-XI	
		Ramakrishna Nagar	Majestic Colony
1	Depots Covered	149 & 152	152 & 151
2	No of House holds	6171	5476
3	No of HSC	4610	3352
4	Population	34486	28992
5	Distribution System	49.95	33.78
6	Pumping/Feeder Main	0.85	1.01
7	Pumping Machineries	150HP/110KW	85HP/62KW
8	Storage Capacity (OHT/UGT)	29 LL / 10LL	19 LL / 8 LL
9	Source of supply	Veeranam / 530 MLD	
10	Hours of supply	3 Hrs	2 Hrs
11	Streets covered	221	239
13	Total No of DMA's under WDS	6 Nos	4 Nos
14	DMA Locations	1.Kamarajar Salai (2Nos) 2.Velan Nagar 3.Lakshmi Nagar 4.Brindavan Nagar 5. Kamatchi Nagar	1.Anna Street 2.Valli Street 3. Bethaniya Nagar 4.Thiru Nagar Annex

Water Supply Assets in the Distribution Areas

1.	**Pipeline in km**				
	100 mm	DI	Km	66.688	
	150mm	DI	Km	8.031	
	200mm	DI	Km	2.400	
	250mm	DI	Km	0.690	
	300mm	DI	Km	2.340	
	350mm	DI	Km	0.790+1.0015	
	400mm	DI	Km	1.576+0.8485	
	450mm	DI	Km	0.238	
	500mm	DI	Km	0.720	
	600mm	DI	Km	0.552	
	Total length			84.025+1.850	
2.	**Specials/Fixtures**				
a.	**Sluice / Butterfly valve (nos.)**				
	80mm	DI	No	-	
	100mm	DI	No	73	
	150mm	DI	No	16	
	200mm	DI	No	11	
	250mm	DI	No	4	
	300mm	DI	No	3	
	400mm	DI	No	6	
	Total, Nos				
b.	**Air valve (nos.)**				
	80mm	DI/CI	No		1
c.	**Pressure control valve (nos.)**				
	WDS				
	350 mm		Nos.		1
	400 mm		Nos.	1	
	600 mm		Nos.	1	1
	DMAs				
	250 mm		No.	2	
	300 mm		No	3	2
	350 mm		No	1	1
	400 mm		No		1

d.	**Full bore Electro Magnetic Flow Meter with Transmitter (nos.)**				
	WDS				
	350 mm		Nos.		1
	400 mm		Nos.	1	
	600 mm		Nos.	1	1
	DMAs				
	250 mm		Nos.	2	
	300 mm		Nos.	3	2
	350 mm		Nos.		1
	400 mm		Nos.	1	1

CHAPTER 1 – GENERAL

1.1 SCHEME DETAILS

"Performance Based Contract for Operation and Maintenance of Water Distribution Stations, Pipeline Networks (Pumping Mains & Distribution Mains), House Service Connections and allied works at Ramakrishna Nagar Head Works & Majestic Colony, Valasaravakkam for 5 Years in Area XI (Package - I)
The major components of the scheme are as follows:

SCOPE OF WORK

The scope of the work for "Performance Based Contract for Operation and Maintenance of Water Distribution Stations, Pipeline Networks (Pumping Mains & Distribution Mains), House Service Connections and allied works at Ramakrishna Nagar Head Works & Majestic Colony, Valasaravakkam for 5 Years in Area XI (Package - I) includes Works and Operation & Maintenance covering Technical Management of the Water Distribution Station along with the network and Customer care as detailed below.

- **Works Include:**
  a) Effecting house service connections including metering.
- **Operations & Maintenance include**
  - **Repair Works:**
    Attending repairs and Leakages reported/detected on existing (HDPE/DI/MS/CI/PE/PVC etc.,) Pipeline Network, House Service Connections connected fixtures (Valves, Tee, and Bends) and installations within the supply Area. Minor repairs of pump & motors, flow and pressure measuring instruments.
  - **Maintenance Activities:**
    Activities involved in the O&M operations covers Préventive maintenance, Routine Maintenance, Asset Maintenance, NRW reduction, Water quality testing & monitoring; chlorination facilities;
  - **Customer Service**
    Grievance Redressal, Ensuring Collection & Citizen Engagement

During the Five years of O&M period, the Contractor shall be required to operate and manage the water supply in the Area and must meet the Performance Targets as specified in Schedule 4, Special Conditions of Contract, Volume I.

Operation & Maintenance Activities:

I) Routine Maintenance Activities:

(a) Manage the water supply in the area as per the existing supply level, try and achieve improvements in supply duration and pressure within the Area through better flow & pressure management and ultimately aim for continuous pressurized water supply when required quantity bulk water is made available by CMWSSB.
(b) Measure Initial NRW and reduce NRW to 40%, thereafter to the design value of 20% and maintain.
(c) Adopt active leakage control and repair the leaks identified network & service connections at the earliest time.
(d) Motivate customers to take new connection & assist in documentation. Provide the new service connections as and when approved by client & extend the network where ever required.
(e) Conduct scheduled water quality testing every day, analysis & reporting and to undertake emergency chlorination measures at times of outbreak of epidemics and any such emergency situations.

(f) Getting tested the customer water meters for their working condition and accuracy in the test bench located in Chennai Metro premises when there is dispute with customers.
(g) Ensure Customer Billing activities, Customer Care operation, managing the customer complaints related water supply services & network system leakages.

II) NRW Reduction

(a) System diagnostic: Contractor will undertake a rapid diagnostic assessment of the system to identify problematic areas and prioritize leak detection activities. The assessment will include a review of the operational data as available with client; a review of the as-built maps and hydraulic drawings; water audit; pressure monitoring; and physical surveys to inspect above-ground infrastructure, verify valve locations and identify locations of visible leaks.
(b) District Metered Areas (DMA) formation: In Area where DMAs have not been formed or are inadequate, the Contractor will undertake verification/review of hydraulic assessment of the scheme, create sub-zones/DMAs in coordinate with CMWSSB, the need for additional valves for isolation of DMA from rest of the water distribution system for carrying out zero pressure test and step test, identify locations and determine specifications for flow meters, pressure reducing valves (PRVs) and pressure monitoring devices, including the protection chambers (if required).
(c) Prioritization of DMAs or zones for leak detection: The Contractor will undertake water auditing, Minimum Night Flow Assessment, and conduct step test to identify sub-zones/DMAs having higher physical losses. This activity shall be completed at least once in four months in the first week. As much as possible the contractor shall rely on EMF data and when sufficient information is not available the consultant shall undertake field measurements using clamp-on devices.
(d) Leak detection: Based on the above assessments, the Contractor shall undertake leak detection activities in the selected DMAs, in the water mains covering feeder mains and the distribution network and house service connections. The Contractor shall employ relevant methodologies and technologies that shall pinpoint the location of the leakages. The Contractor is expected to make available relevant equipment for this activity such as Leak Noise Correlator, Ground Microphone, Listening Sticks, Electro-magnetic Pipe Locator etc., for the minimum set of equipment that needs to be made available as per field requirements.
(e) Leak repairs: The Contractor shall pin point the potential leakage points and undertake repairing leaks and address other damages with good quality repair materials/kits within shortest possible time. Contractor must estimate & maintain as a minimum stock of leak repair materials/kits in his stores. The consultant shall document the leaks repaired on Autocad/GIS platform for future references and claims. Post repair activities, the Contractor will conduct Water Auditing and establish NRW values post active leakage control (This should be done only using data available on the existing EMF). The process shall be continued until the recommended levels of physical losses achieved and NRW is brought down to under 20% and maintained thereafter.

III) Assets maintenance

Contractor is expected to maintain all water supply assets in the good working conditions following the best CPHEEO/international practices. As a minimum maintenance activities listed in Asset Management, must be followed, documented and submitted along with the report for claiming the Fixed Remuneration.

Bill No.II. Effecting new HSC the following works are included

Sl.no	Description
A	**Boring and tapping from water main**
1	Making bore and tapping in the DI pipe line, supplying and fixing of specials consisting of plastic moulded clamp saddle with (SS304) female threaded metal insert ,sealing rubber and plastic wide strap including suitable bolts and nuts, Polypropylene compression fitting adopter with metal insert(SS 304-male threaded),Polypropylene compression fitting 90 deg elbow, UPVC Ball Valve(stop cock) with compression joint at one end and female threaded at other end and suitable enclosure(HDPE) with top side openable for housing UPVC Ball Valve(stop cock) and testing house service connections including cost of water etc. complete for following sizes.
B	**Laying of MDPE pipes at road portion**
1	Supplying and laying of MDPE (PE80) Blue pipe (IS:4427) with necessary specials including earth work excavation laying jointing testing, refilling the trenches and disposal of surplus earth etc. complete.
2	Hire charges for power breaker to dismantle the concrete / asphaltic road surfaces
3	Hire charges for diesel pumpset for 3 HP with fuel and crew charges including transportation and operating charges
4	Providing Iron Barricading of size 2.50 m width and 1.75 m height using 40x40x4 mm angle for outer frame supports, 25 x 25 x 3 mm angle for inner frame supports and 20 gauge thickness MS sheet for name board (as per drawing) including cutting, welding, fabrication charges and one coat of primer and 2 coats of enamel paint of approved quality, writing "METRO WATER" & work detail/ caution sign, providing necessary interlocking arrangements with adjoining units, fixing danger flags, danger lights, reflectors, fixing stickers etc, including watching during night and placing the barricading units as directed at the sites
	Road Cut Restoration
5	Providing Wet mix macadam including premixing the material with water at OMC in mechanical mix plant carriage and laying in uniform layers and compacting etc. Complete as per clause 406 of MORT&H specifications
	Boring pit
	Pipe laying portion excluding pit (1.00x1.00m)
6	Cement concrete 1:2:4 using Crushed stone sand (M-sand) and 12 to 20mm gauge hard broken stone jelly for plain concrete work including laying compacting curing, etc., complete. (For restoration of road surfaces)
	Boring pit
	Pipe laying portion excluding pit (1.00x1.00m)
7	Providing and laying Bituminous concrete to 40mm thick
	Boring pit
	Pipe laying portion
C	**Additional works for SWD crossing**

Sl.no	Description
1	Providing 65mm dia GI casing pipes across SWD
2	Hire charges for power breaker to dismantle the side walls of SWD including transportation and operating charges
4	Cement concrete 1:2:4 using Crushed stone sand (M-sand) and 12 to 20mm gauge hard broken stone jelly for plain concrete work including laying compacting curing, etc., complete.
	Repacking of side walls of SWD
	Deduction for pipe
D	**Supplying and Fixing of customer ultrasonic water meter (15mm to 25mm)**
E	**Asset Mapping**
	The Contractor must obtain the existing Static GCP points from CMWSSB which should be considered as the control point with known coordinates X, Y and Z. Survey consultant to ensure the closing error is in permissible limits (SoI Standards) while transferring the levels from the existing Static GCP points and the same to be presented as a report. The same process shall be adopted for random verification of positional accuracy of points established using the PBMs as base. As built survey for every sewage and water pipeline and other assets must be done using DGPS based RTK method by transferring the coordinates from the nearest Static GCP of CMWSSB. Where there are signal interruptions for the RTK method, Total Station can be used. The coordinates from the static GCP shall be transferred to the Total Station by RTK method and the co- ordinates of the assets can then be captured by Total Station. All the features, attributes of all the assets, utilities captured shall be Geo referenced as per standard Coordinate reference system (WGS 84 UTM Zone 44N). The final base map with assets and utilities shall be furnished in (.shp) format. The geo referenced assets and utilities along with the attributes (as specified by the GIS Wing, CMWSSB) shall be converted into proper geo database (FGDB / PGDB) with the attributes. One set Hard and Soft Copy of all the CMWSSB assets and utility has to be prepared category wise network wise in A0 Print for verification in a print scale of 1:1000 in A0 plot, with standard legends in international and NUIS standards and should be legible and three sets of final Hard Copy in A0 print.
1	For the Underground / Surface Assets along the roads for the distance ranging from: (less than 2 Km)
2	For the Point Underground / Surface Assets along the roads

Bill no.II. b Supplying and Fixing of customer ultrasonic water meter (15mm to 25mm), UPVC/MDPE pipes, collars, union, all materials including labour charges for threading, jointing and fixing

Sl.No	Description
1	Meter fixing charges including specials
2	Meter charges
3	Surface box

Bill No. III. Attending Leaks

a. Leak to be rectified Using MJ Collar

Sl.No	Description of Works
1	Earthwork excavation and depositing on bank with initial lead of 10 metres and initial lift 2.00m in hard stiff clay stiff black cotton, hard red earth, shales, Murum, gravel, stoney earth and earth mixed with small size boulders S.S.20-B. including refilling excavated earth (excluding timbering and bailing out sub-soil water) as per P.W.D. standard schedule of rates for Chennai City.
2	Hire charges for diesel pumpset above 5HP for dewatering the trenches
3	Providing Iron Barricading of size 2.50 m width and 1.75 m height using 40x40x4 mm angle for outer frame supports, 25 x 25 x 3 mm angle for inner frame supports and 20 gauge thickness MS sheet for name board (as per drawing) including cutting, welding, fabrication charges and one coat of primer and 2 coats of enamel paint of approved quality, writing "METRO WATER" & work detail/ caution sign, providing necessary interlocking arrangements with adjoining units, fixing danger flags, danger lights, reflectors, fixing stickers etc, including watching during night and placing the barricading units as directed at the sites
4	Dismantling of Bitumen/concrete road surface using power breaker
5	Cutting of DI mains
6	Supply of Ductile Iron Socket/Spigot Pipes as per IS 8329/2000
7	Laying of Ductile Iron Socket/Spigot Pipes as per IS 8329/2000
8	Supply and Delivery of MJ Collars
9	Conveying and fixing of MJ Collars
10	Refilling with excavated earth (other than sand)
11	Providing Wet mix macadam including premixing the material with water at OMC in mechanical mix plant carriage and laying in uniform layers and compacting etc. Complete as per clause 406 of MORT&H specifications
12	Cement concrete 1:2:4 using Crushed stone sand (M-sand) and 12 to 20mm gauge hard broken stone jelly for plain concrete work including laying compacting curing, etc., complete. (For restoration of road surfaces)
13	Disposal of surplus earth

b. Joint leak to be rectified using Cement joints

Sl.No	Description of work
1	Earthwork excavation and depositing on bank with initial lead of 10 metres and initial lift 2.00m in hard stiff clay stiff black cotton, hard red earth, shales, Muram, gravel, stoney earth and earth mixed with small size boulders S.S.20-B. including refilling excavated earth (excluding timbering and bailing out sub-soil water) as per P.W.D. standard schedule of rates for Chennai City.
2	Hire charges for diesel pumpset above 5HP for dewatering the trenches
3	Providing Iron Barricading of size 2.50 m width and 1.75 m height using 40x40x4 mm angle for outer frame supports, 25 x 25 x 3 mm angle for inner frame supports and 20 gauge thickness MS sheet for name board (as per drawing) including cutting, welding, fabrication charges and one coat of primer and 2 coats of enamel paint of approved quality, writing "METRO WATER" & work detail/ caution sign, providing necessary interlocking arrangements with adjoining units, fixing danger flags, danger lights, reflectors, fixing stickers etc, including watching during night and placing the barricading units as directed at the sites
4	Dismantling of Bitumen/concrete road surface using power breaker
5	Making cement joint for including cost of cement, spun yarn and labour charges
7	Providing Wet mix macadam including premixing the material with water at OMC in mechanical mix plant carriage and laying in uniform layers and compacting etc. Complete as per clause 406 of MORT&H specifications
8	Cement concrete 1:2:4 using Crushed stone sand (M-sand) and 12 to 20mm gauge hard broken stone jelly for plain concrete work including laying compacting curing, etc., complete. (For restoration of road surfaces)
9	Disposal of surplus earth

c. Leak to be rectified using SS Clamp

Sl.No	Description of work
1	Earthwork excavation and depositing on bank with initial lead of 10 metres and initial lift 2.00m in hard stiff clay stiff black cotton, hard red earth, shales, Muram, gravel, stoney earth and earth mixed with small size boulders S.S.20-B. including refilling excavated earth (excluding timbering and bailing out sub-soil water) as per P.W.D. standard schedule of rates for Chennai City.
2	Hire charges for diesel pumpset above 5HP for dewatering the trenches
3	Providing Iron Barricading of size 2.50 m width and 1.75 m height using 40x40x4 mm angle for outer frame supports, 25 x 25 x 3 mm angle for inner frame supports and 20 gauge thickness MS sheet for name board (as per drawing) including cutting, welding, fabrication charges and one coat of primer and 2 coats of enamel paint of approved quality, writing "METRO WATER" & work detail/ caution sign, providing necessary interlocking arrangements with adjoining units, fixing danger flags, danger lights, reflectors, fixing stickers etc, including watching during night and placing the barricading units as directed at the sites
4	Dismantling of Bitumen/concrete road surface using power breaker
5	Making cement joint for including cost of cement, spun yarn and labour charges
6	Refilling with excavated earth (other than sand)
7	Providing Wet mix macadam including premixing the material with water at OMC in mechanical mix plant carriage and laying in uniform layers and compacting etc. Complete as per clause 406 of MORT&H specifications
8	Cement concrete 1:2:4 using Crushed stone sand (M-sand) and 12 to 20mm gauge hard broken stone jelly for plain concrete work including laying compacting curing, etc., complete. (For restoration of road surfaces)
9	Disposal of surplus earth

1.2 SPECIFICATION DRAWINGS:

The specification drawings are formulated in Volume-4. These indicate the detailed alignment of the pipeline in plan of the pipeline profile.

The scope of the contract includes designing and preparation of additional or modified detailed drawings wherever these are necessary and as demanded by the Engineer in charge and getting his approval.

1.3 MATERIALS:

a. The term “Materials” shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the works.

b. Except as may be otherwise specified for particular parts of the Works, the provision of clauses in “material and workmanship” shall apply to materials and workmanship for any part of the works.

c. All materials shall be new and of the kinds and qualities described in the contract and shall be at least equal to approved samples.

d. Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the works under this contract.

1.4 SAMPLES AND TESTS OF MATERIALS:

a. The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier’s premises or at a laboratory approved by the Engineer.

b. Samples shall be submitted and tests shall be carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

c. The Contractor shall give the Engineer minimum fifteen days’ notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier’s premises or at a laboratory approved by the Engineer. The Engineer or his nominee shall attend the test at the appointed place within fifteen days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed upon date in his presence. The Contractor shall in any case submit to the Engineer within seven days of every test such number of certified copies (not exceeding six) of the test readings as the Engineer may require.

d. Approval by the Engineer for placing orders for materials or for samples or tests shall not prejudice any of the Engineer’s powers under the Contract particularly under the provisions of Conditions of Contract.

e. The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

1.5 STANDARDS:

a. The special attention of the Contractor is drawn to the relevant sections and clauses of the National Building Code of India (latest revision) and latest I.S. Specifications (latest editions as amended) and should follow all the specifications and conditions strictly.

b. Materials and workmanship shall comply with the relevant Indian Standards or any other National standards equivalent or higher than Indian standard (with amendments) current on the date of submission of tender only.

c. Where the relevant standard provides for the furnishing of a certificate to the Employer, at his request, stating that the materials supplied comply in all respects with the standards, the Contractor shall obtain the certificate and forward it to the Engineer.

d. The specifications, standard and codes listed below are made a part of this specification. All standards, tentative specifications, specifications, code of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

e. If no standard is indicated, the relevant Indian Standard, if any, shall apply, Indian standards are published by:

Bureau of Indian Standards
Manak Bhavan,
9, Bahadur Shah Zafar Marg,
NEW DELHI – 110 002.

f. In case of discrepancy between the specification and the Standards referred to herein, the Specification shall govern.

i) Materials – Applicable Indian Standards:

IS: 269-1989	Specification for ordinary and low-heat Portland cement.
IS: 383 – 1970	Specification for coarse and fine aggregates from natural sources for concrete.
IS: 515-1959	For concrete
IS: 432 – 1982	Specification for mild (part I & II) steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS: 455 – 1989	Specification for Portland slag cement
IS: 1489 – 1991	Specification for Portland pozzolana cement
IS: 1786 – 1985	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS: 4990 - 1993	Specification for plywood for concrete shuttering work.
IS: 780-1984	Specification for sluice valves for water works purposes (50 to 300mm size)
IS 2906-1984	Specification for sluice valves for water works purposes (350 to 1200mm size) (Protective coating)
IS: 6909 – 1990	Specification for super sulphated cement
IS: 8041 – 1990	Specification for rapid hardening Portland cement
IS: 8043 – 1991	Specification for hydrophobic Portland cement
IS: 8112 – 1989	Specification for 43 grade ordinary Portland cement
IS: 12269 – 1987	Specification for 53 grade ordinary Portland cement
IS: 1726 – 1991	Specification for Cast Iron Machine holes Covers and Frames.
IS: 883 – 1994	Code of practice for design of structural timber in building.
IS: 1077 – 1992	Common Burnt Clay Building Bricks – Specification.
IS: 8329-2000	Centrifugally cast (spun) Ductile iron pressure pipes for water, gas and sewage.

ii) Tests

IS: 516 - 1959	Method of test for strength of concrete
IS: 1199 – 1959	Method of sampling and analysis of concrete
IS: 2386 – 1963	Method of test for (Part I & VIII) aggregate for Concrete
IS: 5640 – 1970	Method of test for determining aggregate impact value of soft coarse aggregates
IS: 2720-1972	Methods of test for soils (Parts I & XLI) (latest revisions)
IS: 3025 – 1964	Method for sampling and test (physical and chemical) for water used in construction.

iii) Code of practice

IS: 456 – 2000	Plain and Reinforced concrete – Code of Practice
IS: 800 – 1984	Code of practice for general construction in steel
IS: 2502 – 1963	Code of practice for bending and fixing of bars for concrete reinforcement
IS: 3558 – 1983	Code of practice for use of immersion vibrators for consolidating concrete
IS: 10005 – 1994	SI Units and Recommendations for the use of their Multiples and of certain other units.
IS: 10262 – 1982	Recommended guidelines for concrete mix design.

iv) Construction Safety

IS: 3696-1987,1991	Safety code of scaffolds (Parts I & II) and ladders (latest revisions)
IS: 2750 – 1964	Specification for steel scaffolding
IS: 3764 – 1992	Code of safety for excavation work
IS: 7969	Safety code for handling and storage of building materials.

v) Steel

IS: 2751 – 1979	Code of practice for welding of M.S. Plain & Deformed Bars for reinforced concrete construction
IS: 9417 – 1989	Recommendations for welding cold worked steel bars for reinforced concrete construction
IS: 10790 - 1984	Methods of sampling of steel for pre stressed and reinforced concrete part 2 Reinforcing steel.
IS: 1566 – 1982	Specification for Hard-drawn steel wire fabric concrete reinforcement.
IS: 280 - 1978	Specification for Mild Steel Wire for General Engineering.
IS: 19560-1982	Specification for mesh reinforcement.

vi) Brickwork plastering

IS:1077-1992 Requirements for common burnt clay building bricks.

IS: 2116 – 1980	Specification for Sand for masonry mortars.
IS: 3495 – 1992	Methods of test of Burnt clay Building Bricks. (Part 1 – 4)

vii) Sluice Valves

IS: 1364	Hexagon Head Bolts, Screws and Nuts of product Grade A and B (Part 1 – 6 latest revision)
IS: 638 – 1979	Specification for sheet rubber jointing and rubber insertion jointing.
IS: 2685 – 1971	Code of practice for selection, installation and maintenance of sluice valves.
IS: 14846 – 2000	Sluice valve for water works purposes (50 to 1200mm size) – Specification
IS:2806-1984	Specification for sluice valves for water works.
IS:1538-1993	Cast Iron fittings for pressure pipes

viii) Ductile Iron Pipes

IS: 8329 – 2000	Centrifugally cast (spun) Ductile Iron pressure pipes for water, gas and sewage - Specification
IS: 5382 - 1985	Specification for Rubber sealing rings for gas mains, water mains and sewers.
IS: 3400	Methods of test for vulcanized rubbers (Part 1 – 23 - latest revisions)
IS: 13655 – 1993	Guidelines for Heat Treatment of Cast Iron.
IS: 1500 – 2005	Methods for brine ll hardness test for metallic materials.
IS: 9523 – 2000	Ductile Iron fittings for pressure pipes for Water, Gas & Sewage – Specification.
IS: 12288 – 1987	Code of practice for use and laying of Ductile Iron Pipes.
IS: 2062 – 1999	Steel for General Structural purposes – Specification.

ix) MDPE Pipes and fittings

IS: 781 - 1984	Specification for cast copper alloy screw down bib taps and stop valves for water services
IS: 778 - 1984	Specification for copper alloy gate, globe and check valves for water work purposes.
IS: 2692 – 1989	Specification for Ferrules for Water Services.

x) Deleted

xi) Manuals

a) Manual on Water Supply and Treatment - CPHEEO (Central Public Health Environmental Engineering Organisation)

b) Manual on Sewerage and Sewage Treatment published by CPHEEO

c) Tamil Nadu Building Practice

Hand books:

SP 20 - Handbook on masonry design and construction.

SP 23 - Handbook on concrete mixes.

SP 34 - Handbook on concrete reinforcement and detailing

1.6 CONSTRUCTION WATER:

The Contractor shall make his own arrangement for the fresh water required for construction of civil works and testing of pipeline and hydraulic structures as well as for the potable water required for his labour camps.

1.7 CONSTRUCTION POWER:

The Contractor shall make his own arrangement for supply of electrical energy required at his sites and the works.

1.8 TEMPORARY FENCING:

The Contractor shall, at his own expense, erect and maintain in good condition temporary fences and gates along the boundaries of the areas assigned, if any, to him by the employer for the purpose of the execution of the works.

The Contractor shall, except when authorized by the Engineer, confine his men, materials and plant within the site of which he is given possession. The Contractor shall not use any part of the site for purposes not connected with the works unless prior written consent of the Engineer has been obtained. Access shall be made to such areas only by way of approved gateways.

1.9 SANITARY FACILITIES:

The Contractor shall provide and maintain in clean and sanitary condition adequate W.C.'s and wash places, which may be required on the various parts of the site or use of his employees, to the satisfaction of the Engineer. The Contractor shall make all arrangements for the disposal of sewage of drainage in accordance with the directions of the Engineer.

1.10 RESTRICTED ENTRY TO SITE:

The Contractor shall get the prior permission of the Engineer before any person not directly connected with the works to visit the site.

1.11 EXISTING SERVICES:

Drains, pipes, cables, overhead electric wires and similar services encountered in the course of the works shall be guarded from injury by the Contractor at his own cost, so that they may continue in full and uninterrupted use to the satisfaction of the Employer

and the Contractor shall not store materials or otherwise occupy any part of the 'site' in a manner likely to hinder the operation of such services. The Contractor must make good or bear the cost of making good, the damage done by him on any mains, pipes, cables or lines (whether above or below ground), whether shown or not shown in the drawings, without delay to the satisfaction of the Engineer and the Employer.

1.12 ELECTRIC POWER SUPPLY:

The Electrical Power required has to be obtained by the Contractor from the Tamil Nadu Electricity Board.

The Contractor is forewarned that there can be interruptions in power supply for reasons beyond the control of the Tamil Nadu Electricity Board and therefore the contractor is advised to make his standby arrangement to provide and maintain all essential power supply for his work area at his expense. The contractor shall not be entitled to any compensation for any loss or damage to his machinery or any equipment or any consequential loss in progress of work and idle labour as a result of any interruptions in Power supply.

1.13 NOTICE TO TELEPHONE, RAILWAYS & ELECTRICITY SUPPLY UNDER TAKING:

Before commencing operations the contractor has to obtain permission from local bodies / Highways Department when he wants to cut any section of the road. the employer will give necessary assistance such as sending letters and attending meetings if required. The employer will also pay necessary charges towards restoration of roads to the Corporation of Chennai / State Highways and National Highways. Any delay in getting the permission from the Corporation / Panchayats / Municipalities, State Highways Department, National Highways Department, Railway Department, Electricity Board, Telegraphs Department, Traffic Department attached to the police and other departments or companies for carrying out the work will be to the account of contractor.

The contractor before taking up operations, which involve cutting of roads, shifting utilities etc., during the progress of the work, shall give notice to the concerned authorities viz. the Corporation / Panchayats / Municipalities, State Highways Department, National Highways Department, Railway Department, Electricity Board, Telegraphs Department, Traffic Department attached to the police and other departments or companies as may be affected by the work. The notice should identify the specific details so that the necessary diversion of traffic may be arranged and permissions obtained. The contractor shall co-operate with the department concerned and provide for necessary barricading of roads, protection to existing underground cables etc., met with during the excavation of trenches. The contractor shall provide at his own expenses watching and lighting arrangements during day and night and erect required notice board such as "Caution Road closed for Traffic" etc.,. He should also provide and maintain at his own cost the necessary supports for underground cables etc., to afford best protection to them in consultation with the authorities in charge of the properties and to their best satisfaction. The contractor has to make necessary arrangements to get supply of electricity from TNEB for operating the machinery and equipment's. The employer will pay the necessary service connection and S.D charges. The contractor should obtain all approvals for installation and commissioning of machinery and accessories offered by them from the respective inspecting authorities such as CEIG or CEFG etc., Fees if any, to be paid to the inspecting authorities will be reimbursed by the Employer.

1.14 PERMISSION FOR ROAD CUTS:

Wherever the Contractor considers that it is necessary to cut through an existing road or track he shall submit details to the Engineer for approval, a minimum of seven days before such work commence.

In the event of cutting a road by the Contractor without the written permission from the Engineer, the Contractor shall be responsible for the cost of reinstating the road as undertaken by the Municipal Road Department or the Highways Department, as the case may be, notwithstanding the general procedures included in Chapter 5, Earthwork. Where all permissions are correctly obtained the cost of such reinstatement will be paid directly by the employer.

1.15 TEMPORARY DIVERSION OF ROADS:

During the execution of the work the Contractor shall make at his cost all necessary provision for the temporary diversion of roads, cart-tracks, footpaths, drains, water courses, channels etc., if he fail to do so, the same shall be done by the Engineer and the cost thereof will be recovered from the Contractor.

1.16 BARRICADING:

The trench shall be barricaded (Iron Barricading arrangements) on all four sides. The Contractor who has dug up the trench shall be responsible for any mishap, which may occur. Non-barricading of trenches by the Contractor shall be liable for a fine of Rs.500/- per day, per location from the interim payment certificates prepared in accordance with Sub Clause 60.2 of the conditions of particular application. Such deduction will not relieve the Contractor of any liability or duty under the Contract.

1.17 FILLING IN HOLES AND TRENCHES ETC.:

The Contractor immediately upon completion of the Works shall fill up holes and trenches which may have been made or dug, level the mounds, or heaps or earth that may have been raised or made, and clear away all rubbish which may have become superfluous or have been occasioned or made in the execution of the works, and the Contractor shall bear and pay all costs, charges etc.

1.18 ACCIDENTS:

It shall be the duty of the Contractor to arrange for the execution of the works in such a manner as to avoid the possibility of the accidents to persons or damage to the properties at any state of the progress of work. Nevertheless he shall be held wholly responsible for any injury or damage to persons and properties, which may occur irrespective of any precautions he may take during the execution of the works. The Contractor shall make good all claims and loss arising out of such accidents and indemnify the Employer from all such claims and expenses on account thereof.

1.19 WATER AND LIGHTING:

The Contractor shall pay all fees and provide water and light as required from Municipal mains or other sources and shall pay all charges, thereof (including storage tanks, meters etc.) for the use of the works and workmen, unless otherwise arranged and decided on by writing with Engineer. The water used for the works shall be free from earthy vegetable or organic matter and from salts or other substances likely to interfere with the setting of mortar or otherwise prove harmful to the work and conform to relevant standards.

1.20 PAYMENT TO LABOURERS:

The Contractor should note, that in the event of emergency, he shall pay all labourers every day and if this is not done, the Board shall make requisite payment and recover the cost from the Contractor. The Contractor shall not employ any labourer below age of 15 years.

1.21 EQUIVALENCE OF STANDARDS AND CODES:

Whenever reference is made in the contract to the respective standards and codes in accordance with which plant, equipment or materials are to be furnished and work is to be performed or tested the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly set forth in the contract. Where such standards and codes are national in character, or relate to a particular country or region, other authoritative standards which ensure equal or higher quality than the standards and codes specified will be accepted subject to the prior review and written approval by the Engineer. Difference between the standards specified and the proposed authoritative standards must be fully described in writing by the Contractor and submitted to the Engineer well in advance for approval. If on the prior review, the Engineer determines that such proposed deviations do not ensure equal or higher quality; the Contractor shall comply with the standards set forth in the contract documents.

The Contractor should use only accepted makes of materials and plant and should construct the entire Works according to Specifications, Standards, data sheets, drawings etc. If no makes are specified then only manufacturers of Plant and materials corresponding to the state of the Art technology and / or confirming to the latest Indian / International standards shall be used. Providing materials of approved quality and confirming to the standards does not relieve the Contractor from being responsible for the successful performance of all system components.

1.22 SAFETY PROVISION:

1.22.1 General Requirements for Health and Safety:

The safety provision shall be brought to the notice of all concerned by displaying on a notice board at a prominent place at the work spot, persons responsible for ensuring compliance with the safety provision shall be named therein by the Contractor.

To ensure effective enforcement of the rules and regulations relating to safety precautions, arrangements made by the Contractor shall be open to inspection by the Engineer or his representative and the inspecting officer.

Notwithstanding the above provision Contractor is not exempted from the operation of any other Act or rules in force relating to safety provisions.

1.22.2 Protection of the Public:

No material on any of the sites shall be so stocked or placed as to cause danger or inconvenience to any person or to the public. The Contractor shall provide all necessary fencing and lights to protect public from accidents and shall be bound to bear expenses of defense of every suit, action or proceedings of law that may be brought by any person for injury sustaining, owing to neglect the above precautions and to any such suit, action or proceedings to any such person or which may with the consent of the Contractor be paid to compromise any claim by any such person.

1.22.3 Scaffolding and Ladders:

The Contractor shall ensure that suitable scaffolds are being provided for workers for all the works, which cannot safely be done from the ground or from solid construction, except such short period work, as can be done safely from ladders.

When a ladder is used an extra mazdoor shall be engaged for holding the ladder and if the ladder is used for carrying materials as well, suitable footholds and handholds shall be provided on the ladder and the ladder shall be given an inclination not steeper than ¼ to 1 (¼ horizontal to 1 vertical). IS code for scaffolding and ladders, IS: 3696 Part – I and Part II and its latest revision is to be followed. Every ladder shall be securely fixed. No portable single ladder shall be over 7m in length. Width between side rails in rung ladders shall in no case be less than 30cm. for ladders; this width shall be increased by atleast 6mm for each additional 30cm length. Uniform steps spacing shall not exceed 30cm.

Scaffolding or staging more than 3.25 metres above the ground or floor swung or suspended from an overhead support or erection with stationary support shall have guard rail properly attached bolted, braced or otherwise secured atleast at 1 metre high above the floor or platform and the scaffolding of staging and extending along the entire length of the outside and ends thereof with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or the structure.

All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in a safe condition and no scaffold, ladder of equipment shall be altered or removed while it is in use.

1.22.4 Working Platforms:

Working platform, gangways and stairways shall be so constructed that they do not sag unduly or unequally and if height of a platform or gangways or stairway is more than 3.25 meters above ground level, it shall be closely boarded having adequate width and be suitably fenced as described in 1.24.3 above. Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing with a minimum height of 1 meter. Safe means of access shall be provided to all working platforms and other working places.

1.22.5 Precautions when using Electrical Equipment's:

Adequate precautions shall be taken to prevent danger from electrical equipment. When workers are employed on electrical installations, which are already energised, insulating mats, wearing apparel such as gloves, sleeves and boots, as may be necessary shall be provided. Workers shall not wear any rings, watches and carry keys or other materials, which are good conductors of electricity.

1.23 DEMOLITION:

Before commencing any demolition work and also during the process of the work, safety code for demolition of building IS: 4130 of the latest revision shall be followed:

a. All roads and open areas adjacent to the work site shall either be closed or suitably protected.
b. No electric cable or apparatus, which is liable to be a source of danger for a cable or apparatus used by operator, shall remain electrically charged.

c. All practical steps shall be taken to prevent danger to persons employed from risk or fire or explosion or flooding. No floor, roof or other part of a building shall be so overloaded with debris or materials as to render it unsafe.

1.24 SAFETY EQUIPMENT:

1.24.1 General Requirements:

All necessary personal safety equipment as considered adequate by the Engineer shall be available for use of persons employed on the site and maintained in a condition suitable for immediate use and the Contractor shall take adequate steps to ensure proper use of equipment by those concerned.

a. Workers employed on mixing asphaltic materials, cement and lime mortars / concrete shall be provided with protective footwear, hand gloves and goggles

b. Those engaged in handling any materials which is injurious to eyes shall be provided with protective goggles

c. Stone breakers shall be provided with protective goggles and protective clothing

d. When workers are employed in confined spaces (sewers, machine holes etc.), which are in use, the Contractor shall ensure that machine holes covers are opened and machine holes are ventilated atleast for an hour before workers are allowed to get into them. Machine holes so opened shall be cordoned-off with suitable railing and warning signals of boards provided to prevent accident to public. Before entry by any worker the Contractor shall ensure that a gas detector is lowered into the confined space and the atmosphere is shown to be safe.

e. The Contractor shall not employ any person below the age of 15 the work of painting with products containing lead in any form. Women shall not be employed on the work of painting with products containing lead in any form. Whenever men are employed on the work of lead painting the following precautions shall be taken:

i) No paint containing lead or lead products shall be used except in the form of paste of ready-made paint.

ii) Suitable face makes shall be supplied for use by workers when paint is applied in the form of spray or a surface having lead paints dry rubbed and scarped.

iii) Contractor shall supply overalls to workmen and adequate facilities shall be provided to enable working painters to wash during and on cessation of working periods.

1.24.2 Working near water:

When the work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provisions made for prompt first aid treatment of all injuries likely to be sustained during the course of the work.

1.24.3 Hoisting Machines:

Use of hoisting machines and tacks including their attachments, anchorage and supports shall conform to the following:

a) i) These shall be of good mechanical construction, sound material and adequate strength and free from patent defects and shall be kept in good repair and in good working order.

ii) Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength, and free from patent defects.

b) Every crane driver or hoisting appliance operator shall be properly qualified and no person under the age of 21 years shall be in-charge of an hoisting machine, including any scaffold winch or giving signals to operator.

c) In case of every hoisting machine and of every chain ring hook, shackle, swivel and pulley block used in hoisting machine or lowering or as means of suspension, safe working load shall be ascertained by adequate means. Every hoisting machine and all gear referred to above shall be plainly marked with safe working load in case of hoisting with safe working load. In case of hoisting machine having a variable safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or of any gear referred to above in this paragraph shall be loaded beyond safe working load except for the purpose to testing.

d) Engineer shall notify the safe working load of the machine in case of departmental machine. As regards Contractor's machine, the Contractor shall notify safe working load of each machine to the Engineer. Whenever he brings to the site of work and get it verified by the Engineer.

Motors, gearing, transmission, electrical wiring and other dangerous parts or hoisting appliance shall be provided with such means so as to reduce to the minimum risk and accident descend of load; adequate precautions shall be taken to reduce to the minimum risk of any part of a suspended load becoming accidentally displaced.

1.25 WORKING WITH EXPLOSIVES:

The Contractor shall obtain prior permission of the competent authority such as Chief of Fire services for the site, manner and method of storing explosives near the site of work. All handling of explosives including storage, transport shall be carried out under the rules approved by the "Explosive Department of the Government".

1.26 ENVIRONMENTAL PROTECTION WORK:

The Contractor have to take following measures during construction and commissioning of works for protection of environment as to avoid environmental impacts on air, water and land.

1.26.1 Site Clearance:

The site clearance shall be done with minimum damage to existing structures flora and fauna, electricity and telephone lines and other infrastructure service.

1.26.2 Earthwork and Excavation:

The Contractor shall inform the local authorities / government if any fossils, coins artifacts of value or antiquity, structures and other remains of geological or archaeological interests and excavation shall be stopped until identification of cultural relics by the authorised institution is complete.

The Contractor shall dispose of surplus / waste material at identified sites approved by the Engineer. The Contractor shall ensure that there is minimum hindrance to normal activities and business. The Contractor shall avoid damage to permanent structures and shall avoid loss of standing crops along the road.

1.26.3 Replanting of Trees and Bushes:

The Contractor shall carry out replantation on areas / on the periphery of construction sites to minimize visual impact and soil erosion. The Contractor shall pay special attention to the type of trees to be replanted to prevent fouling of water through falling leaves and bird droppings. A list showing the type of trees to be replanted shall be submitted to the Engineer for approval prior for undertaking any replantation.

1.26.4 Soil Erosion and Water Quality:

The Contractor shall ensure that earth and stone do not silt up existing irrigation / drainage systems. The Contractor shall take suitable measures to prevent direct discharge of polluted waters from construction activity into lakes / rivers / irrigation channels.

The Contractor shall minimize exposure of soil types susceptible to wind and water erosion. The Contractor shall control run-off and erosion through proper drainage channels and structures.

1.26.5 Soil Compaction:

The Contractor shall restrict traffic movements and use low ground pressure machines. The Contractor shall preserve topsoil to be replaced after completion of construction activity. The Contractor shall avoid wet soils as far as possible.

1.26.6 Social Disruption:

The Contractor shall minimize interruptions to utility services through proper planning and scheduling of activities. The Contractor shall provide temporary roads and diversions as may be necessary for smooth flow of traffic and people.

1.26.7 Dust / Air Pollution:

The Contractor shall provide effective dust control through sprinkling / washing of construction sites and access roads. The Contractor shall cover / water stockpiles and storage areas to prevent dust pollution. The Contractor shall cover trucks transporting construction materials to minimize spills. The Contractor shall have a preventive maintenance programme for construction equipment and vehicles to meet emission standards. Oil shall not be used to control dust.

1.26.8 Noise Pollution:

The Contractor shall normally undertake construction work during daytime only (between 7.30 to 18.00 hrs.) and when authorised to work beyond these hours adopt suitable noise control methods during such works. The Contractor shall maintain machines and trucks to keep them with low noise. The Contractor shall install sound barriers and plant tree as appropriate during construction. The Contractor shall monitor the level of noise near the construction site, factory sites and sensitive areas with the following frequency.

a) During construction period:	12 times a year each time including day and night.
b) During commissioning period:	4 times ad hoc monitoring

1.26.9 Construction Camps:

The Contractor shall take adequate measures such as provision of septic tank / pit latrines at construction site / camps. The Contractor shall provide crèches to working

women labour. The Contractor shall provide drinking water conforming to IS: 10500 – 1991 and its latest edition.

The Contractor shall provide garbage can at suitable fixed place and the garbage shall be disposed of regularly.

1.26.10 Aesthetic Improvement:

The Contractor shall through proper housekeeping enhance aesthetic appearance of construction sites. The Contractor shall dispose-off construction wastes at approved disposal sites. The Contractor shall repair pavements immediately following construction of pipeline and appurtenant structures.

The Contractor shall remove after completion of construction, all temporary structures and restore the project and surrounding areas nearest possible to the reconstruction condition.

1.26.11 Conservation of Ecological Resources:

The Contractor shall not use farmland and forest belts as materials borrow sites. The Contractor shall not select arable land as material borrow site. In case excavation in arable land is unavoidable, topsoil layer (30cms depth) shall be saved and returned after construction work is completed so as to minimize impacts on ecosystem, agriculture and animal husbandry. The Contractor shall educate construction workers to protect natural resources, wild plants and animals.

1.27 Use of Trade Names:

Wherever reference is made in the contract to specific manufacturers or trade names the Contractor shall be entitled to substitute Plant and materials supplied by other manufacturers or producers. Such substitution shall be to the approvals of the Engineer, which will not be unreasonably withheld. At the request of the Engineer the Contractor shall provide information to establish that the substituted Plant and materials are equivalent or better than those referred to.

1.28 Direction by the Engineer:

The Contractor is responsible for all activities relating to the construction of the works. Any reference in this Specification to the Engineer directing or ordering, prescribing etc. the Contractor shall be deemed to mean “Contractor to propose a methodology of construction and to submit to the Engineer for approval”. Any such approval by the Engineer shall not limit the Contractor’s responsibilities relating to construction of the Works. Notwithstanding this clause the Engineer shall be entitled to instruct the Contractor whenever the Engineer considers it necessary to do so. Where such an instruction is considered by the Contractor to represent additional work he shall inform the Engineer of his opinion before undertaking the work. No claim for additional work on the basis of an instruction by the Engineer can be considered where the Contractor has failed to provide such prior notification.

1.29 Special requirements:

All structural designs for the construction of Water Distribution Stations (WDS) were made based on the assumed soil safe bearing capacity furnished in the drawing. However, before commencing the execution, the contractor shall conduct detailed survey of the project area, soil investigation tests/ geotechnical investigations, study the earthquake/ seismological data specific to the region/project area and based on the study results, entire structural design has to be redesigned and vetted with a reputed Institution / Structural Engineer as directed by the Engineer. The contractor shall be responsible for

the safety of the structures, correctness of the design and drawing, even after the approval of the Engineer.

1.30 Definition of the Engineer:

Any reference in the Contract Documents to the Engineer in charge, or Board Engineer or Executive Engineer or departmental officers, shall be taken to mean the Engineer.

1.31 TEMPORARY REQUIREMENTS DURING THE CONSTRUCTION PHASE

During the construction phase of the Contract, the following temporary requirements are to be provided by the Contractor for Engineers use under this contract:- a) Site office for the Employers with water supply & sanitary arrangements b) Desk with 3 drawers with locks of size 1500mm x 900mm — 2 nos c) Chairs — 6 nos d) Oscillating desk top or wall mounted fan 400mm dia — 2 nos e) Personal computer of suitable capacity with an Inkjet printer – 1 no f) Pocket steel tape of 5mlength – 3 nos and g) During execution period of the work that is from award of contract to the start of the O&M Contract, the contractor shall provide to Employer abrand new A/C vehicle with driver and required fuel (diesel/ petrol) for day to day supervision of the project.

The expense towards the fuel, maintenance, driver's salary taxes, insurance etc. shall be borne by the contractor and will not be reimbursed by the Employer. In case, the contractor fails to provide the above facility, the Employer shall hire/arrange a suitable vehicle for the said work and deduct the expenses from the running bills of the contractor or a minimum sum of Rs.30,000 (Rupees Thirty Thousand only) per month from the running bills of contractor. In case of any dispute regarding the above, decision of the Employer shall be final.

CHAPTER 2 - SUBMITTALS

2.1 DESCRIPTION:

This section covers additional requirements for submission of schedules, samples, certificates etc., and forms a part of all other sections in which submittals are required. It is subjected to General Conditions of Contract.

Requirements of submissions to be included:

1. PERT / CPM Progress Schedule using project management software such as MS Project, Primavera or equivalent.
2. Samples of all materials pertaining to this work
3. Material lists and equipment
4. Factory test reports
5. Certificates
6. Laboratory test reports

2.2 REQUIREMENTS:

CPM Progress Schedule:

Within 30 days of award of the tender, the Contractor shall submit a critical path method analysis for construction progress control and make such revisions as are required for approval. He shall clearly indicate all construction activities, sub activities and mileposts on a time-oriented basis, with the critical path fully identified for all activities. He shall update and resubmit the charts monthly, flag all slippages and mileposts and attach a narrative description of the proposed corrective actions to the resubmitted charts. The Contractor shall include the following minimum information for each activity and critical path item:

i. Date and initial submittal, as applicable.
ii. Ordering dates for long lead time items.
iii. Dates for materials on site.
iv. Testing and clean up.
v. Final completion and handing over.

2.3 SAMPLES:

The Contractor has to submit samples of all materials used for the work prior to start of the works and get the approval of the Engineer in charge. He shall label or tag each sample or set of samples, identifying the manufacturer's name and address, brand name, catalogue number, project title he intends use.

2.4 MATERIAL LISTS AND EQUIPMENT DATA:

The Contractor has to submit all material lists, equipment lists etc. well in advance before starting the work and get the approval of the Engineer in charge.

CHAPTER 3 - SITE PREPARATION

3.1 CLEARING SITE:

Preliminary work are required to be done before laying of pipes including pegging out, clearing and disposal of shrubs, grasses, bushes, hedges, boulders, debris from the route.

This shall also include the removal of large trees, stumps, structures, service shifting of underground services such as cable, water supply, sewerage, storm water drains etc. or parts thereof lying along the alignment of pipe. The Contractor should inform the Engineer in charge before removing trees, structures and other services, etc. well in advance. The alignment of the mains shall be so fixed as to avoid cutting of any trees. Large trees and other valuables are the property of the Government and it should be properly stacked along the side of the road and conveyed to the places as per direction of the Department Engineer. The cutting of trees or demolition of structures are done in such a way that it should not disturb the traffic and cause inconvenience to the pedestrians.

3.2 REMOVAL OF TOP SOIL, SHRUBS AND OTHER VEGETATION:

All shrubs, vegetation and other plants shall be removed and cleared from the selected stretch of the site. All debris and unsuitable material up to a depth of 30cm between ground level or road level shall be removed. All debris and unsuitable material shall be carted away from the site as per the direction of Board Engineer up to a distance of 10 kms.

3.3 PROBING PITS:

Before starting the excavation of trenches, the contractor shall dig probing pits of size 1m x 1m and 1.5m deep including road cutting at every 100m interval along the alignment to accurately locate and determine the position of existing utilities and obstructions. The contractor shall refill the probing pits in layers of 15cm with excavated earth upto the original ground level. In all cases, the probing pits are to be excavated in accordance with the specification for excavation, refilling etc. No separate payment will be made for these probing pits.

3.4 UTILITIES PROTECTION:

All utility lines and structures, whether indicated on the drawings or not, which are to remain in service shall be protected by the contractor from any damage likely to result from his operations. Relocation wherever necessary will be done by the respective Service Departments on payment by CMWSSB separately. No extra payment will be made for minor relocation, which does not require dislocation from existing condition and shifting to other location. In such a condition, the service lines shall be pushed slightly to facilitate laying of main and brought back to original position after the work is completed wherever necessary. The service lines should be supported at bottom with planks, posts, etc. and tied with ropes properly. Any damage to any utility resulting from the Contractor's operations shall be repaired at the Contractor's expense.

3.5 PAVEMENT REMOVAL:

The Contractor must inform the other concerned departments well in advance before starting the work. The Contractor must provide and maintain proper and efficient traffic control system such as safety lamps, sign boards etc. operating day and night for the full duration of work. The CMWSSB shall not be responsible under any circumstances for any mishappenings therefore. For the purpose of payment for removal of pavement,

steel tapes are to be used and the Engineer's representative and Contractor or his representative shall take the measurement jointly. The width of trenches shall be as per the specification drawing and only such widths shall be taken into account for computing quantities for payment. The Contractor has to pay restoration charges for width excavated in excess of prescribed width. For other elements of work such as making cross connections, fixing other appurtenances etc. the Engineer shall prescribe the dimensions for removal of pavement from time to time.

3.6 MAINTENANCE OF TRAFFIC AND CLOSING OF STREETS:

The work shall be carried out in such a manner, which will cause the least interruption to traffic, and road / street may be closed in such a manner that it causes the least interruption to traffic. Where it is necessary for traffic to cross open trenches, suitable bridges shall be provided. Suitable signs indicating that a street is closed shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

3.7 INTERRUPTION TO SERVICE:

No valve or other control of the existing services shall be operated without the permission of the authority.

3.8 WORK DURING NIGHTS:

No extra payment will be made for doing the work in the nights. The Contractor shall get prior approval from the Engineer in charge before starting the work during nights. It is expected that the intensity of traffic is likely to be less in the night from 10.00 PM to 5.00 AM. Hence, for efficient uninterrupted work, the contractor shall equip himself with the required manpower, materials, and lighting arrangements to do the work in the nights.

CHAPTER 4 - DISMANTLING

4.1 DISMANTLING OF EXISTING STRUCTURES:

The structure shall be dismantled carefully and materials removed without causing damage to the serviceable material to be salvaged, the part of the structure to be retained and any properties of structures nearby. Any avoidable damage to the articles to be salvaged and part of the structure shall be made good by the Contractor without extra claims. The Contractor shall be responsible for any injury to the lookers or the public.

Structure should be removed 45cm below Ground and portion which in any way comes within new construction shall be removed entirely. Contractor shall maintain register or the salvaged material, which shall have signature of the Engineer on entries made.

All the material obtained from the removed structure shall be the property of client. Serviceable materials shall be stacked neatly in such a manner as to avoid deterioration at site or at other places. Non-serviceable materials shall be disposed off by the Contractor without causing any inconvenience.

All rubbish shall be cleared off the site and the Ground let clean and clear and Rubbish and non-serviceable materials shall be carted away upto a distance of 10kms as per the direction of Board Engineer.

4.2 MEASUREMENT AND PAYMENT:

The measurements of work shall be exact length and width and height of the dismantled structure. It shall be priced per unit of the cubic metre. Any excavation that may be necessary for dismantling the structure below 45cm from ground level shall be paid under the item of Excavation and shall include labour for refilling, watering and ramming, spreading on site if required and for disposal of surplus earth.

CHAPTER 5 - EARTH WORK

5.1 DESCRIPTION:

The work specified in this section includes the provision of all labour, machinery, construction equipment and other appliances required to perform all earthwork specified or required, in a sound, workmanlike manner.

5.2 GENERAL:

Excavation shall be required to be done for the following works:

a) Excavation for underground pipelines.
b) Excavations for valve chambers, Thrust blocks and Special structure,
c) No separate payment shall be made for removal of shrubs, which are less than 100mm in diameter at breast height, grass, small bushes and stumps. The alignment of the main shall be so fixed as to avoid cutting of any trees.
d) No extra payment shall be made to the Contractor for working in a confined space.

5.3 CLASSIFICATION:

The excavation work shall be classified into the following categories by inspection of faces of cutting:

i) Loamy, clayey soils like black cotton soils, red earth, hard gravel, mixture of gravel and soft disintegrated rock like shale, ordinary gravel, stony earth and earth mixed with fair sized boulders, except rock requiring blasting, chiseling, wedging etc.

ii) Hard rock and boulders to be removed by benching, chipping, chiseling, wedging, barring and by controlled blasting wherever permissible.

5.4 TRENCH EXCAVATION:

General:

Trench excavation means excavation of trenches into which the pipe is to be laid. Before commencing trench excavation, the route of the trenches shall be pegged out accurately and the natural ground levels and the alignment shall be agreed with the Engineer in charge. The Contractor shall dig probing pits or appropriate size and depth including cutting the road at every 100m interval or as directed by Engineer in charge. The quantity of excavation beyond the normal dimensions will be paid under relevant items of excavations in various stages.

Stripping Surface Materials:

Before the surface of any part of the site is disturbed or the works there on are started, the Contractor shall take and record levels in the presence of the Engineer or his representative. Before commencing the excavation, the surface materials shall be carefully stripped and set aside for reuse as directed by the Engineer.

5.5 WIDTH OF TRENCH:

The width of the trench at bottom between the faces of sheeting shall be Nominal diameter of the pipe plus 300mm clearance on either side of the pipe. Trenches shall be of such extra width, when required as will permit the convenient placing of timber supports, strutting and planking and handling of specials.

The width of trenches measured at the crown of the pipe shall permit adequate working space. The trenches shall be widened at sockets and other structures as may be found necessary. Payment for excavation shall be made on quantity basis as per width given in the Table. Care should be taken to avoid excessive trench width and thereby increasing the load on the pipes.

5.6 DEPTH OF EXCAVATION OF TRENCHES:

The depths for the trenches will be calculated from the surface to the bed of the pipes and in case when a layer of bedding is to be placed below the pipeline, the depth to the bottom of the bedding will be paid.

The trench shall be so dug that the pipeline may be laid to the required gradient and to the required depth, mentioned in the Table below. A minimum cover of 1.0m is to be provided above the crown level of pipe upto the Ground level / Road level.

TABLE SHOWING DETAILS OF TRENCH SIZE

Diameter (mm)	Trench width (m)
100	0.50
150	0.55
200	0.60
250	0.65
300	0.70
350	0.75
400	0.80
450	0.85
500	0.90
600	1.30
700	1.40
750	1.45
800	1.50
900	1.60
1000	1.70
1100	1.80
1200	1.90
1300	2.00
1400	2.10
1500	2.20
1600	2.30

5.7 MAXIMUM LENGTH OF OPEN TRENCH:

Except by special permission of the Engineer, only that length of trench excavation shall be permitted in advance of the pipe jointing, such that laying and jointing of pipes can reasonably be expected to be completed and the trench refilled not later than 3 days after excavation of the trench. The Contractor will not be permitted to keep trenches open for unduly long periods, creating public hazards. The Engineer's decision in this respect shall be final.

5.8 TRENCH SIDES

Loose boulders shall be removed from the sides of the trenches before allowing workmen into the excavation, and the trench sides shall be stabilized with screening or other methods approved by the Engineer. Trench slopes shall be kept moist where necessary as ordered by the Engineer to prevent local sliding.

5.9 WIDENING TRENCH AT JOINTS, ETC.

Any widening or deepening of the trench, whether in ordinary soil or rock, necessary to accommodate curves, joints or bends as shown on the drawings or ordered by the Engineer shall be carried out by the Contractor, after taking all the necessary safety measures.

5.10 OVER-EXCAVATION OF TRENCH BOTTOMS:

All excavation carried below the grades shown on drawings or bottom of the bedding shall be refilled with sand / concrete at the Contractor's expense.

5.11 EXCAVATED MATERIAL:

The material from the excavation shall be deposited on either side of the trench leaving clear berm on one side at least 40cm wide or at such further distance from the edges of the trench as may be necessary to prevent the weight of materials from causing the side of the trench to slip or fall, or at such a distance and such a manner as to avoid any wall or structure or causing inconvenience to the public or other persons or otherwise as the Engineer may direct, till it is carted away.

The excavated soil should be so placed and handled as not to inconvenience the usual traffic, till it is carted away. The Contractor should also provide necessary bridging over the excavated trenches for the house-holders and pedestrians to cross over and vehicular crossings if and where required at no extra cost; if the Engineer decides that there is no hindrance to traffic due to not carting away the excavated earth, he will give instructions to that effect. The Contractor shall be responsible for making all arrangements for the disposal of surplus excavated material upto a distance of 10kms.

5.12 PIPE BEDDING:

i) Sand Bedding:

Where specified by Engineer, the river sand bedding of required thickness and level shall be provided below pipe prior to laying the pipe in trenches. It shall be compacted with a light hand hammer. Any reduction in compaction shall be made up by adding sand during ramming. For the purpose of bedding under this item, only screened fine sand of grain size not larger than 2mm shall be used. The sand shall be clean, uncoated and free from clay lumps, injurious amount of dust, soft particles, organic matter, loam or other deleterious substances.

If the sand supplied is unclean, it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities described in IS: 383 shall apply. Sieved and washed sand shall be stored on the works in such a manner as to prevent intrusion of any foreign matter, including coarser particle of sand or any clay or metal or chips. Tests as indicated above shall be performed if called for by the Engineer at the expense of the Contractor.

ii) Concrete Bedding:

This type of bedding is as per the drawing appended with the tender document and is to be provided at locations shown in the drawings or as specified by the Engineer. A concrete bedding using M15 grade is to be adopted. The concrete work related to this specification is detailed in the specifications of concrete and allied works.

5.13 EXCAVATION FOR APPURTENANCES:

Excavation in trenches for foundation of valve chambers, pedestals etc. shall be as per the plan or as directed by the Engineer. The dimensions of the excavation shall be measured as the projection in plan of the outermost edges of the structure.

5.14 KEEP EXCAVATION CLEAR OF WATER:

Where ground water is encountered or anticipated, the Contractor shall provide sufficient pumps to handle the ingress of water and must provide and maintain in working order. Standby pumping units are to be made available and employed in the event of mechanical failure. The Contractor must also arrange for night and day operation of the pumps wherever necessary to ensure that the work proceeds at all times.

5.15 DEWATERING IN AREAS OF HIGH WATER TABLE:

The Contractor shall perform dewatering as required so that all works of the contract are installed on dry areas and excavations, including without limitation the construction of all structures and underground piping. The Contractor shall ensure that dewatering is carried out only to a depth sufficient for the required excavation. The Contractor shall also ensure that, at all times, during construction, no groundwater shall come into contact with any concrete surface or reinforcement and that any structure shall be capable of withstanding any hydrostatic pressure to which it may be subjected during construction and until completed.

The Contractor shall be deemed to have included in the tender price for maintaining all works in a dry condition during construction. Any water removed from excavations shall wherever practicable, be pumped directly to the natural drainage channel or to storm sewers if approved via an efficient system of discharge lines. No water may be discharged into the sewerage system or onto open spaces.

The Contractor shall include for the diversion of all water courses encountered in the work until the scheme is completed and put into operation.

Notwithstanding any previous approval, the Contractor shall be fully responsible for maintaining dry excavations.

Where deemed necessary by the Engineer, working drawings and data shall be submitted for review or approval showing the intended plan for dewatering operations. Details of locations and capacities of dewatering wells, well points, pumps, sumps, collection and discharge lines, standby units, water disposal methods, monitoring and settlement shall be included. These shall be submitted not less than 30 days prior to start of dewatering operations.

The static water level shall be drawn down to a minimum of 300mm below the bottom of the excavation so as to maintain the undisturbed state of the foundation soils and allow the placement of any fill or backfill to the required density. The dewatering system shall be installed and operated so that the groundwater level outside the excavation is not reduced to the extent that would damage or endanger adjacent structures or property.

The contractor shall, where extensive dewatering is required, be fully qualified to perform the dewatering operations or shall furnish the services of an experienced, qualified, and equipped Dewatering Subcontractor to design and operate the dewatering and ground water recharging systems required for the work, all subject to the Engineer's approval.

Where considered necessary by the Engineer, the Contractor shall establish a specified number of ground water level monitoring stations at each site which will be observed during the work. These shall be located as directed by the Engineer and consist of acceptable open tube piezometers. As directed settlement gauges will be provided to the approval of, and designated by, the Engineer at each site, times and locations to monitor settlement of new and existing facilities.

Dewatering shall not result in the flow of water along the pipe zone material. Full consideration should be given to the use of cut-off walls to reduce the potential for ground water flow along pipe trenches. The contractor shall submit for the Engineer's approval, details of his proposed method of working and temporary works installations to achieve this.

No dewatering system shall be removed without the approval of the Engineer, Monitoring and settlement measurement systems shall be maintained in operation until removal is approved by the Engineer. To the extent approved by the Engineer, well points and like items may be abandoned in place.

5.16 UNSOUND FOUNDATIONS, SOFT SPOTS:

When the specified levels of trench or structure 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 Contractor to excavate further and the further excavation shall be filled with concrete M-10 or river sand. Should the bottom of any trench or structure excavation, while acceptable to the Engineer at the time of his inspection subsequently become unacceptable due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. In this case, the cost of the extra excavation and of the additional foundation materials required will be the Contractor's responsibility if necessitated by his negligence.

The omission by the Engineer to give an instruction under this Clause shall not relieve the Contractor from any responsibility for defect in the works due to the construction being placed upon an unsuitable formation if prior to the construction of the work the Contractor shall have failed to call the attention of the Engineer thereto in writing.

If in the opinion of the Engineer, a formation is unsound as a result of the Contractor failing to keep the excavation free from water, the Engineer will order the removal and disposal of the unsound material and filling of the resulting void. The Contractor shall execute the work as directed and shall have no claim against the Board for any costs thus incurred.

5.17 CAUTION CUM INFORMATION BOARDS:

Before commencing an excavation, "Caution-Cum-Information" board shall be installed at site by the Contractor. Such board shall remain at site as long as the trench remains open. The board shall be installed at both the ends of the trench atleast 100m before the approach to the area, if the trench is less than 600m in length. Additional boards at every 300m shall be installed, if the length of the trench exceeds 600m. If the streetlight is inadequate, lettering with fluorescent paint shall be used for these boards. The boards shall also contain information regarding dates of commencement and completion of the work, name and phone number of the Engineer in charge of the work. See also Clause 5.19. The size of lettering shall be adequate to be read by passing vehicles.

5.18 BARRICADING:

To prevent persons from injury and to avoid damage to the property, adequate barricades, construction sign, torches, red lanterns and guards as required shall be provided and maintained during the progress of the construction work and until it is safe for traffic to use the roadways. The pipe laying trenches, manhole trench shall be barricaded on all four sides. Barricading arrangements consists of Providing Iron Barricading of size 2.50 m width and 1.75 m height using 40x40x4 mm angle for outer frame supports, 25 x 25 x 3 mm angle for inner frame supports and 20 gauge thickness MS sheet for name board (as per drawing) including cutting, welding, fabrication charges and one coat of primer and 2 coats of enamel paint of approved quality, writing "METRO WATER" & work detail/ caution sign, providing necessary interlocking arrangements with adjoining units, fixing danger flags, danger lights, reflectors, fixing stickers etc, including watching during night and placing the barricading units as directed at the sites. The Contractor who has dug up the trench shall be responsible for any mishap, which may occur.

5.19 FENCING, WATCHING, LIGHTING:

The parts of the fencing shall be of timber, securely fixed in the ground not more than 2.50m apart, they shall not be less than 10cm in dia. or not less than 1.25m above the surface of the ground. There shall be no two rails, one near the top of the posts and the other about 0.50m above the ground and each shall be of 5cm to 10cm in diameter and sufficiently long to run from post to post to which they shall be tied with strong ropes. The method of projecting rails beyond the posts and tying together where they meet will not be allowed on any account. All along the edges of the excavated trenches, a bund of earth about 1m high shall be formed when so required by the Engineer for further protection. Proper provision shall be made for lighting at night and watchmen shall be kept to see that this is properly done and maintained. In addition to the normal lighting arrangements, the Contractor shall provide, whenever such work is in progress, battery operated blinking lights (6 volts) in the beginning and end of a trench with a view to provide suitable indication to the vehicular traffic. The Contractor shall also provide and display special boards printed with fluorescent prints indicating the progress of work along the road. In the event of the Contractor not complying with the provisions of the clause, it may be carried out by the Engineer and the cost recovered from the Contractor besides claiming liquidity damages from the Contractor. In all such cases the work may be carried out by Board. The Contractor shall be held responsible for all claims for compensation as a result of accident or injury to persons / non-provision of red flags.

The Contractor shall at his own cost provide all notice boards before opening of roads as directed by the Engineer.

Arrangements shall be made by the Contractor to obtain permission from CMC and traffic authorities for working and to direct traffic when work is in progress. No separate payment shall be paid for this item of work.

5.20 REFILLING TRENCHES:

a) With a view to restrict the length of open trenches, on completion of the pipe laying operations, refilling of trenches shall be started immediately by the Contractor. Pipe laying and testing shall follow closely upon the progress of trench excavation and the Contractor shall not be permitted more than 500 metres of trench excavation to remain open while awaiting testing of the pipe line.

b) i) Refilling with excavated earth:

The trenches shall be refilled with excavated soil not exceeding 15 cm layers. Each layer being watered, rammed and properly consolidated before succeeding pipes are laid.

ii) Refilling with quarry dust:

Where corrosive soils are met, on approval of Engineer, bedding with river sand and refilling with quarry dust should be done.

c) Care shall be taken while back filling, not to injure or disturb the pipe. Filling shall be carried out simultaneously on both the sides of the pipes so that unequal pressure does not occur.

d) Walking or working on the completed pipelines shall not be permitted unless the trench has been filled to a height of at least 30cm over the top of the pipe except as may be necessary for tamping etc., during back filling work.

e) Filling-in shall be done in layers not exceeding 150mm in thickness accompanied by adequate watering, ramming etc. so as to get good compaction upto 300mm above the top of the pipe. Above this level, sea sand shall be placed in layers of 200mm watered and compacted by tamping.

f) The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place.

g) Before and during the backfilling of the trench, precautions shall be taken against the floatation of the pipeline due to the entry of large quantities of water into the trench causing an uplift of the empty or the partly filled pipeline.

5.21 MEASUREMENT AND PAYMENT:

The payment of excavation shall be made on quantity basis as per the actual dimensions of the trench excavated limited to the width as per specification drawings.

a) Trench Excavation:

The length of the trench excavation shall be measured along the center line of pipe at various depths stated in the Bill of Quantities, the total length being segregated into stretches according to the various depths of excavation contained in the Bill of Quantities to fall into the specified categories. Within each stretch, the depth applicable shall be within the range specified in Bill of Quantities.

The depth of excavation shall be measured from the top of the trench at the center before excavation upto the bottom of the bedding under the pipe. If no bedding is provided, the measurement shall be to the top level of the bottom of the pipeline. The width of the trench shall be measured on the basis of the specification drawing. No additional payment shall be made for the deepening and widening at sockets specials, hunching or surrounds beyond the dimensions mentioned in the specification drawing. For excess width excavated the road cutting charges to be paid by the Contractor.

The measurement of depth and width of trench shall be taken at every 20 metres along the alignment and at every change in direction and diameter of the pipe.

b) Structure:

Measurement for structure excavation shall be made as per the projection in plan of the outermost edges of the structure as per the plan at the bottom.

c) Rock excavation:

The depth of rock excavation measured for payment shall not exceed the corresponding depth in ordinary excavation plus 150mm both for structure and trench excavations. The maximum trench widths measured for payment in rock excavations will be as per specification drawing.

In all above cases, no payment will be made for additional selected fill, lean concrete, bedding cradling or hunching concrete that may be specified or ordered by the Engineer as a consequence of excavating beyond the limits specified in the contract documents or ordered by the Engineer.

d) Disposal of excavated material:

All the excavated material shall be carted away and the contractor shall be paid in the following manner for disposal of the same. An item is provided in the bill of quantities and it includes loading, unloading, transporting to a site upto a distance of 10 kms as directed by the Engineer.

e) For excess width of excavation than specified, no payment will be made and the Contractor has to bear the cost of restoration.

5.22 PERMANENT REINSTATEMENT:

a. By Contractor :

Other than Municipal roads all asphalt roads together with other paved areas shall have the permanent reinstatement carried out by the Contractor in accordance with the requirements of the appropriate. Authority shall comprise the provision of surfacing at least equal to that existing immediately before the Contractor first entered thereon.

The contractor shall carry out the permanent reinstatement in accordance with a programme agreed with the Engineer. Permanent reinstatement of private lands will comprise the provision of surface at least equal to that existing immediately before the Contractor first entered thereon.

All permanent reinstatement shall include the contractor's return to site at regular intervals during the period of maintenance to carry out works necessary to ensure that surfaces are finally left in a condition at least equal to that existing before the contractor first entered there on.

The cost of permanent reinstatement including such visits and any remedial work as well as charges to be paid to the concerned authority shall be deemed to have been included in the contract price.

b. Highways:

Restoration and re-instatement of Highways head and sidewalk surface shall be done by Highway Department and CMWSS Board will pay the cost.

c. Municipal Roads:

The reinstatement of the Municipal roads, i.e. Asphalt and WBM roads and side walk surface will be carried out by the Municipal Roads Department of the Chennai Municipal Corporation or by the Highways Department and CMWSSB Board will pay the cost.

d. Private properties:

However, any damages to the private properties such as compound wall, fencing, etc. during the execution or immediately afterwards due to contractor carelessness, the same has to be restored by the Contractor to the original shape at Contractor's own cost.

5.23 SHORING AND STRUTTING:

Open cuttings and trenches shall be suitably shored, sheeted and braced, if required by the Engineer or by site conditions or to meet local laws, for protecting life, property of the work.

Adequate shoring and strutting shall be provided by the Contractors at their own cost. Warped or deformed timber shall not be used. The shoring shall project at least 150mm above ground level and shall extend to a suitable depth below the bottom of the trench. Wherever necessary, the planks or struts shall be driven by compressed air pile drivers. The planks shall be fixed close enough to avoid any running in of sand earth through the joints. The shoring material shall not be of sizes less than those specified below, unless steel sheet piling is used or unless approved by the Engineer in writing.

a) Planks : 38mm thick

b) Walling pieces : 100 cm x 100 cm

c) Struts : 15 cm x 20 cm

For walling pieces round timber shall not be allowed. In a vertical plane, there shall be at least three struts or more as directed by the Engineer. They shall rest on walling pieces. The spacing of the struts shall be as per the requirement of the design. At the bottom, extra struts shall have to be provided if ordered by the Engineer. The rates for excavation do not include the cost of shoring, which shall be paid for separately as per relevant item of the Bill of Quantities. The Contractors shall be held responsible for providing secure shoring, and for adopting every other precaution, which may be necessary for protecting nearby structures, which are likely to be damaged as a result of excavation. The Contractors shall design the shoring required for actual site conditions and shall provide shoring accordingly. The design shall be submitted to the Engineer on demand. The shoring shall be so designed that lowering of pipe of normal length or any other pipe laying operation does not necessitate the removal of any strut or any other member of shoring. If the Engineer requires the adoption of any special measures or precautions, the Contractor will comply with the same immediately. If any part of a nearby structure is cut out or removed for facility of work, the same shall be made good on completion of the work by the Contractors at their cost.

In the event of the Contractors not complying with the provisions of this contract in respect of shoring the Engineering may, with or without notice to the Contractors, put up shoring or improve shoring already put up or adopt such other measures as he may deem necessary, the cost of which shall be recovered from the Contractors. Such action on the part of the Engineer, shall not, however absolve the Contractors of their responsibilities under this contract.

No part of the shoring shall, at any time, be removed by the Contractors without obtaining permission from the Engineer. While taking out shoring planks, the hollows formed shall be simultaneously filled in with soft earth and shall be well compacted as directed.

No payment will be made if the Contractors leave shoring material in the trench on his own or merely to suit their own convenience. The work of providing shoring shall be measured and paid for one the basis of areas of planks provided up to ground level and no separate payment will be made for providing and fixing of walling pieces, struts, dog spikes etc. the cost of which shall be deemed to have been covered by the rate for shoring.

The planks shall project at least 150mm above the ground level. For the purpose of payment, however, measurements shall be taken up to ground level only and no payment will be made for planking above ground level.

5.24 QUALITY CONTROL TEST:

Trenches other than in roads and paved areas shall be backfilled as specified in Clause 5.19.

Trenches other than in roads and paved areas shall be back filled with selected excavated material. Compaction of dry density of the material as per the compaction control tests procedure as specified below shall be obtained.

a) Moisture control test one test for every 250 cubic meters of soil.

b) Compaction control test

A minimum of one field density test (as per IS:2720-part XXVIII) for each 500 sq.m of the compacted area of each layer. Result shall be based on the mean value of a set of 5 to 10 density determination.

CHAPTER 6 - BRICK WORK

6.1 BRICK WORK:

6.1.1 Masonry Mortars:

Proportioning:

Mix proportion of cement sand mortar shall be as indicated. The mixes specified are by volume. 50 kg. of cement shall be taken as equal to 0.035 cum. to determine bulk. The quantity of water to be added to cement sand mortar shall be such that working consistency is obtained. Excess water shall be avoided.

Preparation of Cement Mortar:

Mixing shall be done preferably in a mechanical mixer. If done by hand, mixing operation shall be carried out on a clean watertight platform. Cement and sand shall be mixed dry in the required proportion to obtain a uniform colour. The required quantity of water shall then be added and the mortar hoed back and forth for 5 to 10 minutes with additions of water to a workable consistency. In the case of mechanical mixing, the mortar shall be mixed for atleast three minutes after addition of water. Cement mortar shall be freshly mixed for immediately use. Any mortar, which has commenced to set, shall be discarded and removed from the site.

Time of use of Mortar:

Mortars with cement as an ingredient shall be used as early as possible after mixing, preferably within half an hour from the time water is added to the mix or at the latest within one hour of its mixing.

Workability of Masonry Mortar:

The working consistency of the mortar is usually judged by the work during application. The water used shall be enough to maintain the fluidity of the mortar during application, but at the same time it shall not be excessive leading to segregation of aggregates from the cement.

6.1.2 Brick Masonry:

a. Manufacture:

Common burnt clay building bricks shall conform to the requirements of IS: 1077 and shall be of quality not less than class 20 with moisture absorption rate not exceeding 15 percent as defined in IS:1077. The bricks shall be chamber burnt and shall have sharp corners and smooth faces and shall not be damaged in any manner and sizes shall conform to the works sizes specified with tolerances as given in 6.2 IS: 1077.

b. Samples:

The Contractor shall deliver samples of each type of brick to the Engineer, and no orders shall be placed without the written approval of the Engineer. All the bricks used in the works shall be of the same standard as the approved samples. The samples shall be preserved on site, and subsequent deliveries shall be checked for uniformity of shape, colour and texture against the samples. If in the opinion of the Engineer any deliveries vary from the standard of the samples, such bricks shall be rejected and removed from the site. Samples of bricks shall be tested in accordance with IS: 3495 by the Contractor.

c. Uniformity:

The bricks selected for exposed pointed brickwork walls shall be of uniform colour, deep cherry red or copper colour, and uniform texture. Only such bricks as are permitted by the Engineer shall be used.

6.2 SETTING OUT:

All brickworks shall be set out and built to the respective dimensions, thickness and heights as indicated.

6.3 SCAFFOLDING:

Scaffolding shall be strong to withstand all dead, live and impact loads, which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work overhand work shall not be allowed.

For exposed brick facing double scaffolding having two sets of vertical supports shall be provided. For brickwork, which is to be plastered over, single scaffolding may be provided. In single scaffolding one end of the putlogs shall rest in the hole provided in the header course of brick masonry. Not more than one header for each putlog shall be left out. Such holes shall not be allowed in the case of pillars of narrow masonry portions between openings, which are less than one metre in width or are immediately under or near the structural member supported by the walls. The holes left shall be made good on removal of scaffolding to match with the face work / surrounding area.

Timber or bamboo scaffolds shall be erected in accordance with the provisions contained in IS: 3696 (Part I) - 1987. Safety code for scaffolds and ladders, Part I - Scaffolds, to ensure safety of workmen and others. Steel scaffolding shall be erected in accordance with the provisions contained in IS: 2750-1964. Specifications for steel scaffolding and relevant provisions of IS: 3696 (Part I) - 1987 for safety code for scaffolds (Parts I & II) and ladders shall be followed.

6.4 SOAKING OF BRICKS:

Bricks shall be soaked in water before use for a period of the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When bricks are soaked, they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked-on clean place, where they are not again spoiled by dirt, earth, etc.

6.5 LAYING:

All loose materials, dirt and set lumps of mortar which may be laying over the surface on which brickwork is to be freshly started, shall be removed with a wire brush and surface wetted slightly. Bricks shall be laid on a full bed of mortar. When laying, the bricks shall be properly bedded and slightly pressed with handle of trowel so that the mortar can get into all the pores of the brick surface to ensure proper adhesion. All the joints shall be properly flushed and packed with mortar so that no hollow spaces are left. Care shall be taken to see that the required quantity of water is added to the mortar at the mixing platform to obtain required consistency. Addition of water during laying of the course shall not be permitted. In the case of walls two bricks thick and over, the joints shall be grouted at every course in addition to bedding and flushing with mortar.

Bricks shall be laid with frog up. However if the top course is exposed, bricks shall be laid with frog down. Care shall be taken to fill the frogs with mortar before embedding the bricks in position.

All quoins shall be accurately constructed and the height of courses checked with storey rods as the work proceeds. Acute and obtuse quoins shall be bonded, where practicable, in the same way square quoins; obtuse quoins shall be formed with squint showing a three quarter brick on one face and quarter brick on the other.

6.6 BOND:

All brickwork shall be built in English Bond, unless otherwise indicated. Half brick walls shall be built in stretcher bond. Header bond shall be used for walls curved on plan for better alignment. Header bond shall also be used in foundation footings, stretchers may be used when the thickness of wall renders use of headers impracticable. Where the thickness of footings is uniform for a number of course of the footings shall be headers.

Half or cut bricks shall not be used except where necessary to complete the bond.

Overlap in stretcher bond is usually half brick and is obtained by commencing each alternate course with a half brick. The overlap in header bond which is usually half the width of the brick is obtained by introducing a three quarter brick in each alternate course at quoins. In general, the cross joints in any course of brickwork shall not be nearer than a quarter of brick length from those in the course below or above it.

6.7 UNIFORMITY:

The brickwork shall be built in uniform layers; corners and other advanced work shall be raked back. No part of a wall during its construction shall be raised more than one metre above the general construction level, to avoid unequal settlement. Parts of walls left at different levels shall be properly raked back. Toothing may be done where future extension is contemplated but shall not be used as an alternative to taking back.

For half brick partition to be keyed into main walls, indents shall be left in the main walls.

6.8 THICKNESS OF JOINTS:

The thickness of joints shall be 10mm + 3 or – 3mm, unless otherwise specified. Thickness of joints shall be kept uniform. Slight difference to thickness of bricks shall be adjusted within joint thickness. Where brickwork is to match the existing work, the joints shall be of the same thickness as in the existing work.

6.9 STRIKING JOINTS:

Where no pointing, plastering or other finish is indicted, the green mortar shall be neatly struck flush. Where pointing, plastering or other finish is indicated, the joints shall be squarely raked out to a depth not less than 10mm for plastering and 15mm for pointing.

6.10 CURING:

The brickwork shall be constantly kept wet for atleast 7 days.

6.11 FACING:

In case of walls one brick thick and under, atleast one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the face shall be kept even and in proper plane.

For exposed brickwork selected bricks of the specified class and sub-class shall be used for the face work, where however, use of facing bricks is indicated, brick walls shall be faced with facing bricks. No rubbing down of brickwork shall be allowed.

Brick walls shall be plastered pointed or otherwise finished, as indicated. Joints of external faces of brick walls in foundation upto 15cm below ground level and of internal faces of brick walls in foundation and plinth below sub-floor level shall be struck flush when the mortar is green, as the work proceeds.

6.12 CLEANING:

Face of brickwork shall be cleaned on the same day it is laid and all mortar droppings removed.

6.13 CONSTRUCTION DETAILS:

Holes for Pipes etc.

All necessary holes for pipes, air flues, ventilators, etc. shall be cut or formed as work proceeds and grouted in cement and sand mortar 1:3 of cement concrete 1:2:4 as required and made good.

CHAPTER 7 - CONCRETE WORKS

7.1 CONCRETE:

General:

a. The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix whether reinforced or otherwise, shall conform to the applicable portions of this Specification.

b. The Engineer shall have the right to inspect the source/s of materials, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and Engineer's approval obtained, prior to starting of concrete work.

7.2 MATERIALS FOR STANDARD CONCRETE:

The ingredients to be used in the manufacture of concrete shall consist solely of Portland cement, clean sand, natural coarse aggregate, clean water, and admixtures, if specifically called for and conditions at site warrant its use.

a. **Cement**: Cement shall conform to IS: 12269 – 1987.

b. **Aggregates**: Aggregates shall comply with the requirements of IS: 383 – 1970.

i. General

a) "Aggregate" in general designates both fine and coarse inert materials used in the manufacture of concrete.

b) "Coarse Aggregate" is aggregate most of which is not passed through on 4.75mm IS sieve.

c) "Fine aggregate" is aggregate most of which is passed through on 4.75mm IS sieve.

d) All fine and coarse aggregate proposed for use in the works shall be subject to the Engineer's approval and after specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Engineer.

e) Aggregates shall, except as noted above, consist of natural sands, crushed stone from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, strong, hand, durable against weathering of limited porosity and free from deleterious materials that may cause corrosion of the reinforcement or may impair the strength and or durability of concrete. The grading of aggregates shall be such as to produce a dense concrete of specified strength and consistency that will work readily into position without segregation and shall be based on the "mix design" and preliminary tests on concrete specified later.

f) Aggregates having a specific gravity below 2.6 (saturated surface dry basis) shall not be used without the special permission of the Engineer.

ii. Fine Aggregate:

a) General:

Fine aggregate shall consist of natural or crushed sand conforming to IS: 383. The sand shall be clean, sharp, hard, strong and durable and shall be free from dust, vegetable substances, adherent coating, clay, alkali, organic matter, mica, salt or other deleterious substances, which can be injurious to the setting qualities / strength / durability of concrete.

(i) **Machine-made Sand:** Machine-made sand will be acceptable, provided the constituent rock-gravel composition shall be sound, hard, dense, non-organic, uncoated and durable against weathering.

(ii) **Screening and Washing:** Sand shall be prepared for use by such screening or washing, or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fraction.

(iii) **Foreign material limitations:** The percentage of deleterious substances in sand delivered to the mixer shall not exceed the following:

Percent by weight:

S.No	Description	Uncrushed	Crushed
(A)	Material finer than 75 micron I.S. Sieve	3.00	15.00
(B)	Shale	1.00	--
(C)	Coal and lignite	1.00	1.00
(D)	Clay lumps	--	--
(E)	Total of all above substances including items (A) to (D) for uncrushed sand and items (C) and (D) for crushed sand	5.00	1.00

b) Gradation:

(I) Unless otherwise directed or approved by the Engineer, the grading of sand shall be within the limits indicated under here:

IS Sieve	Percentage passing for			
	Grading	Grading	Grading	Grading
Designation	Zone – I	Zone – II	Zone – III	Zone AVE
10mm	100	100	100	100
4.75mm	90 – 100	90 – 100	90 – 100	95– 100
2.36mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18mm	30 – 70	55 – 90	75 – 100	90 – 100
600micron	15 – 34	35 – 59	60 – 79	80 – 100
300micron	5 – 20	8 – 30	12 – 40	15 – 50
150micron	0 – 10	0 – 10	0 – 10	0 - 15

(II) Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron I.S. sieve, by total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron I.S. sieve or to percentage passing any other sieve size on the coarser limit of Grading Zone I or the finer limit of Grading Zone AVE. Fine aggregates conforming to Grading Zone AVE shall be used. Mix designs and preliminary tests shall show its suitability for producing concrete of specified strength and workability.

c) Fineness Modulus:

The sand shall have a fineness modulus of not less than 2.2 or more than 4.2. The fineness modulus is determined by adding the cumulative percentages retained on the following I.S. sieve sizes (4.75mm, 2.36mm, 1.18mm, 600micron, 300micron and 150micron) and dividing the sum by 100.

(III) Coarse Aggregate:

a) Coarse aggregate for concrete, except as noted above, shall conform to IS: 383. This shall consist of crushed stone and shall be hard, strong, durable clean and free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, slag, alkali, mica, organic matter or other deleterious matter.

b) Screening and Washing:

Crushed rock shall be screened and or washed for the removal of dirt or dust coating, if so requested by the Engineer.

c) Grading:

Coarse aggregate shall be either in single size or graded, in both cases the grading shall be within the following limits.

d) Water: Water for mixing concrete, mortar or grout shall conform to IS:456 – 2000. If required to do so by the Engineer, the Contractor shall take samples of the water and test them for quality.

IS Sieve Desig-nation	Percentage passing for single sized aggregate of normal size					Percentage passing for graded aggregate of normal size			
	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
63 mm	100	--	--	--	--	100	--	--	--
40 mm	85 100	100	--	--	--	95 100	--	--	--
20 mm	0 20	85 100	100	--	--	30 70	95 100	100	--
16 mm	--	--	85 100	100	--	--	--	90 100	--
12.5 mm	--	--	--	85 100	100	--	--	--	90 100
10 mm	0 5	0 20	0 30	0 45	85 100	10 35	25 35	30 70	40 85

7.3 TRANSPORTING AND DEPOSITING CONCRETE:

Mixing plant shall be located as close as possible to the point of placement. Concrete shall be placed within 30 minutes after mixing and shall be transported from the mixer to its final placement as rapidly as practicable, taking care to see that no segregation or loss of ingredients take place. It shall also be ensured that the concrete is of the required workability at the point and time of placing.

Dropping of concrete from an excessive height or running or working it along forms will not be permitted. Any concrete which, before placement has begun to set and has become stiff shall be rejected.

Concrete shall not be disturbed after it has been placed in the form and has begun to set. Concrete shall be carefully placed in horizontal layers which shall be kept at an even height throughout the work. Concrete shall not be allowed to slide or flow down

sloping surfaces directly into its final position but shall be placed in its final position form the skips, trucks, barrows, down pipes or other placing machines or device or, if this is impossible it shall be shoveled into position, care being taken to avoid separation of the constituent materials. Concrete placed in horizontal slabs from barrows or other tipping vehicles shall be tipped into the face of the previously placed concrete.

Concrete dropped into place in the work shall be dropped vertically. It shall not strike the formwork between the point of its discharge and its final place in the work and except by approval of the Engineer, it shall not be dropped freely through a height greater than 1.5 metres. Chutes & Conveyor belts shall be so designed that there is no segregation or loss of mortar and shall be provided with a vertical tapered down pipe or other device to ensure that concrete is discharged vertically into place.

Where a lift of concrete is built up in layers each layer shall be properly merged into the proceeding layer before initial set takes place.

7.4 QUALITY ASSURANCE
General Procedure:

A. General:

In order to achieve the required strength and associated properties of concrete, proper control of the Water / Cement ratio by weight need be enforced. The strength shall be prime consideration and W.C. ratio as prescribed by Engineer in charge shall have to be observed.

B. Operators:

At no time whatsoever 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 Contractor in the presence of the Engineer or his representative. If batching is by volume, the Contractor shall be required to fabricate such volumetric batches and water containers as the Engineer may determine and require so as to simulate the ideals of the trial mix without recourse to assessments by site staff and workmen.

D. Weighing:

The Contractor shall make available always a weighing machine if so required, guaranteed by the Contractor for its accuracy, for weighing cement and batches of aggregate as and when the Engineer or his representative or his assistant may require. The machine shall be capable of weighing upto 75 Kilograms and shall be accurate to half (0.5) Kilogram.

E. Compaction:

All concrete shall be thoroughly compacted and fully worked round 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 where required by the quickest and most efficient means so as to prevent pre-set or segregation or any loss of ingredients

and shall maintain required workability. Any laitance from previous mixes shall be removed.

7.5 SAMPLING, TESTING AND STORAGE OF MATERIALS:

Samples of aggregates for mix design and determination of suitability shall be taken under the supervision of Engineer and delivered to the laboratory well in advance of the scheduled placing of concrete. Records of tests made on proposed aggregates and on concrete made from this source of aggregates shall be furnished to the Engineer in advance of the work for use in determining aggregate suitability. The cost of all such tests, sampling etc. shall be borne by the Contractor.

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

A. Cement:

Cement shall, whether supplied by the Board or not, comply with the requirements of IS: 8041, IS: 455, IS: 8043, IS: 6909, IS: 1489, IS: 12269. The testing laboratory at the discretion by 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 site, cement shall be stored in weatherproof silos designed for the purpose or in dry weather-tight and properly ventilated structures will 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 separately and the Contractor 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 the Contractor in the prescribed register and shall be made available to inspecting authorities for store verification.

2. The Contractor 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 Contractor 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 standard have been delivered to the Engineer.

B. Water for Concrete Mixing & Curing:

Water shall be clean, clear and free from injurious quantities of salt, traces of oil, acids, alkalies, organic matter and other deleterious materials. The sources 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 4.3 of IS: 456 – 2000. Generally potable water is fit for mixing and curing.

C. Aggregates:

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 Contractor 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 Engineer's prior approval.
2. Aggregate shall be obtained from an approved source and shall conform to the requirements of IS: 383.
   For the aggregate grading, in table of IS: 383 – 1970 shall be applicable. Aggregate shall not be flaky or elongated particles, defined as particles having a maximum dimension greater than five times the minimum dimension. Aggregate shall have water absorption not exceeding two percent when tested in accordance with IS 383.
3. The Contractor shall sample and carry out analysis in the presence of the Engineer's representative, or 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 such more frequent intervals as the Engineer may require. The grading of all aggregates shall be within the respective limits specified in the codes. For aggregates, which vary more than the approved fineness modulus, the Engineer may instruct the Contractor to alter the relative proportions of the aggregate in the mix to allow for such difference, or may require further trial mixes.
4. Storage of aggregates 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 by the ground or other foreign matter shall be effectively prevented at all times, and each heap of aggregate shall be capable of draining freely. The Contractor shall ensure that graded coarse aggregates are dumped, stored and removed from store in manner that does not cause segregation.

   Coarse aggregate shall be piled in layers not exceeding 1.2m in height to prevent coning or segregation. The aggregates must be of specified quality not only at the time of receiving at site but more so as the time of loading into mixer.

   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 Contractor 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.

7.6 MIX DESIGN:

Mix design is normally a prerequisite to any concreting job and will be required on all major works. If so required, an approved testing laboratory shall, at the Contractor'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 Contractor 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 the minimum and maximum dry aggregate to cement ratios specified. The mixes shall be designed to produce average concrete cube strength at twenty eighth day after manufacture not less than the trail 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 Contractor 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 tests, the Contractor 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 Contractor propose to use in the works. The proportion of cement, aggregates 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 find aggregate and each nominal size of coarse aggregate used.

D. 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 Contractor 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 Contractor'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.

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 Contractor will 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 weigh batching will not relieve the Contractor of his obligations to consistently produce concrete of the specified and approved strength and durability as determined by works tests.

However in any particular work / part of work, the Engineer may decide to adopt mix design (mix) concrete.

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 Contractor proposes to use when handling, transporting and compacting that class of concrete in the works.

Grades of concrete:

The concrete shall be in grades designed in Table 2 IS: 456 – 2000. All the water retaining structures shall be of grade as specified in IS 3370 (Part-1): 2009, Code of practice for Concrete structures for storage of liquids and its latest edition.

Concrete Mix Design:

Procedure for designing concrete mixes shall be as per IS: 10262 – 82. "Recommended guidelines for concrete mix design".

7.7 BATCHING:

Cement:

All cement used in making concrete shall be measured by weight either with an approved weighing machine or by making 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 CI 9 of IS: 12269 - 1987. In case of ordinary mixes, the cement bag shall be taken to be 50 kg. (35 litres).

Aggregate:

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

Gauge Boxes:

Gauge boxes shall be soundly constructed by the Contractor, 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 aggregate for which it is intended. When calculating the size of the gauge box for fine aggregate, 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 Contractor shall put 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.

Water Container:

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, or such fractions of the quantity as are approved by the Engineer. Containers shall have spouts, the pill 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.

Weigh-Batching:

Weigh batching machines shall provide facilities for the accurate control and measurement of the materials 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 are controlled.

Addition of Water and Mixing:

A. Water:

The addition of water to a mixer shall be controlled such that between five and ten percent of the water enters the mixer before the cement and aggregate and a further five to ten percent of water enters the mixer after the said materials have been batched. The remainder of the 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 contents of the aggregates shall be determined before the commencement of concreting or at such intervals as may be necessary or as required by the Engineer. The Contractor shall make due allowance for the 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 consistently the 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 1 ½ minutes. In case, 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 they shall be mixed thoroughly to give dry mortar. Water is then added gradually in required proportion, turning the mass, to give desired consistency mortar. The required quantity of coarse aggregate is then placed on mixing platform, wetted and mortar added. The entire mass is turned and returned 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.

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. Contractor's Returns:

The Contractor shall render to the Engineer, 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 of various classes of concrete shall be furnished. In addition daily details of time of starting concrete, closure, No. of batches through mixer, W.C. ratio, slump, date of striking form works etc. shall be maintained. This day-to-day record shall be authenticated by responsible supervisory staff.

E. Plant and Equipment Generally:

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

7.8 CONCRETING:

Preparation:

The Contractor 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 or concrete and the next is required, in the opinion of the Engineer's representative, the Contractor shall have the surface wire brushed after initial set of the concrete or have it bush-hammered at no extra cost to the Board. 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 75mm thick, or waterproof, building paper, or polythene sheeting immediately after completion of the final trimming of the excavation.

7.9 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 surface 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 shoveled into position care being taken to avoid segregation. No concrete shall be dropped more than 1.5m. 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 falls of materials on the surface of the wet concrete.

As far as possible, concrete for any particular portion shall be done in one continuous operation leaving construction joints, if specified by drawing.

Before commencing subsequent concrete on the one left incomplete, 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. The successive layer shall follow within 30 minutes or earlier.

7.10 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. Vibrating by 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:

Vibrators 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 75mm into the previous freshly compacted layer. The vibrators shall not be allowed to come into contact with the reinforcement of 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 (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 an 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.

7.11 UNDER WATER CONCRETING:

No concrete shall be placed in water without the Engineer's written permission, which may only be granted if in his opinion it is not practicable to place the concrete in the dry. Concrete shall not be placed is running water nor shall concrete be allowed to fall through water. Any water entering the area where concrete is being placed shall, at the Contractor's expense, be kept clear of the concreting works. If under water concreting is permitted, the specified mix of concrete shall be strengthened by increasing the cement content by atleast 10.0% and reducing the water / cement ratio to no more than 0.45, and the placing shall be only through a tremie approved by the Engineer. The volume or mass of the coarse aggregate shall not be less than 1 ½ times not 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 100mm and not more than 180mm.

7.12 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 or a layer of sand kept covered with water is also permissible for a continuous period of fourteen days at least from the date of placement. Should the Contractor fail to water concrete continuously, the Engineer may provide labour and materials required for curing and recover the cost from the Contractor.

7.13 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 C.M. 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.

7.14 JOINTS:

Construction Joints:

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

a. Submittal:

No concreting shall be started until the Engineer has approved the methods of placing, the positions and form of the construction joints 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 wherever 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 clean and damp.

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 Contractor 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.

3. 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 10mm.

4. 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.

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

7.15 BUILDING IN :

GENERAL:

The contractor shall build in pipes, fittings and other items including any plant supplied by the Board or by other contractors under the project or supplied by himself. The contractor shall also build in any plant supplied and erected by others. The contractor 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, cements and mortar or cement grout as directed by the Engineer.

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.

7.16 TESTING OF CONCRETE:

Sampling and strength test of concrete shall be as per 14 of IS: 456 – 2000.

7.17 TESTING CONCRETE STRUCTURES FOR LEAKAGE

The Contractor shall take special care for concrete for liquid retaining structures, underground structures and those others specifically called for to guarantee the finish and water tightness.

The Contractor shall make all arrangements for hydro-testing of structure as per BIS: 3370 part I, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines etc.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other methods as may be approved by the engineer-in-charge. All such rectification shall

be done by the contractor to the entire satisfaction of the engineer-in-charge at no extra cost to the department.

Hydrostatic test for water tightness shall be done at full storage level i/c free board as may be directed by the Engineer-in-Charge, as described below:

In the case of structures whose external faces are exposed, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are buried and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling; the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs over a period of seven days. The total drop in surface level over a period for seven days shall be taken as an indication of water tightness of the structure. The Engineer-in-Charge shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

CHAPTER 8 - FORM WORK

8.1 MATERIAL:

All formwork for concrete work shall be mostly of M.S. Plates. The plates shall be free from wrinkles, lumps or other imperfections. Steel plates shall have sufficient thickness to withstand the construction loads and the pressure exerted by the wet concrete as well as vibration during placing of concrete. Normally the thickness shall not be less than 18 gauge for M.S. Plates.

The formwork may also be constructed of timber, 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. One copy of the Contractors shoring and formwork drawings shall be submitted to the Board 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 Contractor shall be responsible for the calculations and designs for the formwork. The Contractor 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.

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 in the drawings. The forms shall comply with the requirements of IS: 456.

8.2 ARRANGEMENTS:

All formwork shall conform to the shape, lines, dimensions as shown on the plans of the concrete members. the formwork shall include all wedging, bracing, the rod, clamps, stop off boards and other devices necessary to mould the concrete to the desired shape. The formwork shall be constructed as to remain sufficiently rigid during the placing and compacting of the concrete and shall withstand the necessary pressure, ramming and vibrations without any deflection from the prescribed lines and curves. It shall be properly strutted and braced in at least two directions. It shall be sufficiently tight to prevent loss of liquid slurry from the concrete. It shall be strongly and firmly erected. The moulds shall be free from holes, open joints, and other imperfections. The formwork shall be so arranged as to permit easy erection initially and easy removal without jarring or disturbing the concrete finally. Wedges and clamps shall be used wherever practicable instead of nails.

Where the depth of formwork exceeds 1.5 metres, the Contractors shall keep one side partly open, from which the concrete could be placed and the planking on the open side could be raised as the work proceeds. This will avoid segregation of material in concrete and also facilitate its proper vibration.

Before concrete is placed, all rubbish shall be removed from the interior of the form and the surfaces of the formwork in contact with concrete shall be cleaned and thoroughly wetted. The inside surface of the formwork shall be treated with a coat of lime, oil or any other material approved by the Engineer. Care shall be taken to see that the above approved composition is kept out of contact with the reinforcement. The slab centering shall be covered with “Double Wax” water proofing paper or tar paper or polythene sheet as directed by the Engineer.

Where no special finish is desired and where form finish is acceptable, the formwork may be prepared out of water proof black board, which shall give a good finish to the concrete surface and thus there will be no necessity of providing cement plaster finish. For work, which are of repetitive nature, such as column footings, pedestals for pipes, pedestal footings; the formwork shall be fabricated out of steel plates and structural to obtain uniform finish throughout the work. In all cases the formwork shall be inspected and approved by the Engineer, before any concreting is started. The Contractor shall, however, be solely responsible for the proper design, adequacy and stability of the formwork. If at any time, in the opinion of the Engineer, the formwork provided is not considered sufficiently rigid and / or is defective, the Contractor shall improve or strengthen the same in such manner as the Engineer may direct. In no circumstances shall form be struck off until the concrete attains adequate strength as required or without obtaining permission of the Engineer. All formwork shall be removed without such shock or vibration as would damage the concrete. Before the soffit and the struts are removed, the concrete surface shall be exposed where necessary in order to ascertain that the concrete has hardened sufficiently. The responsibility for the removal of the formwork whether whole or part, shall rest, entirely with the Contractor who must nevertheless be guided by the opinion of the Engineer in this regard. The work of striking and the removal of formwork shall be conducted in the presence of the Engineer and under personal supervision of a competent foreman in the employment of the Contractor.

8.3 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 sticking 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.

1. Vertical surfaces of wall	1 day
2. Columns & vertical sides of beams	2 days
3. Slab bottoms with props left under	7 days
4. Beam bottom with prop left under	7 days
5. Removal of props under slabs	
Span upto 4.5 m	7 days
Span over 4.5 m	14 days
6. Removal of props to beam and arches	
Span upto 6.0 m	14 days
Span over 6.0 m	21 days

Sequence of striking formwork shall be approved by the Engineer.

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

1. Shoring and False work Removal:

In retaining wall construction shoring and false work 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. Portable water supply with hoses or buckets shall be ready at each removal location before removal operations are commenced.

8.4 SURFACE TREATMENT & FINISH:

When the formwork is struck, all the faces of concrete shall be smooth and sound, free from voids and air holes. Any roughness or irregularity on the exposed surfaces shall be immediately filled up while the concrete is still green with cement grout, cement wash and / or 1:1 mortar properly troweled and finished. Such patching of the concrete face shall be carried only with the permission of the Engineer. If the concrete is found honey-combed, the honeycombed portion and whatever surrounding concrete that may be considered unsatisfactory by the Engineer shall be dismantled and fresh concrete of proper quality shall be provided at Contractor's cost.

CHAPTER 9 - REINFORCEMENT

9.1 GENERAL:

Reinforcement shall be either plain round mild steel bars Grade I as per IS: 432 (Part - I) or medium tensile steel bars as per IS: 432 (Part – I) or high strength deformed bars as per IS: 1786. Wire mesh or fabric shall be in accordance with IS: 1566. Substitution of reinforcement will not be permitted except upon written approval from the Engineer.

9.2 STORAGE:

The reinforcement shall not be kept in direct contact with the ground but stacked on top of an arrangement of timber sleepers or the like. If the reinforcing rods have to be stored for a long duration, they shall be coated with cement wash before stacking and / or be kept under cover or stored as directed by the Engineer. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deterioration.

9.3 QUALITY:

a. All steel shall be of Grade I quality unless specifically permitted by the Engineer. No re-rolled material will be accepted. If requested by the Engineer, the Contractor shall submit the manufacturer's test certificate for the steel. Random tests on steel supplied by the Contractor may be performed by the Engineer as per relevant Indian Standards. All costs incidental to such tests shall be at the Contractor's expense. Steel not conforming to specifications shall be rejected.
b. All reinforcements shall be clean, free from grease, oil, paint, dirt, loose mill scale, loose rust, dust, bituminous material or any other substances that will destroy or reduce the bond. All rods shall be thoroughly cleaned before being fabricated. Pitted and defective rods shall not be used. No welding of rods to obtain continuity shall be allowed unless approved by the Engineer. If welding is approved, the work shall be carried out as per IS: 2751 according to the best modern practices and as directed by the Engineer. In all cases of important connections, tests shall be made to prove that the joints are of full strength of bars welded. Special precautions, as specified by the Engineer, shall be taken in the welding of cold worked reinforcing bars and bars other than mid steel.

9.4 SUBMITAL OF DRAWINGS AND SAMPLES:

Drawings:

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

Samples:

At least one month in advance of placing an order by him, the Contractor shall submit four samples of reinforcing bars which he intends ordering in case, the steel is to be supplied by the Contractor.

The samples shall conform to IS: 10790 Part 2 – 1984. The Engineer may carry out any test he may require to satisfy that the steel to be brought by the Contractor complies with the test Specifications.

9.5 LAPS AND SPLICES:

Laps and splices for reinforcement shall be as per IS: 456 – 2000. Splices in adjacent bars shall be staggered and the locations of all splices, except those specified on the approved Drawings, shall be only as approved by the Engineer. The bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

9.6 DOWELS:

Where and as designated 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 bolting devices shall be used.

9.7 BENDING:

a. Reinforcement bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done cold and without damaging the bars.
b. All bars shall be accurately bent according to the sizes and shapes shown on the approved detailed working drawings / bar bending schedules. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and in a manner that will injure the material; bars containing cracks or splits shall be rejected. They shall be bend cold, except bars or over 25mm in diameter which may be bent hot if specifically approved by the Engineer. Bars, which depend for their strength on cold working, shall not be bent hot. Bars bent hot shall not be treated beyond cherry red colour (not exceeding 845 degree C) and after bending shall be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only if the means used for straightening and rebending be such as shall not, in the opinion of the Engineer, injure the material. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

9.8 FIXING:

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position by the use of blocks, spacers and chairs, as per IS: 2502, to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with number 16 gauge annealed soft iron wire. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do no perceptibly sag between adjacent spacer bars.

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

Mesh reinforcement, where specified shall conform to IS: 1566 – 1982.
Binding wire shall be annealed wire conforming to IS: 280.

9.9 COVER:

Unless indicated otherwise, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish) shall be as follows:

(i) At each end of a reinforcement bar, not less than 25mm nor less than twice the diameter of the bar.

(ii) For a longitudinal reinforcing bar in a column not less than 40mm, nor less than the diameter of the bar. In case of columns of minimum dimension of 20cm or under with reinforcing bars of 12mm and less in dia. a cover of 25mm may be used.

(iii) For longitudinal reinforcing bars in a beam, not less than 25mm nor less than the diameter of the bar.

(iv) For tensile, compressive, shear or other reinforcement in a slab, or wall, not less than 15mm, nor less than the diameter of such reinforcement.

(v) For any other reinforcement, not less than 15mm, nor less than the diameter of such reinforcement.

(vi) For footing and other principal structural members in which the concrete is poured on a layer of lean concrete, the bottom cover shall be minimum of 50mm.

(vii) For concrete surfaces exposed to the weather or the ground after removal of forms, such as retaining walls, grade beams, footing sides and tops, etc. not less than 50mm for bars larger than 16mm diameter and not less than 40mm for bars 16mm diameter or smaller.

(viii) Increased Cover thickness shall be provided for surfaces exposed to the action of harmful chemicals or exposed to earth contaminated by such chemicals acids, alkalis, saline atmosphere, sulphurous smoke etc. and such increase of cover may be between 15mm and 50mm beyond the figures mentioned here as may be specified by the Engineer.

(ix) For liquid retaining structures, the minimum cover to all steel shall be 40mm or the diameter of the main bar, whichever is greater. In the presence of soils and waters of a corrosive character, the cover shall be increased by 10mm.

(x) The correct cover shall be maintained by cement mortar cubes or other approved means. Reinforcement for footing, grade beams and slabs on sub grade shall be supported on precast concrete blocks as approved by the Engineer. The use of pebbles or stones shall not be permitted.

(xi) The 28 day crushing strength of cement mortar cubes / precast concrete cover blocks shall be at least equal to the specified strength of concrete in which these cubes / blocks are embedded.

(xii) The minimum clear distance between reinforcing bars shall be in accordance with IS: 456.

9.10 INSPECTION:

All continuous inspections shall be performed by the Engineer's Representative. Erected and secured reinforcement shall be inspected and approved by the Engineer prior to placement of concrete.

9.11 REINFORCEMENT BARS PROCUREMENT:

All reinforcement steel (TMT) should be procured as per IS 1786:2008 Grade Fe415/Fe500. Steel to be procured only from Primary steel producers/ Integrated Steel Plants such as TATA / SAIL / RINL / JSW / SHYAM STEEL using iron ore as the basic raw material and having in-house iron making facilities followed by production of liquid steel and crude steel with in-house rolling, adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel guidelines. No Re-rolled material/secondary steel will be accepted or allowed for any structural works.

As per IS.1786:2008, under clause 4.2.3, Low-alloyed/Micro alloyed/CRS steel can also be used by adding alloying elements like Cr, Cu, Ni, Mo and P, either individually or in combination to improve allied product properties. However the total content of these elements shall not be less than 0.40%. In such alloy steels when phosphorous is used, it shall not exceed 0.12% and carbon shall be restricted to a maximum of 0.15%.

The steel manufacturing company should have latest ISO accreditation for Quality Management System.

Every lot of supply shall require to be accompanied by manufacturers test certificate for establishing correlation with TMT/CRS bars supplied.

Every lot shall be tested in the independent laboratory to assess whether the properties are confirming to IS.1786:2008.

The Contractor shall arrange for transport, loading, unloading and storage at the work sites. The Contractor should plan the procurement of steel in such a way that at least required quantity of steel of specified sizes is available at site for 3 months period.

In case Board supplies steel, the carting from Board stores to work site is included in the item. 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.

The rate quoted for steel reinforcement shall be inclusive of taxes, transport incidental charges etc., apart from labour component as specified in the respective item in the Bill of Quantities.

Steel brought on site shall be stored in a proper manner as approved by the Engineer so as to avoid distortion, deterioration and corrosion. The Contractor shall maintain proper registers for the steel account, showing the steel received at site, steel used, and the balance stock on site, to the entire satisfaction of the Engineer. Further, it shall be obligatory on the part of the Contractor to submit monthly, quarterly and yearly statements giving the full account of steel on the works and the balance on hand.

9.12 WELDING OF REINFORCEMENT :

Reinforcement which is specified to be welded shall be welded by any process which conforms with the requirements of I.S.2751 and the contractor can demonstrate by bend and tensile tests to ensure that the strength is not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and no departure from this procedure shall be permitted.

Welds in position other than those shown on the approved drawing shall not be permitted. Tack welding to lightly secure reinforcement in place will be permitted subject to approval of the Engineer.

Welding shall be carried out only by qualified welders. The standard for welding will be that required by IS:2751-79 “code of practice for welding of mild steel bars used in reinforced concrete construction” and IS:9417-1989 “Recommendation for welding cold worked steel bars for reinforced concrete construction”

9.13 ANTI CORROSIVE TREATMENT FOR REINFORCEMENT:

9.13.1 The item covers providing fusion bonded epoxy coating not less than 175 microns thickness and upto 300 microns to reinforcement steels bars of all diameters as per IS Code 13620-1993 for RTS rods for RCC works including testing of coating at plant.

CHAPTER 10 - PLASTERING

10.1 DEFINITIONS:

a) The term “plastering” shall cover all types of rough or fair finished plastering, rendering, floating and setting coat or finishing coat, screed, etc., in mud, lime, cement lime or cement mortar.

b) “Dubbing out” shall mean filling in hollows in the surface of wall and roughly levelling up irregular or out of plumb surfaces, prior to rendering.

c) “Rendering” or “rendering coat” shall mean the plaster coat, which is applied following the “Dubbing out” or the final coat in case of one coat work.

d) “Floating coat” shall mean the second coat in a three-coat plasterwork, to bring the rendering coat to a true and even surface before the setting or finishing coat is applied.

e) “Setting of finishing coat” shall mean final coat in a two or three coat plaster work.

f) “Thickness of plaster” shall mean the minimum thickness at any point on a surface. This does not include thickness of dubbing out.

g) The term “even and fair” as referred to finishing of the plastered surface shall mean a surface finished with a wooden float.

h) The term “even and smooth” as referred to finishing of the plastered surface shall mean a surface levelled with wooden float and subsequently smoothened with a steel trowel.

10.2 SCAFFOLDING:

Where possible, independent scaffolding shall be used to obviate the subsequent restoration of masonry in putlog and other breaks in the work. Stage scaffolding shall be provided for ceiling plaster.

10.3 PREPARATION OF MORTAR FOR PLASTERING:

10.3.1 Materials:

Cement Mortar:

Cement mortar shall have the proportion of cement to sand as mentioned in the item or in the special provisions and shall comply with following:

Cement:

Cement shall conform to IS: 12269 - 1987 Ordinary Portland Cement shall be used. The weight of ordinary Portland cement shall be taken as 50 kg. per bag. The Contractor shall ensure that the cement is of sound and required quality before using it. Any cement, which has deteriorated, caked or which has been damaged shall not be used. The Specifications covered under the section brickwork and concrete work shall be applicable in addition.

Water:

Water shall be clean, clear and free from injurious quantities of salt, traces of oil, acids, alkalis, organic matter and other deleterious materials. The sources 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 4.3 of IS: 456 – 2000. Generally potable water is fit for mixing and curing.

Fine Aggregate:

All fine aggregate shall conform to IS: 383 – 1970 and relevant portion of IS: 515 –1959.

Sand shall be clean, well graded, hard, strong, durable and of gritty particles free from injurious amounts of dust, clay, kankar nodules, soft or flaky particles, shale, alkali, salts, organic matter loam mica or other deleterious substances and shall be approved by the Engineer. The maximum size of particles shall be limited to 5mm. If the fine aggregate contains more than 4 percent of clay, dust or silt, it shall be washed.

The fine aggregate for cement mortar for masonry and first cost of plaster should generally satisfy the following grading:

I.S. Sieve	Percent by wt. Passing sieve
4.75mm	100
2.36mm	80-95
1.18mm	70-90
600microns	40-85
300microns	5-50
150microns	0-10

The fineness modules shall not exceed 3.00.

The fine aggregate for cement mortar for fine joints of ashlars masonry, pointing and second coat of plaster may have the following grading:

I.S. Sieve	Percent by wt. Passing sieve
4.75mm	100
2.36mm	100
1.18mm	75-100
600microns	40-85
300microns	5-50
150microns	0-10

The fineness modulus shall not exceed 1.6.

IS: 2116 – 1980 shall generally apply for sand for plaster. The fine aggregate should be stacked carefully on a clean, hard surface so that it will not get mixed up with deleterious foreign materials.

10.3.2 Proportion:

Cement and sand shall be mixed in specified proportions, sand being measured in measuring boxes. The proportions will be by volume. The mortar may be hand mixed or machine mixed.

10.3.3 Preparation:

In hand mixed mortar, cement and sand in the specified proportions shall be thoroughly mixed dry on a clean impervious platform. Fresh and clean water as specified above shall be added gradually and thoroughly mixed to form a stiff plastic mass of uniform colour so that each particle of sand shall be completely covered with a firm of wet cement.

The water cement ratio may be as under or as directed by the Engineer.

Cement	Sand	Water – Cement ratio	Quantity of water per 50 kg. of cement (Litres)
1	1	0.25	12.5
1	1 ½	0.28	14.0
1	2	0.30	15.0
1	2 ½	0.35	17.5
1	3	0.40	20.0
1	4	0.53	26.5
1	5	0.60	30.0
1	6	0.70	35.0
1	8	0.90	45.0

Machine mixed mortar shall be prepared in an approved mixer. Water cement ratio shall be as per hand mixed mortar. The mortar so prepared shall be used within 30 minutes of adding water. The mortar remaining unused after that period, mortar, which has partially hardened or is otherwise damaged shall not be re tempered or remixed. It shall be destroyed or thrown away.

10.4 PREPARATION OF BACKGROUND FOR APPLICATION OF PLASTER:

Cleanliness:

All dirt, dust and other foreign matter on masonry and laitance on the concrete surfaces shall be removed by watering and brushing as required. If the background contains soluble salts particularly sulphates, the application of plaster shall be done only after the efflorescence of the salts is complete and the efflorescence is completely removed from the surface.

Joints in brickwork, stone masonry and hollow block, masonry shall be raked out to a depth of not less than 10mm as the work proceeds. Local projection in brickwork and masonry beyond the general wall face shall be trimmed off where necessary.

Roughness:

Smooth surfaces of in-situ concrete walls and ceilings etc. shall be roughened by wire brushing, if it is not hard; and by hacking or bush hammering if it is hard, to provide for proper adhesion. Projecting burrs of mortar because of gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition concrete surface shall be pock marked with a pointed tool at spacing of about 50mm, the pocks made to be not less than 3mm deep.

Suction Adjustments:

Adequate drying intervals shall be allowed between the erection of masonry and plastering to bring the surface suitable for suction adjustment. High rate of suction makes the plaster weak, porous and friable. The wall shall not be soaked but only damped evenly before applying the plaster. If the surface becomes dry in spots, such areas shall be moistened again to restore uniform suction. Excessive water leads to failure of bond between the plaster and the background.

Evenness:

Any local unevenness must be leveled and projections removed to avoid variance in the thickness of plaster.

Immobility:

Differential movements between the background and the plaster due to moisture change, temperature change, structural settlement, defection, etc. cause cracks. The major part of such movements shall be allowed to set in before the plaster is applied.

10.5 PLASTERING:

Plastering Generally:

The type and mix of mortar for plastering, the number of coats to be applied, the surface finish of the plaster and the background to which the plaster is to be applied shall be as indicated.

The mortar for dubbing out and rendering coat shall be of the same type and mix. Dubbing out may be executed as a separate coat or along with the rendering coat.

Protection:

All existing work and fittings that are likely to be damaged in the application of plastering shall be protected. Care shall be taken to avoid, as far as possible, the splashing of mortar on to the finished surfaces such as joinery, paint work and glazing; all such splashes shall be cleaned off immediately.

Screeds 15 x 15cm shall be laid vertically and horizontally not more than 2m apart to serve as guides in bringing the work to an even surface.

Plastering shall be done from top to bottom and care shall be taken to avoid joints in continuous surface.

Maintenance of proper time intervals:

To avoid break down of adhesion between successive coats, drying shrinkage of first coat shall be allowed to be materially completed before a subsequent coat is applied.

All corners, arises, angles, junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering of corners, arises and junctions shall be carried out with proper templates to the required size. Plastering of cornices, decorative features, etc. shall normally be completed before the finishing coat is applied.

In suspending the work at the end of the day, the plaster shall be cut clean to the line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scraped clean and wetted with lime putty or cement slurry before plaster is applied to the adjacent area. Partially set and dried mortar shall not be re tempered for use.

Cleaning of completion:

On completion, all work affected by plastering and pointing shall be left clean, special care shall be taken when removing any set mortar form glass and joinery, etc. to avoid damaging their surface.

10.6 ONE COAT PLASTER WORK:

Mortar shall be firmly applied to the masonry walls and well pressed into the joints and forcing it into surface depressions to obtain a permanent bond. The plaster shall be laid in a little more than the required thickness and levelled with a wooden float. On concrete walls, rendering shall be dashed on to roughened surface to ensure adequate bond. The dashing of rendering coat shall be done using a strong whipping motion at right angles to the face of walls. The surface shall be finished even and fair. Unless indicated to be finished even and smooth.

10.7 TWO COAT PLASTER WORK:

First Coat:

The first coat of the specified thickness shall be applied in a manner similar to one coat plasterwork. Before the first coat hardens, the surface of the cement and cement lime plasters shall be scored to provide key for second coat. In case of lime plasters the surface shall be beaten with edges of wooden thapies and close dents shall be made on the surface, to serve as a key to the subsequent coat. The rendering coat shall be kept damp for atleast two days, it shall be allowed to become thoroughly dry.

Second Coat:

Before starting to apply second coat, the surface of the rendering coat shall be damped evenly. The second coat shall be completed to the specified thickness in exactly the same manner as the one coat plaster work.

10.8 NEERU FINISH:

After applying and finishing the undercoats and before they set, the finishing coat of specially prepared lime putty about 1.5mm thick shall be applied. It shall be well polished with a trowel.

10.9 SAND FACED PLASTER:

After the undercoat of cement and sand mortar 1:4 not less than 10mm thick, has been applied and finished, the final coat of cement and sand mortar 1:4 shall be applied to a thickness not less than 5mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.

10.10 CURING:

Each coat shall be kept damp continuously for at least two days. Moistening shall commence as soon as the plaster has hardened sufficiently and is not susceptible to injury. The water shall be applied preferably by using a fine fog spray. Soaking of wall shall be avoided and only as much water as can be readily absorbed shall be used. Excessive evaporation on the sunny or wind ward sides of buildings in hot dry weather shall be prevented by hanging matting or gunny bags on the outside of the plaster and keeping them wet.

After the completion of finishing coat, the plaster shall be kept wet for at least seven days and shall be protected during that period from extremes of temperature and weather.

10.11 WATER PROOFING PLASTER:

Integral water proofing compound shall be mixed with cement in the proportion indicted by weight. Care shall be taken to ensure waterproofing material gets well and integrally mixed with cement and does not run out separately when water is added.

CHAPTER 11 - DUCTILE IRON PIPES

11.1 MATERIALS:

Ductile Iron:

Ductile iron is an iron / carbon / silicon alloy, in which the carbon exists in a pure form as spherical graphite due to addition of small amount of magnesium to molten cast iron. The spherical shape of its graphite increases the mechanical properties such as tensile strength, toughness and ductility. The pipes manufactured by ductile iron shall conform to IS: 8329 – 2000.

Cement:

The cement used for internal cement mortar lining shall be ordinary Portland cement and shall conform to IS: 12269 - 1987 with its latest amendments.

Aggregate:

The aggregate shall conform to IS: 383 with its latest amendments.

Water:

The water used in the preparation of cement mortar mix shall conform to the requirements of mixing water given in IS: 456.

Rubber Gaskets:

The Rubber Gaskets used for push-on joints shall conform to IS: 12820 – 2004. The quality of rubber required shall be as per IS: 5382. Rubber ring bundles from every lot shall carry with them manufactures test certificate for the following mechanical properties.

a) Hardness

b) Tensile strength

c) Compression strength

d) Oil immersion test

e) Water absorption test

f) Stretch test and visual examination

The test procedures, the scale of sampling and the criteria for acceptance shall be as per IS: 5382 and IS: 3400.

The Engineer or his representative shall at all reasonable times have free access to the place of manufacture for inspection and examining the test conducted by manufacturer.

Rubber rings shall be clearly labeled in bundles to indicate the type of ring, the type of joint, the size of the pipe with which they are to be used, the manufacture’s name and trademark, the month and year of manufacture.

Rubber gaskets should be stored in a cool, dark place protected from excessive exposure to heat, direct sunlight, ozone, oil and grease. The rubber gasket should, whenever possible, be stored in a relaxed form free from tension, compression or any other deformation.

11.2 CLASSIFICATION:

Pipes have been classified as K7, K8, K9, K10, K12, K14 depending on service conditions and manufacturing process.

11.3 INSPECTION:

All works and materials under specification will be inspected during all phases of manufacture and testing and such inspection shall not relieve the Contractor of his responsibility to furnish materials and performed work in accordance with this specification.

The Contractor shall notify the Engineer, in advance of the production of materials and fabrication thereof, in order that the employer may arrange for mill and shop inspection.

The Engineer may reject any or all materials or work that do not meet with any of the requirements of these specifications. The Contractor shall rectify or replace such rejected material / performed work at his own cost to the satisfaction of the Engineer.

The Engineer shall have free access to those parts of all plants or any other premises and sites that are concerned with the furnishing of materials or the performance of work under this specification.

The Contractor shall furnish to the Engineer or his representative responsible facilities and space without charge for inspection, testing and obtaining of any information he desires in respect of the character of material used and the progress and manner of the work.

The Contractor shall furnish all the test results from an approved laboratory at any time during the progress of work to the satisfaction of the Engineer. The laboratory shall be approved by the Board.

11.4 MANUFACTURE OF D.I. PIPES:

The metal used for the manufacture of pipes shall be such that the pipes are of ductile iron complying with the metallurgical properties specified in IS: 8329. Therefore the manufacturer shall arrange good quality control system for selection of raw material. It shall be manufactured by any method at the discretion of the manufacturer, provided that the requirements defined in IS: 8329 are complied with. It is also essential that either the Contractor / supplier or the manufacturer should ensure that the manufacture of D.I. pipes and Specials should be fully covered by ISO 9000 certification.

The pipes shall be stripped with all precautions necessary to avoid warping or shrinkage defects. the pipes shall be free from surface or other defects. Pipes showing small imperfections which result from 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 with the consent of the Engineer in charge.

Pipes centrifugally cast shall be head treated in order to achieve the necessary mechanical properties and to relieve casting stresses in accordance with IS: 13655-1993.

If the specified mechanical properties and Brinell hardness are not as per the standard, the pipe may be subject to reheat treatment.

In case of push-on flexible joints, the spigot ends shall be suitably chamfered for smooth entry of pipe in the socket fitted with the rubber gasket.

In case of flanged pipes, the flanges shall be at right angle to the axis of the pipe and machined on the face. The bolt holes shall be drilled.

The bolt hole circle shall be concentric with the bore and the two flanges of the pipe shall be correctly aligned.

11.5 SAMPLING:

Sampling criteria for various tests, unless specified in the standard, shall be as laid down in IS: 11606 - 1986.

The material acceptance tests shall be carried out on ductile pipes grouped in batches as follows. Each batch shall be made up of pipes cast successively as under:

DN	80 to 250	200 pipes
DN	300 to 600	100 pipes
DN	700 to 1000	60 pipes

11.6 MECHANICAL TESTS:

Mechanical tests shall be carried out during manufacture. Test shall be conducted for every four hours of production. The results obtained shall be taken to represent all the pipes of all sizes made during that period.

11.7 DUCTILE IRON FITTINGS:

The fittings shall conform to IS: 9523 – 2000. The manufacture of fittings is similar to the Ductile Iron pipes and the mechanical properties of these fittings also similar to pipes.

11.8. TENSILE TEST:

Two test pieces obtained by cutting bars from spigot end of two pipes selected for testing when tested in accordance with the methods specified in IS: 9523 – 2000 shall satisfy the following requirements:

Grade	**Nominal Diameter (Dn) mm**	**0.2% Proof Stress Min, MPa**	**Tensile Strength Min, MPa**	**Percentage Elongation after fracture, Min on Gauge Length = 5.65 S_o**
1	80-1000	300	420	10
2	1100-2000	300	420	5

NOTE: The proof stress shall only be measured when specially agreed between the manufacturer and the purchaser.

11.9 BRINELL HARDNESS TEST:

For checking the Brinell hardness, the test shall be carried out on test bars cut from the fitting used for test conforming to IS: 1500 – 2005. The Brine ll hardness shall not exceed 230 HB on the external unmachined surface.

11.10 HYDROSTATIC TESTS:

For hydrostatic tests, all fittings shall be kept under pressure for 15 seconds; they may be struck moderately with a 700-g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. As far as possible, hydrostatic test shall be conducted before coating the fittings.

11.11 WORKS AND INSTALLATION TEST REQUIREMENTS:

All fittings shall withstand hydrostatic test pressure at works as specified in the following Table:

Table: Hydrostatic Test Pressure For Fittings for K9 Class	
Nominal Diameter - (Dn) (1)	**Hydrostatic Test Pressure for Fittings - Mpa (as per IS 9523)**
Upto 300	6.0
350 to 600	5.0
700 to 1000	4.0
1100 to 2000	2.5

11.12 CEMENT MORTAR LINING:

The process of lining for D.I. pipes is done at the factory itself and it shall conform to IS 11906 - 1986 and its latest amendments.

11.13 MORTAR:

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

Additives may be used, provided that they do not prejudice the quality of the coating and that of the transported water and that the lining remains in accordance with all the requirements of International Standard.

The mortar shall be thoroughly mixed and shall have 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.

11.14 CONDITION OF THE INTERIOR SURFACE OF THE PIPE BEFORE APPLICATION OF THE LINING:

All foreign bodies, loose scale or any other material, which could be detrimental to good contact between the metal and the lining, shall be removed from the surface to which the lining is to be applied. The inner surface of the pipe shall also be free of any metal projections likely to protrude beyond 50% the thickness of the lining.

11.15 APPLICATION OF THE LINING:

The mortar of the lining is case centrifugally inside the pipe.

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.

The mortar shall be free of any cavities or visible air bubbles and care shall be taken to ensure maximum density at all points. The consistency of the mortar, the time required and the speed of centrifuging the pipe shall be controlled so that segregation of the sand in the lining is reduced to a minimum.

Once centrifuging is finished, the lining shall be cured at temperatures greater than $0^{o}C$. Any loss of water from the mortar by evaporation shall be sufficiently slow that hardening is not impeded.

Repairs to damaged or defective areas are allowable. The damage mortar shall first be removed from these areas. Then the defective part shall be repaired by using a trowel with fresh mortar so that a continuous lining having a constant thickness is again obtained.

For the repair operation, the mortar shall have a suitable consistency; if necessary, additives may be included to obtain good adhesion against the side of the existing undamaged mortar.

11.16 THICKNESS OF THE LINING:

The normal thickness of cement mortar lining shall not be less than for various size of pipes as shown below:

Diameter DN(mm)	Lining Thickness (mm)
80 – 250	3
300 – 900	5
over 900	6

Thickness of lining shall be checked frequently as the Engineer may direct in order to maintain proper control on the lining operations. Graduated needle or other approved appliance shall be used for measuring the thickness. The tolerance in the lining thickness shall be +3mm and no minus tolerance is allowed.

11.17 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 free from corrugations or ridges that could reduce the thickness of the lining to less than the minimum value at one point, as specified in the above table.

On contraction of the lining, the formation of cracks cannot be avoided. These cracks, together with other isolated cracks, which may result from manufacture or may develop during transportation, are acceptable up to a width of 0.8mm.

The structure of the lining is related to the centrifuging process.

On the inner surface of the lining, a thin layer of the sand and cement is formed which may extend up to approximately one quarter of the total thickness of the mortar.

The manufacturer shall take maximum care in keeping the internal surface of pipe even and uniformly smooth. The check of unevenness of pipe shall be done as per IS 11906 - 1986.

CHAPTER 12 - LAYING AND JOINTING OF D.I. PIPES

12.1 TRANSPORTATION:

The transportation of materials to work site and stacking shall be done in such a manner as to cause minimum inconvenience to the traffic and other construction works. Pipes shall be protected during handling against impact, shocks and free fall to avoid cracks and damage. Pipes shall be loaded for transportation is in such a way that they are secured and no movement can take place on the vehicle during transit. The same care shall be taken if pipes are transferred from one vehicle to another, however short the journey may be. The cement mortar lining of pipes that are damaged during transportation is to be repaired by hand application if possible; otherwise it has to be rejected. The decision for rejection shall be taken by the Engineer in charge.

12.2 UNLOADING OF PIPES:

Each pipe consignment shall be inventoried and inspected with care upon arrival even though the pipes have been inspected and loaded with care at the factory. Overall examination shall be made during unloading to ensure that the pipes have reached destination in good condition. If there is any sign of rough treatment on the coating, each pipe shall be inspected for damage.

While unloading, pipes shall not be thrown down from the truck to the hard roads. Cranes or Mechanical equipment shall be used for unloading the pipes from the truck. If mechanical equipment is not available, care should be taken to unload the pipes on timber skids. Unloading them on timber skids without a steadying rope and thus allowing the pipe to bump hard against one another should not be allowed. In order to avoid damage to the pipes specially to the spigot end, pipe should not be dragged along concrete and similar pavements with hard surfaces.

The pipes shall be laid on timber battens and secured with wooden wedges. The pipes shall be stacked with each tier at right angles to the preceding tier.

12.3 LOWERING OF PIPES AND FITTINGS:

The pipes shall be lowered cautiously to prevent disturbances of the bed and sides of the trench.

Proper implements, tools and facilities satisfactory to the Authority shall be provided and used for the safe and convenient execution of the work. All pipes, fittings, valves and hydrants shall be carefully lowered into the trench, piece by piece, by means of a derrick, ropes or other suitable tools or equipment, in such a manner as to prevent damage to pipes materials and protective coatings and linings. Under no circumstances shall pipes materials be dropped or dumped into the trench. Pipes over 300mm diameter shall be handled and lowered into trenches with the help of chain pulley blocks or preferably by cranes. Tripod supports used for this purpose shall be regularly checked to prevent all risks of accidents.

12.4 CLEANING OF PIPES AND FITTINGS:

All lumps, blisters and excess coating material shall be removed from the socket and spigot end of each pipe. The outside of the spigot and the inside of the socket shall be wire-brushed and wiped clean and dry and free from oil and grease before the pipe is laid.

12.5 LAYING:

Before lowering the pipe, the trench section shall be got approved from the Engineer in charge. Trenches are to be dug to the specified level / grade. Sufficient cushion shall be provided for protection from surface traffic, future changes in the ground elevation. The width of the trench shall be to the required specifications providing room

for pipe laying operation, backfilling, compaction etc., Trenches should be shored and braced when conditions so warrant.

The bottom of the trench shall form a continuous bed for the pipe. Where rock is encountered, trenches shall be dug deeper and then filled and compacted to grade with suitable bedding material. The Contractor shall have to provide and maintain sight rails and boning rods wherever required till the completion of work. The pipe shall be laid in reasonably dry condition and under no circumstances they shall rest on slushy bedding.

The pipes shall be lowered slowly into the trench by means of chain pulley block and tripod stand or with the help of ropes and suitable size of wooden bullies or with the help of cranes. They shall be brought to the required level by giving packing with wooden sleeper pieces and ultimately with well-consolidated hard murum if required. The chain pulley block and tripod stand must be approved from the Engineer in charge. Under no circumstances pipe shall be allowed to be thrown in the trenches.

At the end of each day, the end of the pipe should be plugged to prevent entry of rodents, foreign substances, water etc.

12.6 SUPPORT OF PIPE FOR NALLAH / RIVER CROSSING:

Venteak piles are proposed for portion of pipeline which crosses the nalla / river or slushy soils. Each pipe shall be supported on a pair of Venteak piles driven upto 3.50m or firm ground whichever is met earlier.

One pair of timber piles shall be driven about 150mm behind the shoulder of toe socket and another pair about 750mm in front of the spigot end of the pipe.

The size of timber section to be used for Venteak piles shall be:

100mm x 100mm for pipe sizes upto 300mm

150mm x 150mm for pipe sizes above 300mm

A cross piece of section same as that of pile shall be bolted to a pair of piles which have been driven to the required depth.

The level of the cross piece should be such that when the pipe rests on its top, its Invert level coincides with the proposed invert of the pipe.

The pipe shall be aligned for straightness and secured in position by wooden wedges nailed down to the wooden cross piece.

The spigot end of each pipe shall be thoroughly homed in to socket of preceding pipe and jointing made.

The pipe shall be further secured from moving upwards by timber crosspieces bolted to the supporting piles. The section of the crosspiece shall be same as that of pile.

The socket ends of all pipes shall face up hill irrespective of the direction of water flow. Any deviation either in plan or elevation of less than 11 ¼ deg. angle shall usually be effected by laying straight pipes round a flat curve, of such radius that rubber gasket shall not be disturbed in its place.

Wherever new pipes laid are to be jointed with existing pipeline, first pipe laying work of new pipes are to be completed. Jointing of new pipe line with existing pipe line has to be completed within a stipulated time as per the instructions of Engineer in charge to keep the distribution system ready to supply water to the city. No extra payment will be made for this time bound urgent work.

12.7 TESTING:

After laying and jointing, the pipeline must be pressure tested to ensure that the pipes and joints are sound enough to withstand the maximum pressure likely to be developed under working conditions. The Contractor shall submit for the Engineers approval, details of his proposed methods and programme for testing including details of test equipments and shall arrange for all tests to be witnessed by the Engineer or his representative. The Contractor shall provide all things necessary for carrying out testing and cleaning including water pumps, gauges, piped connections, stop ends, and all other temporary works.

Pipelines shall be properly completed and supported before being put under test. No testing will be permitted until ten days after thrust blocks and other holding down works have been completed. In addition to any tests of individual joints or other interim tests which may be specified elsewhere, the Contractor shall submit, all parts of the pipelines to a final test. Notwithstanding the foregoing, the Contractor may at any stage of construction, carry out such other tests as he considers desirable to check materials and workmanship on the pipeline but this shall not relieve the Contractor of his obligations to achieve successful tests under the contract.

All water required for testing and cleaning the pipelines shall be potable water and shall be provided by the Contractor at his cost. The test can be carried out by means of a hand pump or a pressure pump.

Pipelines shall be tested in lengths between valve pits or such lengths as the Engineer may direct or permit.

Fittings required for temporarily closing the openings in pipelines to be tested shall be properly designed for this purpose and shall be adequately strutted to withstand the pressure specified.

The completed pipeline may be tested in sections; the length of section should be decided by considering:

(a) the availability of suitable water;

(b) the number of joints to be inspected; and

(c) the difference in elevation between one part of the pipeline and another.

The maximum length that can be tested in one operation shall be restricted to 500m and minimum length shall be 50m.

Where joints are left uncovered until after testing, sufficient materials should be backfilled over the centre of each pipe to prevent movement under the test pressure.

The Contractor shall make his own arrangements to procure necessary equipments, apparatus etc., required for testing and shall provide necessary labour for filling with water the length of pipes to be tested, fixing all apparatus and for carrying on the testing operations until the length of pipe, specials and connections are firmly passed by the Engineer. If the testing apparatus and equipments are available with the Board, they can be hired by the Contractor at usual conditions and charges.

The length to be tested shall be provided with two blank flanges fastened on the usual manner by collar bands and bolts to the end pipes or if the length to be tested shall have a sluice valve at each end, such blank flanges may be dispensed with.

The length of pipes to be tested shall first be filled in with water from a higher section of pipes already laid or with clean water obtained from a service connection, as the Contractor may arrange with the approval of the Engineer.

Before the actual testing pressure is applied, any air which has logged in the length of pipe to be tested shall be got rid of, by screwing on at the highest part of the length of

pipes or temporary air valve, or by opening a temporary stop-cock or by other means as the Engineer may direct.

The test pressure shall not be less than 10 kg/cm^2.

Each pipeline or section thereof, shall be filled with water and all air removed. The pressure in the pipelines shall be raised steadily until the site test pressure is reached in the lowest part of the section. This pressure should be maintained, by pumping if necessary, for a period of not less than 1 hour. The pump should then be disconnected and no further water permitted to enter the pipeline for a period of 1 hour. At the end of this period, the reduced pressure in the pipeline should be measured, the original test pressure restored by pumping and the loss measured by drawing off water from the pipeline until the pressure has fallen to match the reduced pressure previously noted. The loss shall not exceed 0.02 litre per mm diameter per Kilometer per 24 hours for each bar of head applied. If the pipeline fails to pass the test, the faults shall be located and repaired and the pipeline retested until it passes the pressure test. All exposed pipe, fittings, valves and joints shall be visually inspected during the tests.

If the length of pipeline under test is found to be satisfactory and no leaks or sweating are found at the pipe joints or at the joints of specials and connections, then this length of pipeline will be passed by the Engineer.

But should any pipe, joint, special or connection be found to sweat or leak, Contractor shall make good at his cost such defective joints and the length of pipe line shall be retested until all pipes, joints specials and connections are found to be satisfactory.

After satisfactory test, the Contractor shall remove water from the pipeline and clean it after testing at his own cost, without flooding adjoining areas.

Duration of Hydraulic Test:

The test is for 1 hour only. The rate of allowable leakage is given on per day basis. The leakage observed within one hour shall be converted to per day basis and compared with criteria given.

Maximum field test pressure for pipes with flexible joints:

Table – 1 on page 11 of IS:12288 is not applicable in this case as our test pressures are well below the maximum field hydraulic test pressures given in the table.

Allowance of test pressure for lower elevations:

As regards allowance for lower points, there is marginal level difference in levels, between 2 points in the section to be chosen for testing and hence the difference in pressure developed will be insignificant.

Saturation of pipe material:

As regards saturation of material, it is significant in case of RCC, PSC pipes for DI pipes it is insignificant. We are not clear whether the remark is aimed at saturation of inner CM lining. The adequate curing of the lining will take care of this. Also the duration of the test is long enough to discount such possibility.

12.8 INTERCONNECTION WORK:

The interconnection work between the existing main and the proposed main to be laid under this contract shall proceed from the new main to the existing main. Before actually proceeding with the interconnection work, the Contractor shall make ready necessary tools and plants required for the work at site, such as pump sets, shoring materials etc. He shall also keep ready at site necessary pipes, jointing materials, specials and valves required for the work. The Contractor shall keep necessary skilled

workmen of sufficient strength at site and once the work commenced, the entire interconnection work shall proceed without interruption by engaging labour for carrying out the work on a continuous basis both day and night till the work is completed. The work shall be executed as per programme drawn up by the Engineer and shall be completed within the time ordered by the Engineer, for each individual interconnection. The work shall be carried out under the direction of the Engineer from the beginning to end.

Laying of specials, valves (except straight pipes from the branch of the new main to the connecting point in the existing main) including conveying specials etc. from the stores or site of stacking, excavating, timbering, pumping out water from the trenches, lowering, aligning, jointing specials and valves, cutting the existing mains, dealing with water, inserting the necessary branches, jointing, testing, refilling etc. is included in the item of providing, laying and jointing DI / MS pipes. Any ancillary work either of Temporary or Permanent nature required for interconnection and not covered by schedules shall be executed by the Contractor at no extra cost.

12.9 FLANGED JOINTS:

Flanged joint should be made by painting the facing of the flange with white lead freely and bolting up evenly on all sides. A thin fibre of lead wool may be very useful in making the joints water tight where facing of the pipes is not true.

When packing must be used, it should be of rubber insertion three ply and of approved thickness. The packing should be of the full diameter of the flange with proper pipe hold and bolt holes cut out evenly on both the inner and outer edges. Where the flange is not full faced, the packing may be of diameter of the packing strip only, proper placing of the packing should be checked before another pipe is jointed on.

12.10 DISINFECTION OF MAINS:

Upon completion of a newly laid main or when repairs to existing pipes are made, the main shall be disinfected as directed by the Engineer.

The main shall be flushed prior to disinfection except when the tablet method is used. After initial flushing, the hypochlorite solution shall be applied to the water main with mechanically or electrically powered chemical feed pump designed for feeding chlorine solutions. For small applications, the solution may be fed with a hand pump.

In the case of mains of large diameter, water from the existing distribution system or other approved source shall be made to flow at a constant measured rate into the newly laid pipeline. The water shall receive a dose of chlorine also fed at a constant measured rate. The two rates shall be proportioned so that the concentration in the water entering the pipeline is maintained at not less than 300 mg/l. The chlorine shall be applied continuously and for a sufficient period to develop a solid column of ‘Slug’ of chlorinated water that will, as it passes along the line, expose all interior surfaces to a concentration of at least 300 mg/l. for atleast 3 hours. As the chlorinated water flows through tees and crosses, related valves and hydrants shall be operated so as to disinfect the appurtenances.

In the case of newly laid mains in which scrupulous cleanliness has been exercised, the tablet method can be adopted and in this method, the initial flushing is dispensed with. The calcium hypo chlorate tablets, are placed in each section of pipe and also in hydrants, hydrants branches and other appurtenances. The tablets shall be attached by an adhesive and must be at the top of the main. The main shall then be filled with water and the water shall remain in the pipe for atleast 24 hours.

After the applicable retention period, the heavily chlorinated water shall be flushed from the main until the chlorine concentration in the water leaving the mains is no higher than that generally prevailing in the system or less than 1 mg/l.

After final flushing and before the water main is placed in service, a sample or samples shall be collected from the end of the line and tested for bacteriological quality and shall show the absence of coliform organisms. If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples have been obtained. When the samples are satisfactory, the main may be placed in service.

The Contractor is expected to carry out the disinfection work as a part of laying the pipes and his rates for laying the pipes should include the disinfection and other connected works till the main is placed in service unless otherwise specified in the schedule.

CHAPTER 13 - PUMPS, MACHINERY AND ELECTRICAL WORKS.
General Specifications

Following clauses specify General Electrical requirements and standard of workmanship for the equipment and installations. General Specification clauses shall apply where appropriate except where particularly redefined elsewhere.

I. Electrical Wiring and installation of fittings

1. The materials used shall conform to the relevant I.S.S where applicable. The make and other details of materials to be used should be furnished along with the tender.

2. Continuous earth connection are to be made with 14 SWG T.C. wire.

3. The wiring work done shall be neat, true to line, level etc. and in such a way that it gives an impressive and aesthetic appearance to the building.

4. The actual location and number of points for lights, fan powers plugs etc., may be altered at the time of execution by the Engineer.

5. Entire wiring and cabling work should be done as per IE rules.

6. Any damages or breakages, chipping etc., caused by the electrification works to the structures have to be rectified by the contractor at his cost of the satisfaction of the Engineer.

7. The contractor has to test each and every point after completion of wiring to the entire satisfaction of the Engineer by taking temporary supply from the existing service.

8. Wiring to light point (both internal and external) and fan point will be treated as complete only when supply as well as connection upto the ceiling rose is completed.

9. Whenever conduit pipe wiring is done, cover for switch boards containing switches plugs, etc., should be a hylam sheet or other specified sheet only.

II. Machinery and other Equipments

1. All the materials used shall conform to relevant I.S.S. wherever applicable and should be delivered at site of work. The contractor is responsible for safe custody of materials and equipments under this contract till handling over to the Board.

2. The rates should include all the minor items of civil works if any required for installation complete.

3. All necessary civil works for erection of all equipments for accessories offered by the Contractor under this contract should be done by the Contractor. The rates for civil works are to be quoted wherever called for.

4. Test certified for machinery and equipments should be produced along with the supply.

5. The contractor should supply one set of tools for the pumpset maintenance of the machinery and equipments supplied by them under this contract.

6. The contractor has to operate and maintain the pumpsets and other machinery and equipments for a period of 30 days to the entire satisfaction of the Engineer, free of cost, unless otherwise specified. Fuel, lubricants and power supply if required will be supplied free of cost, for operation and maintenance during that period.

7. The tender should enclose along with their tender performance curves including efficiency curves of the pumpsets, makes and other details and certificates from their claimed manufacturers, stating that the equipments offered by them would be supplied by the manufacturers.

8. The contractor should supply immediately after commissioning three sets of operation and maintenance manuals for all equipments and machinery supplied under this contract.

General

1. Cable lengths given are only approximate and payment will be made for the actual length of cable laid.

2. The contractor has to make necessary arrangements to get supply of electricity from TNEB for operating the machinery and equipments. The necessary Service Connection and S.D. charges will be paid by the Board.

3. The contractor should obtain all approvals for the installation and commissioning of machineries and accessories offered by them from the respective inspecting authorities such as CEIG or CIFG etc., Fees if any, to be paid to the inspecting authorities will be reimbursed by the Board.

4. Before supply of the machinery equipments and other materials, prior approval of the Engineer should be obtained giving the name of maker and other details required.

GENERAL SPECIFICATIONS

1. Equivalency of Standards and Codes

Wherever reference is made in the contract to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards and codes are national or relate to a particular country or region, other authoritative standards which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event the Engineer determines that such proposed deviations do not ensure substantially equal performance, the Contractor shall comply with the standards specified in the documents.

2. Use of Trade Names

Wherever reference is made in the Contract to specific manufacture's or trade names the Contractor shall be entitled to substitute plant and materials supplied by other manufacture's or produce's. Such substitutions shall be to the approval of Engineer, which will not be unreasonable withheld. At the request of the Engineer the Contractor shall provide full evidence to establish that the substituted plant and material is equal to or better than that from the manufactures or supplied mentioned in the Contract.

3. Requirement of Statutory Authorities

The electrical equipment / installations shall comply with the requirements of Rules / Regulations as amended up-to-date, required by Statutory Acts or Authorities.

- The Indian Electricity Rules, 1956
- The Indian Electricity Act.
- The Indian Electricity (Supply) Act, 1948
- The requirements of Chief Electrical Inspector to the Government of Tamil Nadu.
- The requirement of Tamil Nadu State Electricity Board.
- Fire advisory Committee Insurance Act.
- The contractor shall get the drawings, layouts of HT substation etc. approved from TNEB and chief Electrical inspector to the Govt. of Tamilnadu, wherever necessary. The contractor also shall arrange to get the installation inspected by CEIG and carryout modifications/rectification as required by CEIG, prior to commissioning of substation/electrical equipments.

4. Voltage Regulation

During starting of heavy equipment the voltage may drop by a maximum of 15% for period of 45-60 seconds depending upon the duty of the driving equipment. All the electrical equipment

shall, therefore, be suitable for trouble free and uninterrupted operation even during such voltage variation at the time of starting of heavy equipments.

5. Ambient Temperature

Where the equipment is installed outside and exposed to direct sunrays, these shall be suitable for operation at higher ambient temperature and rigorous weather conditions under which they are required to operate.

6. Power Factor

Suitable rating capacitors shall be provided to each individual motor above 1.5 KW rating along with discharge device of appropriate rating to improve the power factor above 0.95.

7. Approval by Fire Insurance Authority

The equipment supplied along with the accessories shall be those approved for use in Electrical installations by the Fire Sectional Committee, Central Regional Council of the Insurance Association of India.

8. Conditions of Operation

The equipment offered shall be suitable for continuous operation under high ambient temperature 45°C. Motors for outdoor installation shall be weather proof.

The switch board shall not be exposed to moisture or corrosive gases.

The Contractor shall submit layout drawings showing the location of switch board and other equipment proposed to be installed for the approval of Engineer.

9. LT Supply

The contractor shall ascertain the availability of LT supply from TNEB and to procure equipments accordingly.

9.1 MV / LT Panel

The medium voltage control panel or motor control panel shall normally have ACBs, MCCB and MCB as the case may be. The number of equipments and capacity of each equipment shall depend on the requirement of a particular pumping station. The Panel shall be made of 12 SWG (2.6mm) sheet steel for the front side and 14 SWG (2.0mm) sheet steel for bottom and other sides with powder coating for long life. Necessary neutral link block to be provided at required locations. These panels shall be front wired, front connected and provided with closing handles with ON and STOP mechanical indication having in built locking system so that back access would not be required for inspection and maintenance. The enclosure shall be dust and vermin proof type. Since the entry of cables of the panel is generally from the bottom, the cable gland supporting plate shall be mounted not less than 300 mm above the floor level.

9.2 Air Circuit Breakers

The medium voltage cubicle type switch board shall consist of four pole Air Circuit Breakers confirming to latest revision of IS:13947 Part 2 / IEC:60947 Part 2. The breaker shall be manually draw out type in open execution with over current trip device adjustable 64% to 110%. Time setting for over load, adjustable current setting for short circuit protection and also earth fault protection adjustment facility shall be provided in the ACB.

ACB shall be fitted with following :

- Heavy duty switch having not less than 4 No. + 4NC contacts
- Built in resin cast current transformer
- Auxiliary contacts
- Shunt and under voltage tripping device
- Neutral CT for earth fault protection
- The ACB shall be suitable for locking the breaker in various position. Provision for door locking ACB shall be provided with the requisite end termination lugs/sockets. Terminal bars for connecting more than one terminal.

The ACB shall have breaking capacity not less than 35kA at 415V AC.

9.3 Moulded case circuit breakers

Moulded Case Circuit Breakers confirming to latest revision of IS:13947 Part 2 / IEC:60947 Part 2 shall be fixed type fitted with trip free, manually closing mechanism, accommodated in a sheet steel housing of robust and vermin proof construction matching with switch boards. All MCCBs shall be tested as per IS-2516 Part-1, Sec-1 and shall be provided short circuit and overload protection. (position of the knob shall clearly indicate ON, OFF and TRIP conditions).

9.4 Terminal Blocks

Terminal blocks shall be 650 V grade, 10 Amps., rated one piece moulded, complete with insulated barriers, screw type brass terminals suitable for stacking on C type rail and identification strips. Marking on the terminal strips shall correspond to wire numbers on the wiring diagrams. The terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. Also CT secondary leads shall be provided with short circuiting and earthing facilities.

All spare contacts and terminal of panel mounted equipment and devices shall be wired to terminal blocks.

At least 20% spare terminal shall be provided on each panel, uniformly distributed on all terminal blocks.

9.5 Indicating Instruments

All electrical indicating instruments shall be digital square type of 144 sq.mm or 96 sq.mm according to the suitability of panel. These shall be suitable for flush mounting with only flanges projecting on vertical panel. Instrument dial shall be white with black numericals and lettering.

Instrument shall conform to IS - 1248 and shall have accuracy class of 1.00 or better. The current coil of ammeters and potential coils of voltmeters shall continuously withstand 120% of rated current and voltage, respectively, without the loss of accuracy.

The meters shall have external zero adjustments. The ammeters fitted in the motor circuits shall have suppressed scale to indicate the maximum starting current. The instrument shall be provided with glass cover to avoid the possibility of measurements due to static charge.

The three phase three wire trivector meter shall comprise of kWh meter and kVARh meter mounted together with kVAh meter in one case with special summator mounted between them to register correct kVAh at all power factors.

All the meters shall have respective maximum demand indicators to record the average power over a period of half an hour. The trivector meter shall conform to relevant IS.

9.6 Equipment wiring

All the switch boards, panels, annunciator panel and mimic panel shall be neatly wired using 1100/660 volt grade PVC insulated stranded copper conductor cable of minimum 2.5 mm to suit the requirement. The wiring shall be bunched in groups by non-metallic clips or bands. Each group shall be adequately supported along its run to prevent sagging and strain on the terminals.

Sharp and tight bends shall be avoided. Each wire shall be identified at both ends by ferrules indicating the designation of the wire in accordance with the Schematic / wiring diagrams. The wire shall be terminated on the terminals of the relays, switches, instrument, conductors, lamps etc., or on the terminal blocks as the case may be. No joints shall be provided in between. Terminal blocks shall have screw type terminals which can take at least two wires per terminal on each side. At least 20% spare terminals shall be provided on each terminal block.

9.7 Interlocking Arrangement

The panels containing the MCCB / MCB etc. shall be enclosed in free standing steel sheet enclosure with front cover so interlocked with the isolator that the door cannot be opened with isolator at 'ON' position.

9.8 Inspection of Circuits

Facility for inspection of the circuits, to ascertain if all the Conductors, relays, fuses, etc. are in proper working order/condition or otherwise shall be provided by means of a push button or selected switch.

9.9 Labeling

Labels of switch gears shall indicate reference number of the switch, the specified current rating and the part of the distribution controlled. Labels on circuit breaker boards shall indicate the reference number of controlling switch. The lettering of all labels shall not be less than 5 mm, high. The schedule and details of the labels shall be submitted to the Engineer for approval.

9.10 Cable Entry

The cable entry shall preferably be from the bottom which shall be dust and vermin proof. The cable entry on each equipment shall be through a compression type cable gland. The cable gland plate shall be sufficiently strong to take the load of the cables and shall be mounted not less than 300 mm. above the floor level. The cables shall be suitably clamped before the cable gland to avoid any strain on it.

9.11 Painting

The panels shall undergo chemical derusting, sand blasting, degreasing, pickling in acid bath and phosphatised as per IS:6005 and primed. The panels shall be thoroughly rinsed with clean water after phosphating, followed by final rinsing with dilute bichromate solution and oven

drying. The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer.

Two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The final finished thickness of the paint film on steel shall not be less than 100 microns and shall not be more than 150 microns. The colour for the finishing paint shall be bright battleship grey as per IS:5 (Shade No. 631). The finished painted appearance of panels shall present an aesthetically pleasing appearance free from dust and uneven surface.

The paint shall withstand humid tropical climate, rain, etc. The paint shall not scale of or crinkle or removed by abrasion during normal handling.

Sufficient quantity for touch-up paint shall be furnished for application at site.

10. Motor Control Panel

The motor control panel shall have the following equipments.

- Main switch fuse or MCB, MCCB with required capacity in case of 415V motor pumps sets.
- ACB or suitable circuit breaker to suit the motor capacity and voltage in case of HT motor pump sets.
- Motor starter - Auto transformer / Star Delta.
- Contactors
- Single phase preventor
- Ammeter with selector switch
- Voltmeter
- Pilot lamps for indication
- Trip Alaram
- Stop push button
- Start Push Button
- Addition equipments if any

10.1 Push Button Operated DOL Starter

DOL starter shall be of double break type and shall incorporate air break contactor with bimetallic thermal electromagnetic overload relays on all three phases with start/stop push button in front of switch board. The starter shall be capable of 10 operations per hour. The DOL starter shall conform to IS-13947 – Part 4 – Sec 1 (IEC 947-4-1 -1990).

10.2 Star / Delta Starter

The push button operated Star Delta Starter shall be of the fully automatic type with an adjustable timer incorporated for automatic change-over from Star to Delta. The starter shall incorporate the electromagnetic or thermal type bimetallic overload releases, pneumatic electro time delay relay, the solenoid coil operated under voltage release and current operating single phasing preventor. The starter shall be capable of 10 operations per hour. The starter shall conform to IS-13947 – Part 4 – Sec 1 (IEC 947-4-1 -1990).

10.3 Auto Transformer Starters

The auto transformer starter shall be of the fully automatic type. For auto transformer starting, magnetically operated starting, accelerating and running contactors shall be provided

either, operating under solid state or electronic timing devices. The auto transformer shall limit the starting current to 1.5 times full load current for motors upto 100 HP and 1.25 times full load current for motor above 100HP with appropriate tapping. The auto transformer shall be provided with one under voltage coil, three magnetically operated overload coils, and a single phasing preventor relay. One ammeter of ample capacity to take care of the starting current shall also be provided in the starter. The starter in general confirm to IS-13947 – Part 4 – Sec 1 (IEC 947-4-1 -1990).

10.4 Soft Starters

The Low Voltage Soft Starter shall generally confirm to IS 13947. The starter shall employ semiconductor components (IS 12974 latest publication) or reactors (IS 555 Part 3) for limiting the starting current. The starter shall be suitable to operate at 415volts +/-10%, 3 phase / 50 hz +/-3% power supply. The Soft Starter shall be rated equivalent to the motor rated power and shall be capable of operating satisfactorily with the motor under the various loading and starting conditions of the motor over the entire operating range. The Soft Starter shall reduce the starting current of the motor within the levels prescribed by the electricity supply authority. The Soft Starter shall be so rated as to allow six starts per hour.

The soft starter shall work on the principle of full sine wave control and shall not lead to generation of harmonics.

The three phase windings of the Soft Starter in case of series reactor type, shall be with insulation class H and maximum temperature of winding shall be limited to that of class B. The reactor shall be such that the losses due to the reactor shall be least.

The Soft Starter shall be housed in a sheet steel enclosure of thickness not less than 14 gauge and painted with corrosion resistive paint such as epoxy or Polyurethane. The degree of protection shall be I.P.41. Soft Starter shall have a built in facility for bypassing the current limiting component after the motor reached the full speed so that the incoming voltage to the motor in equal to the supply voltage.

Routine test :-

Manufacturer should have following mandatory test facilities for routine tests at his shop.

1. High voltage test.
2. Full current injection test – A.C. Current equal to designed motor starting current should be injected in to FCMA coils for time equal to starting time.
3. Insulation resistance test.

Performance Tests:

Manufacturer should prove the motor starting current on the site as guaranteed by measuring the same with analog tong-tester.

10.5 Timer

Knob type electro-pneumatic time delay relay range 0-60 sec. It shall conform to IEC.337-1-1970 or IS-5834 Part I, convertible from ON delay to OFF delay or vice versa, suitable for 110 VAC 50 Hz rating, 1.5 Amps, terminal capacity for 2.5 mm^2 copper control wire, with 1 No + 1 NC.

10.6 Isolating Switches

Isolating switches shall be on load double break type and shall have suitable current and voltage ratings. The “ON” and “OFF” position shall be clearly marked.

Isolators used for motor control circuits shall be of motor cut type, capable of carrying the starting current of the motor.

10.7 Fuses and Fuse Carrier

All fuses shall be HRC cartridge type conforming to IS:13703, mounted on plug-in type fuse bases. All accessible line connections to fuse base shall be adequately shrouded. The fuses shall have operation indicators for indicating blown fuse condition. The fuse and fuse carrier shall be suitably selected for rated and fault currents. The fuse for motor control circuits shall be so selected that the same shall not operate during motor starting.

10.8 Contactors

The three pole contactors with minimum of 2 No. + 2 NC working contacts and one number of 1 No + 1 NC spare contact shall be used. The contact made of anti-weld silver cadmium shall be designed to give minimum bounce to ensure long contact life. The rating of the contactor shall suit the motor and capacitor circuit duty. The contactor shall be suitable for 415V, 50Hz, AC 3Phase duty in respect of making and breaking operations at specified power factors. The contactors shall conform to IS:13947 Part-1 and Part-4.

10.9 Single Phase Preventor

The single phasing preventor shall be provided for all 415 V, motors above 5 kW rating. The single phasing preventor shall be current operated type using minimum current detection / negative phase principle. Necessary current transformers shall be provided to suit the requirement of the single phasing preventor. The single phasing preventor shall be stable during the starting of the motor. The maximum operating time to the single phasing preventor shall not exceed 2/3 second even in the starting condition of motor.

11. Cables and Cable Laying

Following type of cables shall be used.

1.	For LT Power Supply	:	3½ core, 3 core or 2 core 1100 / 600 V PVC insulated PVC sheathed armoured cables.
2.	For control cables	:	Multicore copper cable minimum 2.5 mm^2 with PVC insulation, armoured and PVC sheathed.
3.	Submersible Motor cable	:	According to Manufacturer

The minimum size of control cable shall not be less than 2.5 mm^2.

All cables shall be suitably de-rated for grouping and higher ambient temperature. For selecting cable sizes, 45^0C ambient temperature shall be taken as base.

The cables shall conform for LT to IS:1554 - Part I and for HT to IS 1554 - Part - II., IS: 7098.

11.1 Cable Accessories

All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards / as specified. For 1100V grade cables Siemens type gland and crimping type lugs shall be used.

11.2 Cable Laying

The power cables and its accessories shall confirm to latest relevant Indian Standards. While laying the cables care shall be taken to avoid formation of kinks and damages to the cables.

LT cable shall be laid on wall with suitable clapping or trays or buried underground with appropriate protection. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LT cables when laid on the cable racks shall be properly dressed and clamped as required without crisscrossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

11.3 Laying of LT underground cables.

The laying of UG cables on ground is by excavating a trench of 0.75 meter depth for LT cable. Before the cable is laid in the trench, the bottom of the trench shall be cleared from stones and other sharp materials and filled with sand layer of 150 mm.

The width of the trench at bottom shall be 0.4 meters for one cable. In case the total number of cables laid in trenches is more than one, then the width shall be such that the spacing between cables is not less than 150 mm. Each run of cable shall be protected by placing bricks / RCC slabs on both the sides and top.

After placing bricks or RCC slabs, the trench shall be filled with the excavated soil, in layers ensuring that each layer is well rammed by spraying water and consolidated. The extra earth shall be removed from the trench and disposed as directed.

When cables pass through roads they must be well protected by either hume pipes or GI pipes of suitable dimensions properly sealed at either end and also at the joints with suitable compound to avoid entry of soil and water.

While removing the cable from the drum, it shall be ensured that the cable drum is supported on suitable jacks and the drum is rotated to unwind the cable from the drum. The cable should never be pulled while unwinding from drum. It shall be ensured that the cables are run over suitable wooden rollers placed in the trench at intervals not exceeding 2 meters.

In routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they lie side by side. Telephone cables shall cross the power cables only at about right angles and these two shall not run in close proximity. LT cables shall be bent in radius not less than 12 times their individual overall diameters.

Routes of these cables shall be arrived at on the basis of the relevant drawings and after consulting the Engineer.

Contractor shall provide all necessary labour, tools, plants and other requisites at his own cost; for carrying out pumping of water and removing of water from trenches if required anywhere at the time of execution.

11.4 H.T. Cables

H.T. 11 KV grade suitable rating 3 core XLPE aluminum conductor cable minimum size 150 mm^2 from TNEB supply point to Employer's 11 KV primary control switch gear and to transformers as per requirement.

11.5 Specifications for H.T. Cables

This specification covers the requirements of high voltage cables and associated accessories like straight joints and termination's etc. The cable sizes shall be calculated based on the fault level of the local system. Minimum size of HT cables shall be 150 mm^2
in case of XLPE cables.

11.6 Codes and Standards

1. The design manufacture and performance of the cables shall comply with all currently applicable statutes regulations, and safety codes in the locality where they will be installed. Nothing in this specification shall be construed to relieve the Contractor of his responsibility in this regard.
2. The cables shall conform to the latest editions of following IS and other relevant IS mentioned therein

IS 7098 (Part-II):	Specifications for cross linked polyethylene Insulated PVC sheathed cables for working voltages from 3.3 KV up to and including 33 KV.

11.7 Drawings and Schedules

Sizes of cables shall be given in single line power diagrams. A cable schedule shall be prepared on the basis of relevant drawings. All cable and wires shall be adequately sized to carry continuously the normal currents expected on the relative circuits. All trenches for electrical cables shall be separate from water or sewage pipe line trenches.

11.8 Splicing and Termination

Straight through joints shall be avoided. In case, these are absolutely necessary they shall be made at convenient locations suitably protected as approved and sanctioned by the Engineer-in-charge but in no case within the conduit pipes or ducts. Branch circuit wiring shall be spliced only in switch boxes, panel switch socket outlet boxes light fixtures outlets and circular junction boxes. They shall be made only with approved porcelain connectors.

Cable glands for strip armored cables shall include a suitable armour clamps for receiving and securely attaching the armoring of the cable in a manner such that no movement of the armour occurs when the assembly is subjected to tension forces. The cable gland shall not imposed on armoring, a bending radius not less than 15 times the diameter of the cable. The clamping ring shall be solid and adequate strength.

Provision shall be made for attachment of an external earthing bond between the clamp of the cable and the metallic structure of the apparatus to which the cable box is attached.

Compression type cable end glands shall be used for cable connections. Double compression cable end glands shall be used for flame proof switch gears. Cable glands shall be of brass with cadmium or nickel plating.

Tinned copper lugs shall be used for cable termination.

Cables shall be tested in accordance with IS:1554 / 7098

11.9 Testing of Cables

Once the cable is laid, following tests shall be conducted in presence of the departmental representatives authorized by Engineer, before energizing the cable.

1. Insulation resistance test (Sectional and Overall).
2. Sheathing continuity test.
3. Continuity and conductor resistance test.
4. Earth test.
5. High voltage test.

Teat conducted shall be as per Indian standard and National Electrical code.

12. Control Switches

Control and instrument switches shall be of rotary type flush mounting having enclosed contacts which are accessible by the removal of cover and shall be provided with properly designated escutcheon plates clearly marked to show the operating positions. Control switches shall have momentary contacts, spring return to centre with pistol grip handle. Instrument and selector switches shall have oval knob.

13. Push Buttons

Push Buttons shall be of momentary contact type with rear terminal connections. The colour of the push buttons shall be “Green” for start and “Red” for stop. Whether required, the push button shall be suitably shrouded to prevent inadvertent operations. They shall be provided with integral inscription plates engraved with their functions. The contact element shall have at least 1 No. and 1 NC contacts. The contacts shall be able to make and carry at least 6 Amp. at 415 AC.

14. Indicating Lamps

Indicating lamps shall be panel mounting type with rear connection. The lamps shall be provided with the built-in series resistors on the lamp holder. The lamp shall have translucent lamp cover, of suitable colour. The cover shall be oil and dust proof poly-carbonate lens. The bulb and lenses shall be interchangeable and replaceable from front of the panel.

15. Safety Equipments to be Provided

The contractor shall provide the following safety equipments as per IE rules,

- Rubber mat conforming to relevant IS, in front of all the MV panel for their entire length - 1000m wide
- Sufficient pairs of electrically tested rubber gloves. These are to be kept in a suitable wooden box.
- A shock treatment instruction chart in Tamil and English duly framed as detailed in. The nearest medical facility available with phone number shall also be kept
- First aid box containing full compliments of medicines for treatment of electrical burns in the main switch room
- Adequate number of portable fire extinguishers of dry powder (store type) as per IS 2171 to suit the individual substation, pumping station requirement.
- Adequate number of caution notices in Tamil and English shall be fixed permanently on the equipment to comply the requirement of IE rules
- Safety posters for vigilance against electrical accidents.
- Adequate number of fire buckets with MS angles stand
- Round bottom fire buckets marked fire shall be provided in the HT sub stations.

16. Lighting & Small Power (IS: 1913, IS: 1777, IS: 1032 Part 5, IS: 13383 Part 2)

16.1 Definitions and Conventional Symbols

The definition of terms shall be in accordance with the Indian Standard Code of Practice for Electrical working installation except for the definition of a “Point”. The wiring and the equipments shall comply in all respects with the requirement of rule 50 and 51 of IE rules / 56 as amended from time to time. The wiring and other electrical equipments shall be suitable for trouble free operation at variation of voltage and frequency prescribed in IE rules.

16.2 Pressure Frequency

Pressure and frequency of supply all current consuming devices shall be suitable for the pressure and frequency of the supply to which these are to be connected and shall function at variation voltage and frequency as per IE rules.

16.3 Point Wiring

Point wiring shall include all work necessary to complete wiring from switch circuit of any length from the tapping point on the distribution circuit switch board to the following.

- Ceiling rose for fans, Lighting etc.
- Socket outlet (in the case of socket outlet points).
- Lamp holder (in the case of wall brackets, batten points, bulk head and similar fittings).
- Call bell buzzer (in the case of the works “via the ceiling rose / socket outlet or bell push where no ceiling rose / socket outlet is provided”).

16.4 Circuit Wiring

Circuit wiring shall mean the length of wiring from the distribution board upto the tapping point of the nearest first points of that circuit, viz., upto the nearest first switch board measured along the run of wiring. Such wiring shall be measured on linear basis.

16.5 System of Wiring

The wiring shall be carried out on such a system as may be specified in the tender schedule or otherwise specified in the special specification (“Power” and “Heating” wiring shall be kept separate and distinct from “Lighting” and “Fan” wiring). Recessed conduit wiring shall be done on distribution system main and branch distribution boards at convenient physical and electrical centers and without fuses at isolated places. All conductors shall run, as far as possible, along the walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. In no case, the open wiring shall be run above the false ceiling without the approval of Engineer-in-Charge. In all type of wiring due consideration shall be given for neatness, good appearance and safety.

16.6 Balancing of Circuits

The balancing of circuits in three phase installations shall be arranged beforehand to the satisfaction of Engineer.

16.7 Drawings

All wiring diagrams shall indicate clearly in plan, the main switch board, the distribution fuse board, the run of various mains and sub-mains and the position of all points with their classification

16.8 Cables

All cables shall confirm to the relevant Indian Standard. Conductors of all cables except the flexible cable shall be of aluminum.

The smallest aluminum conductors for the final circuit shall have a nominal cross-sectional area of not less than 2.5 sq.mm. The minimum size of aluminium conductors for power wiring shall be 4 sq.mm. (1/2.24 mm).

16.9 Rating of Lamp, Fans, Socket Outlet Points and Exhaust Fans

Incandescent lamps installed in pump house & other means shall be rated at 60 watts and 100 watts respectively.

Table fans and ceiling fans shall be rated at 60 watts. Exhaust fans shall be rated according to their capacity.
5 Amps. socket outlet points and 15 amp. socket outlet points shall be rated at 100 watts and 1000 watts respectively, unless the actual values of load are known or specified.

16.10 Joint and Looping Back

Unless otherwise specified the wiring shall be done in the “Looping System”. Phase of live conductors shall be looped at the switch box and neutral conductor can be looped from the light, fan or socket outlet. In non-residential buildings, neutral conductor and earth conductor and earth continuity wire shall be brought to each switch board situated in room and halls. These shall be terminated inside the switch boards with suitable connectors and the switch board shall be of adequate size to accommodate one number 5 amp. socket outlet and control switch in future.

16.11 Control at point of Entry Supply

There shall be a linked main switch gear with fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switch gear. The neutral shall also be distinctively marked. In this connection rule 33(2) of the Indian electricity Rules, 1956 shall also be referred.

16.12 Installation of Main Switch Gear

The main switch gear shall be installed as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid.

16.13 Indication Identifying Earthed Neutral Conductors

On the main switch gear, where the conductors include an earthed conductor of a two wire system or a conductor which is to be connected thereto, an indication of a permanent nature conductor. In this connection Rules 32(1) of the Indian Electricity Rules, 1956, shall be referred.

16.14 Marking of Apparatus

When a board is connected to voltage higher than 250 volts all the terminals or loads on the apparatus mounted on it shall be marked in the following colours to indicate the different poles of phases to which the apparatus or its different terminals may have been connected.

AC Three Phase	:	Red, Blue and Yellow
Neutral	:	Black

When four wire three phase wiring is done, the neutral shall preferably be in one colour and the other wires in another colour.

Where a board has more than one switch gear each such switch gear shall be marked to indicate which section of the installation it controls. The main switch gear shall be marked as such. Where there is more than one main switch board in the building, each switch board shall be marked to indicate which section of the installation and building it controls.

All markings required under this rule shall be clear and permanent.

All distribution boards shall be marked 'Lighting' or 'Power' as the case may be and also marked with the pressure and number of phases of the supply. Each shall be provided with a circuit, diagram and the current rating of the circuit and size of the fuse element.

16.15 Main and Branch Distribution Boards and their Locations

Unless otherwise specified in the special specification main and distribution fuse boards shall be the metal clad type.

Main distribution Boards shall be controlled by a linked fuse unit and a circuit breakers. Each outgoing circuit shall be provided, of MCB with SP / TP as per requirement

Branch Distribution boards shall be controlled by a MCB. Each outgoing circuit shall be provided with a fuse or MCB. The earthened neutral conductor shall have provision for disconnecting individually for testing purpose. At least one spare circuit breaker of the same capacity shall be provided on each branch distribution board.

16.16 Capacity of Circuits

Lights and fans may be wired on a common circuits, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load or 800 watts whichever is less.
Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading.

Where, not specified the load shall be taken as 1 kW per outlet. Wherever the load to be fed is more than 1 kW it shall be controlled by an isolator switch or miniature circuit breaker.

16.17 Passing Through Walls

When conductors pass through walls, any one of the following methods shall be employed. Care shall be taken to see that wires pass very freely through protective pipe or box and that wire pass through in a straight line without any twist or cross in wires, on either ends of such holes.

A conductor shall be carried in an approved heavy gauge solid drawn or lap welded conduit or in a porcelain tube of such a size that it permits easy drawings in. The ends of conduit shall be neatly bushed with porcelain, wood or other approved material.

Where a wall tube passes outside a building so as to be exposed to weather, the outer end shall be well mounted and turned downwards and properly bushed on the open end.

16.18 Fixing to Walls and Ceiling

Plug for ordinary walls or ceiling shall be of well-seasoned teak or other approved hard wood not less than 5 cm. long by 25 cm. sq. on the inner and 2 cm. sq. on the outer end. They shall be cemented into walls within 6.5 mm of the surface the remainder being finished according to the nature of the surface with plaster. Where owing to irregular coarsing or other reasons the plugging of the walls or ceiling with wood plugs present difficulties, the wood casing, wood batten or metal conduit shall be attached to the wall or ceiling in an approved manner. In the case of white washing. Plugging of walls or ceiling can be done in a better way where neatness is the first consideration. In all such case approver type of asbestos or fiber fixing plug (Rawl or Phil plug) with correct size of tees shall be used and done in a workman like manner.

Were this cannot be done, wooden plugs as described can be used with special permission of the Engineer.

16.19 Fittings

Lights, fans and sockets outlets shall be so located as to provide maximum comfort to the occupant and to enable him to utilise the electricity in the most economical manner.

Where conductors are required to be drawn through tube or channel leading to the fitting, the tube or channel must be free from sharp angles or projecting edges.

Non-flammable shade form a part of a light fitting against all risks or fire, celluloid shade or light fitting shall not be used under any circumstances. Vitreous enameled iron shade shall be of size 250 mm x 90 mm (nominal) size with a tolerance to 5 mm). Plastic shade shall not be generally used in the fittings suitable for incandescent lamp.

Enclosed type fittings shall be provided with a removable glass receptacles, arranged to enclose the lamp completely and of such size of construction as to prevent undue heating of the lamp, or if the position of fittings be such that the glass shall be protected by a suitable wire guard. The loads of pre-wired fixture shall be terminated on ceiling rose of connector.

External light fittings and lamps shall have weather proof fittings of approved design so as to effectively prevent the admission of moisture. An insulating distance piece of moisture proof material shall be inserted between the lamp holder nipple and the fittings.

In verandahs and similar exposed situations, where pendants are used they shall be of fixed rod type. Bulk head type fittings shall be of cast iron/cast aluminum body suitably painted white inside and gray outside complete with heat resistance glass cover, P.C. holder and wire guard suitable for 100 watts incandescent lamp. Where specified gasket for cover and shock proof B.C. holder shall be provided. Fluorescent tube light fittings of 40W / 80W fixed type shall be provided in general for conservation of energy and less maintenance.

16.20 Accessories

All switches shall be placed in the live conductor of the circuit and no single pole switch or fuse shall be inserted in the earth or earthed neutral conductors of the circuit.

16.21 Socket Outlets

A socket outlet shall not embody terminal as integral part of it. But the fuse may be embodies in plug in which case plug shall be non-reversible and shall be so arranged and connected that the fuse is connected to phase, live conductor or the non-earthened conductor of the circuit.

Every socket outlet shall be controlled by a switch.

The switch controlling the socket outlet shall be on the 'Live' side of the line.

5 Amps. and 15 Amps socket outlet shall normally be fixed at any convenient space 23 cms above the floor level or near such levels in special cases as desired by the Engineer-in-charge. 15 Amps switch and socket should be an integral provisions of an indicator diode. The switch for 5 Amps socket outlet shall be kept along with socket outlet. However, in special case, if desired by the Engineer the 5 Amps. socket outlet shall be kept at normal switch level and that for 15 Amp along with the socket outlet. However, in special case, if desired by the Engineer the 5 Amp socket outlet shall be placed at the normal switch level.

Where socket outlet are placed at lower levels, they shall be enclosed in a suitable metallic box, as the case may be to harmonise with the system or wiring adopted.
In an earthed system of supply a socket outlet and plug shall be of the three pin type. The third terminal shall be connected to earth.

Conductors connecting electrical appliance with a socket outlet shall be of flexible twin cord with an earthing cored which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance.

16.22 Attachment of Fittings and Accessories

In case of conduit wiring, all accessories like switches sockets, outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes. Accessories like ceiling roses, brackets, battens, stiff pendants, etc. shall be fixed on metal outlet boxes.
Aluminium alloy or cadmium platted iron screws shall be used to fix the accessories to their bases. The blocks/board shall normally be mounted with their bottom 1.25 m from floor level. The Boards shall have a sunmica finish.

16.23 Surface Conduit Wiring System

Conduit pipes of approved gauge thickness shall be used. The maximum number of VIR/PVC insulated 250 volts grade aluminum conductor cable that can be drawn in one conduit of various sizes and the number of cables per conduit shall not be exceeded. The minimum conduit disconnector shall not be less than 25 mm.

In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

16.24 Fixing of Conduit

Conduit pipes shall be fixed by heavy gauge clamps, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of not more than one metre but on either side of the couplers, bends, or similar fittings, saddles shall be fixed at a distance of 30 cm from the centre of such fittings. The saddle should not be less than 24 gauge for conduits upto 25 mm dia and not less than 20 gauge for larger diameter.

Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder lips as required by the Engineer-in-charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall not be less than as stated below:

16.25 Switch Box

Switch box shall be made of metal on all sides, except on the front.

In the case of cast boxes, wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, upto a size of 20 cm x 30 cm and above this M.S. boxes shall be used. Except where otherwise stated 3 mm thick phenolic laminated sheets like sunmica shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators inflush pattern. All fittings shall be flush pattern. Only a portion of the above box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

16.26 Conduit Wiring System

Conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements specified in the following clauses.

The chase in the wall shall be neatly made and ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, fixed work, special care shall be taken to fix the conduit and accessories in position along within the building work, to avoid damage to the finished wall etc.

All outlets such as switches, wall sockets etc. shall be flush type.

The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of earth attachment.

To facilitate drawings of wire in the conduit. G.I mesh wire of 10 SWG shall be provided while laying of recessed conduit.

16.27 Fans, Regulators and Clamps (IS: 374)

Ceiling fans including their suspension shall conform to relevant Indian Standards.

All ceiling fans shall be wired to ceiling roses or to a special connector boxes and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod

For concrete roofs, ceiling fan hooks shall be buried in the concrete during construction. M.S. flat of size 40 mm x 60 x mm bent in the form of an inverted ‘U’ supported on two cross rods or cross flats. 60 mm long which are bound together to the top reinforcement of the roof shall be used. The distance between the vertical legs shall not be less than 15 cm. and the legs shall project at least 13 cm below the ceiling and oval holes shall be made in them for carrying a 15 cm dia rod hook.

Alternatively a 15 mm dia, M.S. rod in the shape of ‘U’ with their vertical legs bent horizontally at the top at least 19 cm. on either side and bound to the top reinforcement of the roof shall be used.

In building with concrete roofs having a low ceiling height where the fan clamp mentioned under clause (c) cannot be used or whatever specified, recessed type fan clamp inside a cast iron box shall be used.

Canopies on top of suspension rod shall effectively hide the suspension.

Unless otherwise specified all ceiling fan shall be hung 2.75 M above the floor.

In the case of measurement of extra down rod for ceiling fan including writing the same shall be measured in units of 10 cms. Any lengths less than 5 cm. shall be ignored.

16.28 Exhaust Fans

Exhaust fans shall conform to the relevant Indian Standards.

Exhaust fans shall be fixed at the places indicated by the Engineer-in-charge. For fixing an exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame, which shall be fixed by means of rag bolts embedded to the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

Exhaust fans for installation in corrosive atmosphere fan shall be painted with a special PVC paint or chlorinated rubber paint (Chloro rubber paint).

Installation of exhaust fans at locations need careful consideration. The regulators of ceiling fans/exhaust fans shall be connected to earth by loop earthling.

16.29 Indoor Decorative Luminaires

Luminaire shall be suitable for use with twin/single T.L. 40 watt 1200 mm (4'). 240V fluorescent lamps, comprising of CRCA sheet steel channel stove enameled grey which incorporates all electrical accessories like quick fit lamp holder, starter holder, polyester filled ballast, power factor correction capacitor and duly prewired upto the terminal block, with earthling arrangement facility, cover made for channel from CRCA sheet steel stove white enameled covering the channel fixed by twin screw, suitable for ceiling or pendent mounting suitable for 19 mm dia conduit, reflector plate for acrylic diffuser and end covers, complete in all respects ready for use. The luminaire shall conform to IS:1913.

16.30 Outdoor Lighting

16.30.1 Poles

Street light poles shall be steel tubular swaged type, conforming to IS:2713 - 1969., suitably long with M.S. base plate with pipe cap and over hung 2 metres long having dia to suit the socket of 70/250 watts, 240V, High pressure sodium vapour lamp or metal halide fitting.

16.30.2 Outdoor Luminaire

The luminaire shall be 250 watt H.P.S.V. with all accessories and shall be deep drawn Aluminium reflector stove enameled grey outside and brightened and annodised inside lined with felt gasket to prevent insect entry.

Die cast Aluminium housing covered with a lid shall be provided to accommodate all electrical accessories, such as independent ballast, power factor improvement capacitor, wired upto terminal block.

A clear acrylic cover shall be fixed to the reflector by means of 4 toggles.

The luminaire shall be mounted on the mast arm of 50 mm O.D. Mirror compartment and tray compartment shall have degree of protection IP 43 and IP 33 respectively. The reflector shall be manufactured of drawn Aluminium sheet and be painted to stove enamel grey outside and brightened and annodised inside.

The housing shall be diecast Aluminium - A6 Grade MBV treated covered with acrylic sheet clear.

17. Emergency Light

Emergency light unit working on 230 volts. A.C. supply shall be self containing unit with 20 watts 600 mm long florescent lamp type 'SWITCH ON MAIN FAILURE'. It shall be electronic automatic fluorescent type which incorporates a unit trickle charge circuit, which shall prevent overcharging of battery. The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IS:9583.

18. Earthing

Earthing in general shall comply with C.P. (Code of Practice) 3043 of Indian Standards.

Earth electrode either in the form of pipe electrode or plate electrode should be provided at all premises for providing earthing system.

As far as possible, all earth connection shall be visible for inspection and shall be carefully made.

Except for equipment provided with double installation, all the non-circuit carrying metal parts of electrical installation are to be earthed properly. All metal conduit trunking cases, sheets, switch gears, distribution fuse boards, lighting fittings and all other parts made of metal shall be connected to an effective earth electrode.

The main earth electrode should be G.I perforated pipes driven into the soil as per standard practice. Continuous looped earthing should be provided with adequate size G.I. wire / feat. Earthing work should conform to I.E Rules.

The earth pit shall conform to IS : 3043 and GI earth electrodes of not less than 100 mm external dia shall be driven to a depth of atleast 3m in the ground below the ground level. The surrounding of the electrodes, soil shall be treated up with salt, coke and charcoal.

Earth electrode shall be installed near the main supply point and shall comprise a copper / GI earth of appropriate diameter and driven to depth of 3 metres below ground level, or to a greater depth, if so required to obtain a sufficiently low earth resistance value. Alternatively copper plate may be used as the main earth electrode conforming to IS:3043. The electrodes shall be driven at least 1.5m away from the building or any other earth station.

Minimum requirement of earth pits as per I.E. rules are as under:

The main earth electrodes after being driven into the ground shall be protected at the top by constructing a concrete or masonry chamber of size 300 mm x 300 mm x height 300 mm. and shall be provided with CI cover. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall not exceed 1.0 ohm. The remaining space in the bore hole shall be filled with bentonite. The bentonite will hold the earth rod in position. The neutral conductor shall be insulated throughout and shall not be connected at any point to the consumers earthing system.

An earth continuity conductor shall run continuously from the farthest part of installation to the main earth electrode and shall be connected by branch conductor to all metal casing and sheathing housing electrical apparatus and/or wires and cables. all branches shall be connected to earthing. The earth continuity conductors shall have a cross-sectional area at least half to the size of the phase conductor and in no case less than 1.5 sq.mm of copper / GS.

All earth wires and earth continuity conductor shall be galvanised M.S flats of appropriate size. Interconnections of earth continuity main conductors and branch wires shall be brazed properly, ensuring reliable, permanent and good electrical connections. The earth lead run on structures must be securely bolted. Neutral earth leads shall be run on a separate supports without touching the body of the transformers. Earth wires shall be protected against mechanical damage and possibility of corrosion particularly at the junction points of earth electrodes and earth wire interconnections. Earth electrodes shall be connected to the earth conductors using proper clamps and bolt links.

It shall not be allowed to use the armour of the incoming feeders cable to the sub-distribution board as the only earthing system.

Sheathed lugs of ample capacities and size shall be used for all underground conductors for sizes above 3 mm^2 whenever they are to be fitted on equipment or flat copper conductor.

The lugs shall be fitted on equipment body to be grounded or flat copper only after the portion on which it is to be fixed is scrubbed, cleaned of paint or any oily substance on a subsequently tinned.

No strands shall be allowed to be cut in case of stranded ground round conductors. G.I embedded conduits shall be made electrically continuous means of good continuity fixing and also be rounding copper wires and approved copper clamps.

19.1 Earthing of Lighting Poles

All external poles are to be looped together with continuous 14 SWG TC earth wire clamped at dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

19.2 Earthing for Lighting Installation

This shall be common grid system, the main grounding conductor laid and embedded in concrete being grounded at earth pits outside the buildings at approved locations or other places. The earthing of L.T panels shall be connected to two main grounding conductors each of which along with main cables shall run with cables to distribution boards in each floor. This shall run along with the cable and at the top floor be connected to the same section completing the grid.

19.3 Sizes of Earthing Conductors

Sl. No.	System	Earthing conductor size and Material
1	415V switchgear, DG set, Capacitor Control panel	Suitable to its rating.
2	415V LT Motors	
	- less than 50 HP	25 X 6 mm GI
	- 50 - 150 HP	40 X 6 mm GI
	- above 150 HP	50 X 6 mm GI
3	Lighting distribution Board,	14 SWG GS wire

4	Local push Button Stations, Junction Boxes.	14 SWG GS wire
5	Lighting and receptacle system	14 SWG GS wire
6	Earth Electrode	50 mm dia. 3000 mm long heavy duty GI pipe electrode
7	Street lighting poles	14 SWG TC wire

Note: 1. Conductors above ground shall be of galvanised steel to prevent atmospheric corrosion.
Note: 2. Conductors buried in ground or embedded in concrete shall be of mild steel.

20. Power capacitor

Power shunt capacitors in general shall confirm to latest version of IS:13585, Part-1. Power capacitor control panel shall be housed in metal enclosed cubicle. Power capacitor shall be mounted on MS angle frame works and capacitor control panel along with MV panel.

The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units.

The assembly of the banks shall be such that it provides sufficient ventilation for each unit.

Each capacitor case and the cubicle shall be earthed to a separate earth bus.

Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 13585 Part 1.

Film dielectric, Aluminium foil conductor, impregnated with Non PCB, Non Toxic biodegradable capacitor grade oil, under vacuum, two layers of biaxially oriented propylene film shall be used.

Each unit shall satisfactorily operate at 135% of rated kVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage upto a maximum of 10% above the rated voltage, excluding transients.

20.1 Unit Protection

Each capacitor unit shall be individually protected by an MCCB / MCB fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual

indication so that it may be detected during periodic inspection. The MCB breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

20.2 Capacitor Control Panel

The control equipment shall be mounted in the MV panel made of 2.6mm / 2.0mm cold rolled sheet steel for the front and other sides respectively. The panel shall be of indoor type and shall consist of :

- Isolating switch / MCB / MCCB

- Red and Green lamps for capacitors ON/OFF indication.

20.3 Technical Particulars - The Equipment shall conform IS 13585 Part 1

- General
- Quantity as per requirement
- Rated capacity as per requirement
- Rated Voltage : 433 V
- Rated frequency, and phases: 50 Hz, 3 Phase
- Design Requirements
  Insulation level :2.5 KV (rms)
- Capacitor bank connection :Delta
- Short circuit withstand for busbars :
  Short time (1 sec) : 40 KA (rms)
  Dynamic : 102 KA (peak)
  Switches
  Type of switching : MANUAL switching
  Income current rating :To suit-rated capacity of kVAR

20.4 Tests and Test Reports

- All tests shall be conducted in accordance with the latest edition of IS – 13585 Part 1 and as applicable for the controls.

- Type test certificates for similar capacitor units shall be furnished.

20.5 Drawings

The following drawings shall be submitted for the approval of the Engineers Representative.

- Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.

- Complete schematic and wiring diagrams for capacitor control panel.

21. PUMPING MACHINERIES

21.1 Applicability

The following clauses shall specify general mechanical requirements and standards of workmanship for equipment and installations and must be read in conjunction with the particular requirements of the Contract. These general specification clauses shall apply where appropriate

except where redefined in the particular requirement sections of the Specification which shall be applicable

21.2 Materials

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfection, and selected for long life and minimum maintenance.

21.3 Design and Construction

The plant design, workmanship and general finish shall be of sound quality in accordance with good engineering practice. Design shall be robust and rated for continuous service, at the specified duties, under the prevailing operational site conditions.

The general design of mechanical and electrical Plant, particularly that of wearing parts, shall be governed by the need for long periods of service without frequent attention but shall afford ready access for any necessary maintenance.

Similarly items of Plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same material specification as the originals.

No welding, filling or plugging of defective work will be permitted without the written permission of the Engineer. All welding spatter shall be removed.

It shall be the responsibility of the contractor to ensure that all the equipment selected is fully compatible, mechanically, electrically and also with respect to instrumentation, control and automation.

It shall be the responsibility of the contractor to ensure his equipment interfaces with any existing equipment correctly. Any interfaces must not affect the integrity of the equipment, or invalidate any warranties or guarantees.

Each component or assembly shall have been proven in service in a similar application and under conditions no less than those specified therein.

The plant shall be compatible with the civil structure, when installed, with sufficient space for operator access and maintenance procedures.

All materials shall be of the best commercial quality and free from any flaws, defects or imperfections.

Materials shall be selected to eradicate or reduce corrosion to a minimum.

21.4 Tropicalisation

All plant and materials used shall in all respects be suitable for the climatic conditions of the Chennai as detailed in Table - _ hereof. The following maximum conditions shall be used for all design.

i) Maximum peak ambient shade temperature : 43°C

ii) Maximum daily average ambient shade temperature : 38°C

iii) Maximum yearly average ambient shade temperature : 30°C

iv) Maximum Relative humidity : 100%

In damp situations and wherever exposed to the weather, precautions shall be taken against corrosion of metal work, cable armour, conduit and the like.

All electrical equipment including cables shall be de-rated for continuous operation in an ambient temperature of 45°C in accordance with the appropriate regulations.

All materials and equipment which are subject to certification by testing authorities etc., shall be certified as being tested at 45°C ambient.

Tropical grade materials should be used wherever possible. Some relaxation of these provisions may be permitted where equipment is hermetically sealed.

Iron and steel are in general to be painted or galvanized as appropriate in accordance with the Specification. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electro-magnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting. Cores etc. which are built up of laminations or cannot for any other reasons be anti-rust treated, are to have all exposed parts thoroughly cleaned and heavily enameled, lacquered or compounded.

The use of iron and steel is to be avoided in instruments and electrical relays whenever possible. Steel screws, when used, are to be zinc, cadmium or chromium plated or, when plating is not possible owing to tolerance limitations, shall be corrosion resisting steel. Instrument screws (except those forming part of a magnetic circuit) are to be of brass or bronze. Springs are to be of brass, bronze or other non-rusting material. Pivots and other parts for which non-ferrous material is unsuitable are to be of an approved stainless steel.

Fabrics, cork, paper and similar materials, which are not subsequently to be treated by impregnation, are to be adequately treated with an approved fungicide. Sleeving and fabrics treated with linseed oil or linseed oil varnishes are not to be used.

21.5 Packing and Delivery

All plant and equipment as necessary shall be packed in first quality containers or packing; no second-hand timber shall be used. All packing must be suitable for several stages of handling via sea or air freight, inland transport and movement on site.

Flanged pipes are to have their open ends protected by adhesive tape or jointing and are then to be covered with a wooden blank flange secured by service bolts.

The sleeves and flanges of flexible couplings shall be bundled by wire ties. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross.

Precautions are to be taken to protect shafts and journals where they rest on wooden or other supports likely to contain moisture. At such points wrappings impregnated with anti-rust composition or vapour phase inhibitors are to be used of sufficient strength to resist changing and indentation due to movement which is likely to occur in transit. The form of the protective wrappings and impregnation are to be suitable for a minimum period of twelve months.

Lids and internal cross battens of all packing cases are to be fixed by screws and not nails. Hoop metal bindings of cases are to be sealed where ends meet and if not of rust less material are to be painted. Contents of cases are to be bolted securely or fastened in position with struts or cross battens and not with wood chocks, unless they are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the batten may rest. Cases are to be up-ended after packing to prove that there is no movement of contents.

Where parts are required to be bolted to the sides of the case, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad. All stencil marks on the outside of the casings are to be either of a waterproof material or protected by Shellac or varnish to prevent obliteration in transit. Wood wool is to be avoided as far as possible. Waterproof paper and felt linings are to overlap at seams at least 12mm and the seams secured together in an approved manner, but the enclosure is to be provided with screened openings to obtain ventilation.

Where applicable, indoor items such as electric motors, switch and control gear, instruments and panels, machine components, etc. are to be 'cocooned' or covered in polythene sheeting, sealed at the joints and the enclosures provided internally with an approved desicator.

Bright metal parts are to be covered before shipment with an approved protective compound or coating and protected adequately during transport to site. After erection these parts are to be cleaned by the Contractor.

Each crate or package is to contain a packing list in a waterproof envelope and copies in duplicate are to be forwarded to the Engineer; prior to dispatch. All items of material are to be clearly marked for ready identification against the packing list. All cases, packages, etc. are to be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and to indicate the correct positions for slings, and are to bear an indelible identification mark relating them to the appropriate shipping documents.

The Engineer may require to inspect and approve the packing before the items are dispatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit, and such inspection will not relieve the Contractor for any loss or damage due to faulty packing.

21.6 Workmanship

Workmanship and general finish shall be of first class commercial quality and in accordance with best practice. All covers, flanges and joints shall be properly faced, bored, fitted, fixed, hollowed, mounted or chamfered as the case may be, according to the best approved practice and all working parts of the plant and other apparatus, shall similarly be well and accurately fitted, finished, fixed and adjusted

21.7 Castings and Metals

All castings shall have an homogenous structure and be free from blowholes, flaws and cracks. Any casting having a thickness in parts in excess of 3 mm to that which it is purported to be shall be rejected. No repairs or patchwork to castings shall be allowed other than that approved by the Engineer.

Castings subject to hydraulic pressure shall be tested to 1.5 times the maximum working pressure. Certified copies of Test Reports shall be forwarded to the Engineer as soon as the test is completed.

Where not otherwise specified steel castings shall be selected from the appropriate grade. as per relevant IS.

All grey iron castings supplied shall be to the appropriate grade of IS:210. The Contractor shall replace any casting which the Engineer considers is not of first class appearance or is not in any way the best which can be produced, although such a casting may have passed the necessary hydraulic or other tests. No plugging, filling, welding or "burning on" will be acceptable

All spheroidal graphite or modular graphite iron shall be to the appropriate grade of IS.1865.

Where not otherwise specified the bronze used shall be made of a strong and durable zinc free mixture as per relevant IS:318.

Aluminium and Aluminium alloys shall not be utilised unless alternative materials are considered unacceptable. The use of Aluminium requires the approval of the Engineer in all cases. Bars and extruded sections shall be as per relevant IS.

Aluminium and Aluminium Alloy Castings shall be manufactured as per IS:617:1994 and subjected to a chill cast to increase tensile strength. Immersed structures or structures that are periodically immersed shall not be constructed from Aluminium or Aluminium alloys. All chromium plating shall comply with IS 1986.

21.8 Painting and Metal Protection

The surface preparation and painting or application of corrosion protection coatings to the following materials shall be carried out in accordance with relevant IS for the particular environmental conditions where the materials are used.

- Mild Steel
- Cast and Duct Iron
- Aluminium
- Nonferrous Parts
- Other small parts

21.9 Galvanising

Where steel or wrought iron is to be galvanised, it shall be carried out by the hot-dip process and shall conform in all respects with IS:2629. Adequate provision for filling, venting and draining shall be made for assemblies fabricated from hollow section. Vent holes shall be suitably plugged after galvanising.

All surface defects in the steel including cracks, surface laminations, laps and folds shall be removed in accordance with IS:6159. All drilling, cutting, welding, forming and final fabrications of unit members and assemblies shall be completed before the structures are galvanised, the surface of the steelwork to be galvanised shall be free from welding slag, paint, oil, grease, and similar contaminants. The articles shall be pickled in dilute sulphuric or hydrochloric acid, followed by rinsing in water and pickling in phosphoric acid. They shall be thoroughly washed, stoved and dipped in molten Zinc and brushed, so that the whole of the metal shall be evenly covered and the additional weight thereof after dripping shall not be less than 610 grams per square metre of surface galvanised, except in the case of tubes to BS.1387 when it shall be 460 grams per square metre.

On removal from the galvanising bath the resultant coating shall be smooth, continuous, free from gross imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross. Edges shall be clean and surfaces bright.

Bolts, nuts and washers shall be hot-dip galvanised and subsequently centrifuged in accordance with IS:2629. Nuts shall be tapped up to 0.4 mm. oversize before galvanising and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nuts.

During off-loading and erection the use of nylon slings shall be used. Galvanised work which is to be stored in Works or on Site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining.
Small areas of the galvanised coating damaged in any way shall be restored by:-

i. Cleaning the area of any weld slag and thoroughly wire brushing to give a clean surface.

ii. The application of two coats of zinc-rich paint (not less than 90 per cent zinc, dry film), or the application of a low melting-point zinc alloy repair rod or powder to the damaged area, which is heated at 300^0C.

iii. Fastenings of galvanised steelwork shall be hot drip galvanised and subsequently centrifuged in accordance with IS:2629. Nuts shall be tapped upto 0.4 mm oversize before galvanising and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nuts.

iv. Where surfaces of galvanised steelwork are to be in contact with aggressive solutions and\or atmospheres the galvanising shall receive further protection by painting.

21.10 Fasteners

All bolts, nuts and studs with nominal diameters up to and Fasteners including 39mm required to be made in carbon steel shall conform to BS.6104 and threaded in accordance with IS:1367. Bright steel washers 3.0mm in thickness shall conform to BS.4320 and shall be provided beneath bolt head and nut. The above items required to be supplied in stainless steel shall conform to IS:1570. These items together with holding-down bolts and anchor plates required to be supplied in high tensile steel shall conform to BS.970 Ref. Symbol T Drilled anchor fixings for use on concrete structures shall be of a type Fasteners approved by the Engineer's Representative. The positions of all drilled anchors shall be approved by the Engineer's Representative and a Contractor proposing to use such fixings shall be deemed to have undertaken to supply, mark off, drill and fit. All exposed bolt heads and nuts shall be hexagonal and the length of all bolts shall be such, that when fitted and tightened down with a nut and washer, the threaded portion shall fill the nut and not protrude from the face thereof by more than a half diameter of the bolt. Rivets shall conform to BS.641 and tested in accordance with BS.1109.

21.11 Forgings

Carbon steel forgings shall be manufactured heat treated and tested in accordance with IS:2004-1991

21.12 Foundations and Setting of Machinery

The Contractor shall arrange for the provision of all foundations and plinths required for the plant and shall ensure that it is in accordance with the approved drawings.
The Contractor shall provide all necessary templates for suspension of the holding-down bolts during grouting of same. The machinery shall be mounted on flat steel packings of a thickness selected to take up variations in the level of the concrete foundations.

The packings shall be bedded by chipping or grinding of the concrete surface. Only one packing of selected thickness shall be used at each location, which shall be adjacent to each

holding down bolt. The number of shims shall not exceed two at each location and the thickness of each shim shall not exceed 3mm.The machinery shall be aligned, levelled and pulled down by the nuts of the holding down bolts with a spanner of normal length, and no grout shall be applied until the machinery has been run and approved by the Engineer for stability and vibration.

21.13 Bearings and Lubricators

The size of bearing shall be not less than that calculated for Bearings and a minimum L10 basic rating life in accordance with BS.5512 Lubricators Part 1., taking into account all considerations of reliability, materials of manufacture and operating conditions. All bearings shall be rated and sized to ensure satisfactory running without vibration under all conditions of operation for a minimum life of 50,000 hours running. They shall be efficiently lubricated and adequately protected from ingress of moisture, dust and sand and the particular climatic conditions prevalent at the site. All bearings shall be to ISO standard SI unit dimensions where practicable. All ball or roller bearings, except those supplied as "sealed for life" shall be arranged for grease gun lubrication and a suitable high pressure grease gun shall be supplied.

Adequate "Stauffer" screw top pressure grease lubricators with 'tell tale' stems or "Tat" grease nipples shall be provided for all moving parts. The position of all greasing and oiling points shall be arranged so as to be readily accessible for routine servicing. Where necessary, suitable access platforms shall be provided. The type of lubricant and intervals of lubrication, which shall be kept to a minimum (not less than nine days), for each individual item of plant shall be entered on a working schedule, which shall form part of the Operation and Maintenance instructions. A list of recommended Lubricants and their equivalents Bearings and shall be entered in the Operation and Maintenance instructions.

21.14 Labels

The Contractor shall arrange for the supply and fitting of engraved identification labels to all valves and items of plant. The reference numbers of all valves shall be as indicated on the schematic diagram to be supplied under the Contract. All warning labels shall comply with BS 5378 parts 1, 2 and 3 and of screw fixed rigid construction

Designation labels shall be of 5 mm Traffolyte with black lettering on white background. Embossed materials and techniques shall not be accepted.

The Contractor shall provide 2 No. enamelled iron plates worded "Men Working on Plant". The plates shall be 200mm x 75mm with red lettering on a white background. The Contractor shall also provide and fit warning labels for machinery that is operated under automatic control. All identification and warning labels shall be in English and in the local Language.

21.15 Guards

Adequate guards shall be supplied and installed throughout the installation to cover drive mechanisms. All rotating and reciprocating parts, drive belts, etc. shall be securely shrouded to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction they shall also be readily removable for gaining access to the plant without the need for first removing or displacing any major item of plant. The guards shall be of the open mesh type except where retention of fluid spray is required.

21.16 Suppression of Noise

All plant offered shall be quiet in operation. The noise levels in the entire premises shall be as per the norms of the Pollution Control Board. The noise levels measured as per

IS/ISO:4412-1, 2 – 1991 shall be within the levels prescribed by TNPCB. The noise level within the building shall not be more than 85 decibels (+5 per cent on this over the audible frequency spectrum measured at mid-band.) "A" scale when measured along a contour 3 metres from any single item of plant during starting, running and stopping. The noise level outside the building shall not be more than 60 decibels (+5 per cent on this over the audible frequency spectrum measured at mid-band.) "A" scale when measured along a contour 3 metres from the external wall. Noise test measurements shall be made on completion of the installation of the plant at Site to verify that it complies with this Clause. Plant which fails to comply with the noise level limits when tested will render it liable for rejection unless it is satisfactorily modified at the Contractors expense by the programmed commissioning date.

22 Horizontal Split Casing Centrifugal Pumps (Water)

22.1 General

This section covers in general the required specification with respect to horizontal split casing centrifugal water pumps. The details pertaining to the design, drawing, selection of equipment / materials, procurement, manufacture, installation, testing & commissioning however if not mentioned, the same shall of high standard of engineering and shall comply with all currently applicable standards regulation and safety codes.

22.2 System Head Curves

The pump shall be suitable for operation in a pumping system, at the duty points specified for each pump and should be able to satisfactorily operate within the range of operation indicated on the system resistance curve or as specified.

22.3 Codes and standards

The design, manufacture and performance of the centrifugal pumps specified here in shall comply with the requirements of the latest edition of the applicable codes and standards.

Standard	Title
IS 6595	Horizontal centrifugal pumps for clear cold and fresh water
IS 9137	Code for acceptance tests for centrifugal, mixed flow and axial pumps
IS13537 / ISO 5199	Technical specification for centrifugal pumps - Class 2
ISO 5199	Standards of the Hydraulic Institute of USA.

22.4 Design requirements

The pumps shall be capable of developing the required total head at rated capacity for continuous operation. The contractor shall match his pumps to the system - Head curve, and the pumps shall operate satisfactorily within the operating range. The pump shall have a stable head capacity curve, i.e. the total head-capacity curve shall be continuously rising towards the shut off.

The material of the various components shall conform to relevant section of IS.

Performance requirement for the pumps shall be guided by the data specification sheets.

The power characteristic shall be non-overloading and preferably flat for flows higher than the best efficiency flow (BEP).

The required pump NPSH at duty point shall be at least 0.5 metres less than the available NPSH. The pump shall be designed to work with a least two metres suction lift.

Pumps must be suitable for operating alone or in parallel over the entire operating range. The pumps shall operate satisfactorily at any point between the maximum and minimum system resistance, wherever system resistance curve is specified or at the end of pump performance curve, with respect to the NPSH available at the lowest permissible suction water level.

The pump rotational speed shall be selected taking into consideration the NPSH available. The pump R.P.M. shall be such that the suction specific speed shall be limited to 8500.

The pumps shall be capable of reverse rotation up to 125% rated full speed of the drive motor, due to backflow of water, without damage or loosening of threaded components.

The first critical speed shall be away from the operating speed and in no case less than 130% of the rated speed.

Though the specifications for flanges are mentioned elsewhere in this document, it is contractor's responsibility to ensure that correct matching flanges are provided with the pump.

Spare parts supplied with the pump shall be identical to respective pump components and shall be from original manufacturer.

Pumps shall run smooth without undue noise or vibration. Noise levels and amplitude of vibrations shall be within acceptable limits. Noise level shall be limited to 85 db at a distance of 2 m. and amplitude of vibrations (peak to peak) shall be within 2.5 MILS in any plane as per relevant hydraulic institutes' standards and IS.

Unless otherwise specified drive unit power rating shall be the maximum of the following requirements.

a) 15% margin over the pump shaft input power at the rated duty point.
b) Pump shaft input power required considering the overloading of the pump, if any, assuming single pump operation in the event of tripping of one or more of the pumps operating in parallel.
c) Maximum pump shaft input power required for operation of pump at any point on the pump performance curve between pump shut off and pump run out condition.

The pump characteristics of the offered pump should be such that shut off head is at least 15% more than the design head.

Pumps shall be identical and shall be suitable for parallel operation with equal load division.

The design of bearing should be such that the bearing lubricating element does not contaminate the liquid being pumped. Where there is a possibility of liquid entering the bearings suitable arrangement in the form of deflectors or any other suitable arrangement must be provided ahead of bearing assembly.

Bearing shall be easily accessible without disturbing the pump assembly. A drain plug shall be provided at the bottom of each bearing housing.

22.5 Features of Construction

22.5.1 Impeller

The impeller shall be an enclosed impeller, made in one piece and securely keyed on the shaft. The installation will include means to prevent loosening of the impeller during operation, including rotating in the reverse direction. The impeller shall be statistically and dynamically balanced to prevent vibration, as per ISO Standards.

22.5.2 Casing Ring

The pump shall be provided with a renewable type casing ring, to offer wearing resistance. Hardness of the casing ring shall be 50 BHN (Brinell Hardness Number Units), lower than the impeller.

22.5.3 Shaft

Single integral shaft, shall be designed to withstand the torque loads throughout the whole range of operating conditions, for the selected particular impeller diameter as well as all the impeller diameters covered between minimum and maximum impeller diameters when coupled to the motor shaft through flexible coupling. The shaft design should also include the possibility of running the pump with a electric motor of higher power rating meant for future expansion with increases impeller diameters.

22.5.4 Shaft Sleeves

Replaceable shaft sleeves shall be provided to protect the shaft where it passes through stuffing boxes. The end for the shaft sleeve assembly shall extend through the packing gland. Shaft sleeves shall be securely locked or keyed to the shaft to prevent loosening. Shaft and shaft sleeve assembly shall ensure concentric rotation.

22.5.5 Stuffing Boxes

Stuffing boxes at driving end and non-driving end shall be of such design that they can be packed, without removing any part, other than the gland and lantern ring. An axially split glass should be used to facilitate changing the gland packing. Sufficient space shall be available maintenance purposes.

22.5.6 Air Release Valves

Pump shall be provided with arrangement of valve to vent air which may get accumulated in the pump.

22.5.7 Sealing

Self-sealing water connections should be provided.

22.5.8 Flanges

Flanges shall be machined flat, with flange faces vertical and at right angles to the pump mounting surface. Flange drilling shall conform to IS 1538, with suction and discharge connections be flanged and drilled to the specified flange table. Compassion flanges will be

drilled to the same table Cast iron flanges shall be flat faced and be full/spot faced on the back side.

22.5.9 Bearings

Bearings shall be either grease or oil lubricated and should absorb the radial and axial thrush under all operating conditions. Anti-friction bearing shall be of standard type and shall be selected to give 20,000 hours continuous operation at rated operating conditions. The rise in bearing oil/grease temperature with continuous running of the pump shall be within the allowable limits which shall not exceed 20°C for grease and 30ÉC for oil lubricated bearings above ambient temperature. Cooling arrangements shall be provided if required: bush bearings will not be acceptable.

22.5.10 Base plate

The common base plate for pump and motor shall be fabricated from mild steel sections and have sufficient rigidity to resist vibration and distortion. Suitable holes shall be provided for grouping and they shall be so located that the base will be able to be grouped in place, without disturbing the pump and motor. The base plate should be of the drain rim type to collect any gland water leakage and lead to drain. All pumps and motors shall be properly and accurately aligned, bolted and doweled to the base plate. Adequate space shall be provided between pump drain connections and base plate for installation of minimum 15 mm diameter drain pipe. Foundation bolts shall be complete with nuts and flat and shake proof washers.

22.5.11 Coupling

A flexible pin bush type coupling shall be provided, duly bored and keyed to the pump and motor shafts.

The coupling and the pump shafts have to be designed that the breaking load of the coupling system is below that of the shaft.

22.5.12 Accessories

All specified accessories and any other standard accessories required for correct and safe operation of the pump shall be furnished with the pumps. All incidental piping (including valves) required for sealing, lubrication and cooling of stuffing box packing and/or pump bearing shall be furnished by the contractor. A mild steel fabricated coupling guard shall be supplied provided --- rotating parts of the pump and motor.

Eye bolts (as many per pump as required shall be provided for ease of lifting and installation.

The pump shall be fitted with a suitable vent connection at the top.

All the liquid passages in the casing and impeller, which are inaccessible to machining finish, shall be finished to a smooth surface as far as is possible.

Drawings and information to be provided.

During detailed engineering the contractor shall submit the following.

a) All the drawings/data pertaining to selected models with improvements if any. This should necessarily include complete pump performance curve with.

b) H-Q curves for complete range of impellers between minimum and maximum size of

impellers and so efficiency curves super imposed on them, highlighting selected important diameter.

c) Shaft Power - Q curve for complete range of impellers

d) Efficiency -Q furze for Maximum impeller diameter and selected impeller diameter.

e) NPSHR-Q curve for maximum, minimum and selected impeller diameters.

f) Torque-speed curves of pump superimposed on motor curve corresponding to 80%, 90%, 100% voltage.

g) Test reports and other particulars, as required by the applicable clauses of this specification.

22.6 Instruction Manuals

- Instruction manual for erection.
- Instruction for pre-commissioning checkup, operation, abnormal conditions, maintenance and repair.
- Write up on controls and interlocks provided.
- Recommended inspection points and periods of inspection.
- Schedule of preventive maintenance.
- Ordering information for all replaceable parts.
- Recommendations for types of lubricants, lubricating points, frequency of lubrication changing schedule.

22.7 Site Inspection and Testing

The equipment delivered to the Site shall be examined by the Contractor to determine that it is in good condition and in conformance with the approved working drawings and certifications. All equipment shall be installed in strict conformance with the Specification and the manufacturer's instructions.

The commissioning tests shall be performance and reliability trials, mainly for the purpose of satisfying the Engineer that the pumpsets have been correctly assembled and installed and that their performance matches that obtained during the manufacturers works tests. In the event of an unwarranted change in the pump performance characteristics or power consumption, all necessary steps shall be taken as soon as possible to establish the cause and remove the fault. Similar action shall be taken for an undue increase in bearing or gland temperature, increased gland leakage rates, unsatisfactory vibration levels or any other fault or defect in the operation of the pump set.

The site reliability trials shall include the following:

A record of bearing and coupling clearance and alignments shall be tabulated to show the "as-built" condition of each pump

A record of all overload, timing relay and oil pressure relays shall be tabulated to show the "as-built" condition of each motor starter

All cables shall be ‘megger’ tested to confirm the integrity of the insulation. A tabulated record of results shall be made

The control panel shall be statically tested with motors disconnected to confirm the correct sequence of operation

Each pump shall be operated individually over the range from closed valve to maximum emergency top water level, on a recirculation basis, using fresh water, and for a minimum of four hours continuously. During this test the following parameters will be recorded: -

- motor phase currents
- pump output
- ambient and test water temperatures
- motor/pump casing temperature (dry well submersible only)
- power consumed
- power factor
- vibration

The commissioning trials shall extend until each pump unit has run 'continuously' for at least 3 days under all operating conditions. The term 'continuously' shall include running at various speeds or on a start/stop basis as determined by the control system

The Contractor's supervisory staff shall be present during the period of the tests and trials. The Contractor shall be responsible for any failure of the whole equipment or any part thereof, whether such failure shall be determined by the methods detailed herein or otherwise. If the Contractor interrupts the pump test or trial, or through negligence on the part of the Contractors staff, it shall be completely repeated for the pumpset concerned.

22.8 Characteristic Curves

Characteristic and system curves for the pumps shall be supplied to a reasonably large scale which shall show the capacity of the pumps under single and multi pump operation at the duty point.

When tested through their complete range of workable heads at the maker's works, all the pumps shall give results which conform to the curves submitted with the Tender. Curves showing pump efficiency and kW. loading shall also be included.

22.9 Performance Test

Each pump shall be tested at the manufacturer’s premises for the full operating range of the pump. Pump performance shall be within the tolerance limits specified in the relevant standards. The contractor shall furnish the guaranteed values of discharge and efficiency for the total head at duty point for each pump.

22.10 Electric Motors

22.10.1 Supply Voltage and Characteristics for Motors

All LT motors shall be squirrel cage motor and the motor shall be suitable for the following.

Supply voltage	:	415 Volts, 3 Phase, 50 Hz AC supply
Voltage variation	:	± 10%
Frequency variation	:	± 5%
Combined variation of Voltage & Frequency	:	10%

All motors shall be foot / flange mounted squirrel cage induction type and shall be capable of developing at least 10% more power than demanded by the pump or driven equipment over its entire range of safe operation.

Motors shall be continuous maximum rated as per IS:325 and IS:4722 (latest edition) and preferably be designed for low starting current and smooth acceleration except for cases where the driven equipment characteristic demand otherwise. Motors shall be of 4/6/8 pole design fitted with ball .roller bearings and provided with one or more terminal boxes large enough to accommodate armoured PVC insulated Aluminium conductor of appropriate ratings.

22.10.2 Motor Winding

Motor winding shall be insulated with Class F insulation with temperature rise limited to Class B rating as per IS:325 and IS:4722 over an ambient temperature of 450C. The pull out torque of the motors at rated voltage and frequency shall preferably be 200% of FLT in each motor above 5.5 kW rating. Motors shall be suitable for star-delta / or Direct on Line starting.

22.10.3 Starting Current for Heavy Motors

However, when LT motors are switched on, the starting current shall be limited to 400% of full load current for squirrel cage induction motors. All LT motors shall be squirrel cage type.

22.10.4 Motor Protection

All motors shall be provided with protection to IP 55. For hazardous location, flame and explosion proof enclosures shall be provided.

Appropriate water proof enclosures shall be provided to outdoor electric panels and starters, to provide sufficient protection from rains, dust, vermin etc.

Degrees of protection provided by enclosures for rotating electrical machinery shall conform to the requirements of IS:4691. Flame proof motors where applicable shall comply with relevant specification of Mine safety requirements and other applicable specifications for this type motors including IS:5571.

22.10.5 Motor Testing

Testing of motors shall comply with the requirements of IS:4029. Dimensions of foot mounted motors shall comply with the requirements of IS:1231. Generated values of efficiency and power factor at full load and 3/4 load shall be furnished by the tenderer.

22.10.6 Motor starting arrangements

Individual Motor starters / panels for 415 volt 3 Phase 50 Hz Motors shall be as below:-

For Squirrel cage motors up to 3.7 kW : Direct-on-line
Squirrel cage motors above 3.7 kW to 38kW : Star-delta starters
For motors above 38kW to 75kW : Auto transformer
For motors above 75kW : FCMA Starters

Each control panel / starter shall incorporate isolator, HRC fuse conductors, timing relays, overload relays, single phase preventor, Hour meter (for pump running hours) etc. appropriate for the scheme of control. Contactor rating for each motor shall be at least 25% higher than the full load current of the motor and contactor shall comply with the requirements of IS:13947 Part 4 Sec 1 and IS:10118. Reversible starters shall be provided wherever necessary.

23. Diesel Generator

23.1 General

Electrical power supply for each pumping station will be availed from nearby TNEB supply point. According to the load requirement HT at 11kV or LT at 415V - 3Phase will be availed from TNEB.

One Diesel driven alternator set of capacity as specified in the schedule of works shall be provided to permit operation of the Pumping Station in the event of failure of the TNEB electricity supply, complete with all equipment like Control gear, circuit breakers, cabling, synchronizing equipment etc. The DG Set shall confirm to latest version of IS:13364 - 1992.

The Contractor shall also make his own calculations with regard to the rating of the generating set(s), which shall each be large enough to start and run the smaller capacity sewage pump(s) (not the grit pump) and withstand other essential load along with lighting load but which shall not be less than that stated in the schedule, at a power factor of 0.8. The de-rating factors corresponding to the temperature, humidity and pressure should be considered. The continuous rating of the motors shall be used to calculate the maximum demand.

A 10 per cent margin of the capacity of the total load shall be allowed for contingencies and spare capacity.

The engine alternator sets shall be designed such that the starting power peak shall not exceed 10 per cent of the continuous engine rating and the voltage dip shall not exceed 15 per cent whilst starting the connected load under the worst conditions.

The Contract Drawings show the building, floors and other details as they will be constructed and the space allocated for the generating plant, control gear and circuit breakers. If any departures from the proposed layout are necessary, the Contractor shall show the modifications required on the drawings, and shall call the Engineer’s attention to these proposed alterations.

Contractor’s attention is specifically drawn to the operating conditions whereby generator sets could be running at little or no load due to the intermittent and differing flow rates and pump capacities. The diesel generator shall be capable of working at safe minimum working levels.

The D.G. Set shall be enclosed in a acoustic enclosure and the noise levels while operation shall be restricted to the levels as per the Pollution Control Board Norms.

23.2 Detailed Description of Generator Engine

Each engine shall be four stroke, naturally aspirated or pressure charged, water-cooled, vertical diesel type, of the airless injection principle with all cylinders and valve gear totally enclosed.

Each engine shall run at a speed not exceeding 1500 rpm. and be suitable for remote operation provided with forced feed lubrication to all working parts including the camshaft, rocker gear, valve guides etc. A strainer shall be located in a suitable position in each system. The whole of the lubricating oil shall be cooled by means of an inter-cooler situated adjacent to the engine with circulating water dissipating the heat taken from the oil. The necessary circulating pumps shall be provided which shall be integral with the engine together with all the appropriate pipework and appurtenances. Individual flow indicators shall be provided for the jacket and lubricating oil circuits.

A sensitive Class A2 governor or a superior type shall be incorporated and this shall be capable of maintaining a constant speed under all conditions of load. Motor operated speed regulating gear shall be provided to enable the speed of the engine to be varied by 5 per cent up or down from normal speed while in operation. The remote control for this regulating gear is to be operated from the switchboard.

Over-speed protection shall be provided so that in the event of the engine speed exceeding 10 per cent above the maximum operating speed an audible warning and indicator light shall be brought into operation, but should the speed still continue to rise to a figure of 15 per cent above normal speed the fuel supply shall be automatically cut off and the engine brought to rest. The audible warning and indicator light, together with the other indicating lights and alarms specified hereafter, shall indicate on the monitoring panel in the alternator switchboard.

A heavy type of flywheel shall be provided so that there will be a minimum of cyclic irregularity throughout the working range of the engine. Distortion or vibration and oscillation of the crankshaft shall be obviated under all normal working conditions.

The crankshaft shall be of solid forged steel statically and dynamically balanced to very close limits. Hand operated barring gear shall be provided for each engine.

Aspiration air filters shall be mounted directly on each engine and shall be of the heavy duty type, suitable for a sand laden atmosphere.

Protected thermometers in suitable pockets shall be provided for measuring the temperature of the inlet and outlet cooling ion water and lubricating oil. Each engine shall be provided with a temperature indicator on each exhaust branch. Lubricating oil and circulating water pressure gauges shall be provided on the local panel.

A positive driven tachometer and hours counter shall be provided and fixed in a convenient place on each engine and the tachometer shall be connected to an engine speed indicator mounted on a local panel to be mounted on each engine.

In addition to the over-speed alarm, protection devices shall be provided in the lubricating oil circuits and cooling water circuits to operate alarms and indicator lights, in the event of abnormal running conditions prevailing. These lights shall indicate on the remote monitoring panel. The engine shall shut down under alarm conditions.

The whole of the design, rating and testing of each engine shall be in accordance with IS:13364 for solid injection liquid fuel engines.

Each engine shall be designed to operate with an ambient air temperature of 45^0C and be capable of satisfactorily providing an output 10 per cent in excess of the BHp rating at the same speed for any one hour in the duration of 12 hours of consecutive operation.

Each engine with flywheel and alternator shall be mounted and aligned on a common under bed. Anti-vibration mountings shall be provided between the under bed and the concrete foundation. Each cylinder shall have renewable wet liners, and be fitted with individual cylinder heads. Wet liners shall be treated on the water jacket side with a rust inhibitor. Immersion heaters and thermostat control shall be incorporated in each engine oil sump and water jacket to ensure rapid warm up on starting.

Each engine shall be provided with an oil drip tray complete with plugged outlet. The engine shall be painted in accordance with the Manufacturer's recommendations, color finish as advised by the Engineer.

23.3 Engine Cooling Equipment

Each engine shall be cooled by a bed-plate mounted tropical rated radiator and cooling fan, adequately rated to maintain the normal working temperature, under continuous, full load operation, working in conjunction with a pressurized water system, thermostatically controlled with centrifugal water circulating pump, valves and pipework.

23.4 Exhaust System

A complete engine exhaust system shall be provided for each engine and shall incorporate a highly efficient residential quality silencer, expansion box, tubular lengths of exhaust piping and all necessary flexible connections to lead the exhaust fumes to the open atmosphere as per the recommendations of TNPCB.

The exhaust piping shall be adequately lagged and clad within the station with polished aluminum sheeting. All the necessary supports shall be included. Closing plates to apertures in walls shall also be provided. Very special attention shall be paid to the preparation and protection of the exhaust system.

23.5 Bed-plates and Couplings

A rigidly constructed, fabricated steel combined bed-plate shall be provided for each generator set to withstand the weight and shall be suitably machined on top for the reception of the engine and alternator. The bed-plate design shall incorporate anti-vibration mountings to provide complete isolation of vibration from the concrete foundations.

Each alternator shall be directly coupled to its associated engine by means of an adequately rated, flexible, multi-pin, balanced coupling in accordance with section 3 securely keyed to the shaft or close coupled to the engine. Each coupling, flywheel and any other moving part on the generator set shall be fitted with close mesh guards which shall allow access to all greasing and lubrication points. Guards shall be readily removable for maintenance purposes.

23.6 Enclosure of the DG Set

The entire assembly of engine, alternator and controlling equipment shall be housed in an acoustic enclosure as per the notification of the Pollution Control Board. The noise level of the DG Set shall be limited to the prescribed levels as per by the PCB. The enclosure shall be suitable for outdoor erection with relevant IP.

23.7 Starting Equipment

Each of the generator sets shall be started by means of a heavy duty, axial, starter motor, fitted with automatic disengaging mechanism on engine start-up, operating in conjunction with a 24 volt battery panel, installed locally to each generator set.

Batteries shall be of the heavy duty, 24 volt, sealed maintenance free lead acid, and be complete with charger, housing cabinet and necessary interconnecting cable. The capacity of each battery set shall allow for not less than 10 consecutive starts, each of 15 second duration.

Each battery charger shall be connected to the main motor control centre board in the control room.

The first charging of the batteries shall be carried out as per the recommendations of the manufacturer with a suitable battery charger.

23.8 Detailed Description of Alternators

The alternators shall be continuously rated for continuous operation and generate at 415volts, 3 phase 50Hz., with the neutral point connected to a common earth bed. The alternator neutral contactor shall be closed when the alternator is running.

The alternator enclosures shall be protected to IP.23. They shall be suitable in all respects for operating in the climate as detailed elsewhere.

The alternator excitation equipment shall be of the quick response self-exciting, self-regulating brush-less type, suitable for starting the motors.

The insulation of the stator and rotor shall be in accordance with British Standard Class 'F' but the alternator shall be designed for a Class 'E' temperature rise. The efficiencies of the alternator shall be stated in the Schedules and shall be determined in conformity with the procedure laid down in IS:269 and shall be manufactured in accordance with BS.2613.

Each alternator shall be capable of satisfactorily providing an output 10 per cent in excess of the BS rating for one hour in any period of 12 hours' consecutive running.

The rotating parts shall be statically and dynamically balanced to close limits.

Each alternator shall be fitted with anti-condensation heaters of a size to maintain the temperature of the windings 5° above ambient. Each heater shall be provided with a switch and automatic control to disconnect the heater when the alternator is running.

Terminal boxes shall be provided and arranged with sealing chambers for the reception of the cables detailed in the relevant sections of the Specification. Terminals shall be clearly marked to give phase identification.

The alternator shall be painted in accordance with Manufacture's recommendations, finished colour as instructed by the Engineer.

23.9 Daily Storage Tanks

Each engine shall be provided with a free standing daily tank of sufficient capacity to allow 12 hours of continuous operation at full load. For permanent mounted sets each daily tank shall be provided with the following fittings:-

- Air vent of not less than 50mm. diameter.
- Overflow piping of not less than 150 per cent diameter of the Fuel Delivery line.
- Cleaning hand hole and cover of not less than 300mm. diameter.
- Contents gauge graduated in Tamil and English to read "Full - 1/2 Full - Empty". The gauge shall be of the magnetically operated type and shall be complete with low and high level control contacts
- Outlet connection to engine not less than 50mm. above tank base
- Fuel outlet isolating valve lockable in open position
- Drain plug
- Excess fuel return connection.
- Inlet connection from bulk fuel supply system including pipework and connections.

- There shall be allowed a minimum of 5 per cent of the volume of the tank contents as sullage. The top oil level of the tank shall not be less than 75mm from top of the tank.
- Tanks prior to dispatch from manufacturers works shall be tested hydraulically to a pressure 0.5 bars.
- Daily tanks shall be complete with all supports and fixing bolts for mounting remote from engine. Base or skid mounted tanks will not be accepted.
- There shall be provided all necessary fuel oil pipework, unions and valves between the day tank and the engine.
- Fuel connecting pipework to engine shall be seamless steel and all pipes shall incorporate flexible section if not less than 250mm. long (plastic pipes or fittings are not acceptable).

23.10 Warning and Safety Notices

The following warning notice shall be supplied and fixed in a prominent position in the vicinity of each bulk fuel tank with 50mm. plain block black letters on a yellow background, printed in Tamil and English.

NO SMOKING
DIESEL FUEL - HIGHLY INFLAMMABLE

Additional notices shall be provided is required. The wording of the notices shall be subject to the Engineer 's approval.

23.11 Performance Requirement

The diesel generator and accessories shall be so designed as to meet the following performance requirements:

- The unit shall be capable of starting from cold condition, reaching operating speed and taking up load within the shortest possible period.

- The unit shall be capable of delivering continuously at the generator terminals a net output specified. This net output shall be obtained after necessary derating of engine due to site conditions and unit auxiliary power requirements have been taken into consideration.

- The unit shall be capable of a peak output of 10% in excess of the rated output for a period of one hour out of a total of twelve consecutive hours of operation, without exceeding permissible temperature limits and with a fairly visible exhaust.

- The unit shall be continuously rated to supply power for the periods.

The following items of performance shall be guaranteed during site performance tests by the supplier in respect of the diesel generator and the auxiliary for the specified site conditions:

- Net electrical output
- Fuel oil consumption at 1/2, 3/4 and full load
- Jacket water temperature to and from engine
- Lubricating oil temperature to and from engine

- 10% overload for one hour out of a total of twelve consecutive hours of operation without overheating or showing signs of undue stress and within specified frequency variations
- Freedom from vibration and noise
- Governor response, overspeed trip and speed gear capability
- Voltage regulator response
- Excitation at full load and under specified variation of voltage and speed

Window type annunciators shall be supplied and mounted on generator control panel to give visual and audible indication for the following conditions.

- High jacket cooling water temperature
- High lubricating oil temperature
- Low lubricating oil pressure
- Low fuel oil tank level
- Engine overspeed and trip
- Over current
- Earth fault
- Contactor on & off indication
- Voltage out of limit
- Excitation failure
- Generator fault

23.12 Drawings And Data

The BIDDER shall furnish the following drawings/data in the Technical Bid.

- Control panel dimensions and drawing showing plan, front view, foundation details, inside view, terminal block location etc.

- Schematic diagrams of the electrical circuitry

- General arrangement of the complete DG Set.

23.13 Testing and Commissioning

The supplier shall perform all the standard shop tests to ensure that the equipment conforms to the specifications and meets the performance guarantees.

The installation / commissioning of the D. G set shall be as per the applicable code of practice and the MANUFACTURER'S instructions.

CHAPTER 14 - APPURTENANCES
A. SLUICE VALVES

14.1 GENERAL:

All valves shall be double-flanged valves of Indian manufacture and in the size range 50mm to 300mm conforming to IS: 14846 – 2000 or any other national standard equivalent or higher than the Indian Standards mentioned. The materials used in construction, the design and all other relevant features shall be such that the valves are entirely suitable for use of force mains. Valves shall be of suitable pressure rating which shall not be less than twice the normal operating pressure.

14.2 DESIGN:

The design of the valves will be such that erosion, cavitation, vibration and head loss (in the fully open position) shall be a minimum.

14.3 SLUICE VALVES:

Sluice valves shall generally conform to IS: 14846 - 2000. Valves should close with clockwise rotation of the hand wheel. The direction of closing should be marked on the hand wheel. Valves shall be flanged (flat faced) and drilling shall conform to IS: 1537.

14.4 MATERIALS OF CONSTRUCTION:

Body	-	C.I. to IS: 210 Gr. FG 200
Wedge	-	C.I. to IS: 210 Gr. FG 200
Seat Rings	-	Bronze / SS 304
Channel lining	-	Gun Metal
Shoe	-	Gun Metal
Spindle	-	SS A1S1 431

Parameters:

Quantity	-	As per Bill of Quantities
Size	-	As per Bill of Quantities
Rating	-	10 Bar (PN 1.0)

Shop Testing Witnessing:

Seat leakage test	-	10 bar (1.0 M Pa)
Body Hydrostatic test	-	15 bar (1.5 M Pa)
Back Seat Leakage test	-	15 bar (1.5 M Pa)

14.5 VALVE BODIES:

a. Castings:

The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surface of casing which are not machined shall be smooth and shall be carefully filed to remove all foundry irregularities.

b. Forgings:

All major stress bearing forgings shall be made to a standard specification, which shall be submitted if required to the Engineer for approval before work is commenced. Forgings shall be subjected to non-destructive tests to detect flaws if any. Forgings shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for such forging shall be submitted to the CMWSSB. The Executive Engineer or his inspector may inspect such forgings at the place of manufacture with a representative of the Contractor.

c. Workmanship:

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.

All similar items of the valve and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All parts, which can be worn or damaged by dust, shall be totally enclosed in dust proof housings.

d. Protective coating:

Protective coating shall comply with IS: 14846 - 2000.

14.6 LUBRICATION:

All the points where lubrication is needed, the Contractor shall furnish full details of the method to be employed. The supply of the requisite lubricating equipment and lubricants for commissioning and operating and maintaining the valves shall be furnished.

14.7 FLANGES:

Valves of sizes 80mm – 300mm shall have flat flanges as per IS: 1538 Part IV Table – I. The flange-to-flange distances shall be as per IS 14846.

14.8 JOINTING MATERIALS:

Each valve shall be supplied under this Contract, with all requisite joint rings, nuts, bolts and washers for making the joints on all the valves to be installed under this Contract. Jointing material between the connecting flanges shall conform to the relevant IS code. Unless otherwise specified bolting used for jointing exposed connections shall be of carbon steel, conforming to IS: 210 Grade 20 Grade B, with galvanized finish.

14.9 FACTORY TESTS:

All the valves shall be tested at the factory for smooth, trouble free operation and operating torque requirements by operating between fully open and fully closed position three times.

The hydrostatic tests shall consists of

Closed End Tests where valve is held on both sides. Each valve is subjected to three hydraulic tests.

a. Wedge open and pressure applied for 5 minutes to the whole body of the valve pressure given in Section 19.4.

b. Second Test shall be applied to one face with pressure given in Section 19.4.

c. Third Test shall be similar to second, but pressure applied to the other side of the wedge with same pressure.

For valves having terminal position shall be subjected to open-end test.

Testing for valves from Foreign Manufacturers:

i) Sampling: Each valve is recommended to be tested.

ii) Testing and Inspection: For foreign manufacturer: The testing and inspection procedure in this case shall confirm with respective equivalent code.

B. AIR VALVES

14.10 Constructional Features:

Double ball air valves shall be of the kinetic, double orifice type able to release air in small quantities under pressure and in large quantities during filling. They have to allow for large inflow of air during emptying. The type and locations shall be fixed according to the detailed design and after approval by the Engineer in charge. The valves shall have an integrated sluice valve. If required, they shall be installed on a flange welded on the MS pipe / special. The possible air velocity (inflow and outflow) must be at least 20 m/s.

Materials of Construction & Pressure Rating:

Body	CI to IS Gr. FG 200
Cowl	CI to IS Gr. FG 200
Valve seat, nut	Leaded tin bronze
Spindle	SS. AISI 304
Orifice	SS. AISI 304
Ball	Seasoned teak wood, covered with neoprene rubber
Ball seat	Anti-stick material such as nitrile rubber or equivalent
Pressure	Suitable for 16 Kg / sq.cm, Working Pressure.

CHAPTER 15 - FIXING OF VALVES

15.1 FIXING OF SLUICE VALVES:

15.1.1 General:

The specification lays down the requirement for lowering, laying and jointing Sluice valves.

15.1.2 Preparation:

The sluice valves and tailpieces shall be examined before laying for cracks and other flaws. Only undamaged S.S. shall be used.

The sluice valve shall be operated and checked before laying. All grit and foreign material shall be removed from the inside before placing. All the four faces shall be thoroughly cleaned and coated with a thin layer of mineral grease. The tightening of gland shall be checked with a pair of inside calipers. Clearance between the top of stuffing box and the underside of the gland shall be uniform on all sides.

15.1.3 Jointing Materials:

The Contractor shall provide all the necessary jointing materials such as nuts, bolts, rubber packing, white zinc, jute, lead wool etc. at his cost. All tools and plant required for installation of sluice valve shall be provided by the Contractor at his cost. All the jointing materials shall be got approved from the Engineer in charge before use. The nuts and bolts shall conform to IS: 1364 and the rubber packing shall conform to IS: 638.

15.1.4 Installation:

The sluice valve shall be lowered into trench carefully, so that no part is damaged during lowering operation. If necessary tailpieces shall be fitted with sluice valve first outside the trench and then lowered into the trench.

The rubber packing shall be three ply and of approved thickness. The packing shall be of full diameter of the flange, with necessary holes and the sluice valve bore. It shall be even at both the inner and outer edge. The flange faces shall be thoroughly greased. If flanges are not free the Contractor shall use thin fibres of lead.

After placing the packing, nuts and bolts shall be inserted and tightened to make the joint.

The valve shall be tightly closed being installed to prevent any foreign materials from getting in between the working parts of the valve.

Each flange bolt shall be tightened a little at a time taking care to tighten diametrically opposite bolts alternately.

The sluice valve shall be installed in such a way that spindle shall remain in truly vertical position. The other end of the tailpiece shall be fitted with pipes so that continuous lines can work. Extra excavation necessary to facilitate the lowering and fixing of sluice valve shall not be paid for.

15.1.5 Testing:

After installation of sluice valve the same is tested to 1 ½ times of its test pressure. The joints of sluice valve shall with stand the test pressure of pipeline.

Defects noticed during test and operation of sluice valve shall be rectified by the Contractor at his own cost, without any extra claim, to the entire satisfaction of the Engineer in charge.

15.1.6 Mode of Measurement and Payment:

The measurement shall be taken per number of sluice valves of specified size and payment shall be on number basis for providing and fixing.

15.2 FIXING OF AIR VALVES:

15.2.1 General:

The specification placed down requirement for lowering laying and fixing Air Valves.

15.2.2 Preparation:

The air valves and the isolating valves shall be examined before laying for cracks and other flaws. Only undamaged air valve shall be used. The air valves shall be opened and shaken for the air opening below the vulcanite balls on the bronze seats of the balls before fixing. All grid and foreign material shall be removed from the inside before placing. The flanged face shall be thoroughly cleaned and coated with a thin layer of mineral grease. In case of screw down type, the threads shall not be in damaged condition.

15.2.3 Jointing Materials:

The Contractor shall provide all the necessary jointing materials, such as nuts, bolts, rubber packing, white zinc jute, lead wool etc. at his cost. All tools and plant required for installation of air valve shall be provided by the Contractor at his cost. All the jointing materials shall be got approved from Engineer in charge before use. The nuts and bolts shall conform to IS: 1364 and the rubber packing shall conform to IS: 638.

15.2.4 Installation:

The air valves shall be fixed on a branched flange Tee on the main pipeline. The air valve and isolating sluice valve shall be housed in a chamber.

15.2.5 Testing:

The specification pertaining to sluice valve shall also apply to air valves.

15.2.6 Mode of measurement and payment:

The measurement shall be taken per number of air valves of specified size and payment shall be on number basis for providing and fixing.

15.3 FIXING OF FRC M.H. FRAME AND COVER IN RCC SLAB:

15.3.1 General:

The specification includes all requirements of fixing FRC M.H. frame and cover of specified size and weight in the RCC slab with locking arrangement. For fixing the FRC M.H. frame and cover of specified size and weight, the frame shall be fixed generally at the time of casting RCC slab with proper anchoring.

After fixing the M.H. frame and cover locking arrangement shall be provided as per following unless specified in the wording of the item. The size of the M.S. flat shall be 50mm x 10mm with M.S. bar U shape of 16mm dia. The U shape M.S. bars shall be properly embedded in the RCC roof slab and anchored. The FRC M.H. frame and cover and the locking arrangement after fixing shall be painted with anticorrosive black paint. The work shall be done to the entire satisfaction of the Engineer in charge.

15.3.2 Mode of measurement and payment:

The item shall include:

a) All labour for fixing M.H. frame and cover

b) All material and labour of locking arrangement

c) Painting of the frame, cover and locking arrangement

CHAPTER 16 –MISCELLANEOUS

16.1 PRESSURE GAUGES

16.1.1 Material:

The brief specifications for pressure gauges is as follows:

The pressure gauges shall be of Bourdon type having a range between 0 to 9kg / sq.cm. The diaphragm material should be of 316 SS. Accuracy of the pressure gauge shall be 1% with a dial diameter of 150mm. The case shall be of IP 65, die cast Al. The pressure gauge shall be directly mounted with connection of ½ " N.P.T.M.

16.1.2 Erection:

The pressure gauges shall be, mounted as near to the process as possible. Impulse tubing / piping length shall be minimum possible. The pressure gauges shall be mounted in a vibration free location. They shall be readily accessible from grade, platform, fixed walkway or fixed ladder and shall be visible from where related equipment is operated.

The pressure gauges shall have one isolating valve and one drain / vent valves for depressuring. The drain / vent valve shall be plugged. The valves used shall be having ½ " NPTF connections and the material shall be ASTM A 216 GR. WCB or ASTM A 105 unless otherwise specified. The trim shall be AISI 410 unless otherwise specified. All connection shall be made using thread seals preferably PTFE tape. Right tools shall be used and any limits regarding torque for tightening shall be strictly adhered to. Impulse piping shall be done using ½" o.d seamless annealed ss tubing to ASTM A 269 GR.TP –136 L with minimum wall thickness of 1.65mm. Compression fittings shall be used. The impulse piping must be supported by an angle of channel and strapped at every meter length. The angle / channel itself must be supported by welding it to some structure. The pressure gauge shall be covered with box.

16.1.3 WATER METER WITH AMR CAMPATABILITY

Water meter shall measure and indicate cumulative water flow and provided with flanged ends. Measurement of flow shall be independent of pressure, temperature, density and viscosity. It shall be compatible for short inlet outlet connections and also for free pipe cross section. There should not be any additional pressure losses in the pipeline due to installation of electromagnetic flow meters. The calibration of Water meters shall be direct comparison of volume with high accuracy of up to ± 0.2 % of actual value.

Technical specification for 15mm,20mm,25mm &32mm – Multi-Jet 'class B 'Domestic water meter specifications for Multi-jet meters for horizontal and /or vertical installation .

The meter will be used for the measurement of cold, chlorinated potable water.

The meter shall confirm to both IS 779 and ISO 4064 standards with latest amendments.

Valid EEC certification is necessarily for the manufacturing unit from where the meters would be supplied. This certificate shall be valid at least up to end 2015. For EEC meters, the bidders should categorically mention the following.

- Name, address and contact details with phone , fax details of the EEC approval issuing authority.
- Validity of the approval.

Alternative to EEC certificate/Life cycle & accuracy test certificate conducted after May 2010 by FCRI/NABL should be enclosed with the tender documents as well as any other technical document which may help Board in assessing the meters technical merits and its suitability for the prevailing operation conditions.

Meter Type: The water meter with AMR compatability shall be

- Multi-jet
- Inferental meters
- Super dry dial
- Hermitically sealed
- Class B
- Nominal size of water meters shall be 15mm,20mm,25mm &32mm

Material: All the materials used to construct /manufacture customer meters shall confirm to Appendix B of IS 779 or clause 4.7 of ISO 4064-1. in particulars the following.

- Body shall be of Brass. Grade DCB2 of IS 1264-1989
- Registration box shall be made of brass . Grade DCB2 of IS 1264-1989
- Cap ring shall be made of brass. Grade DCB2 of IS 1264-1989/Engg. Plastic
- Screw and studs shall be made of SS 07Cr18Ni9 0f IS6911-1992
- Strainers shall be made of HDPE
- Impeller shall be made of Engineering plastic.
- Impeller shaft shall be either SS 07Cr18Ni9 0f IS6911-1992
- Nipples and nuts shall be of Brass LCB2 of IS 292 -1983.
- Spindle and bearing inside the hydraulic chamber shall be made of polished stainless steel with hard metal tip and sapphire.

Materials which come in contact with the water supply shall withstand 2 ppm (parts per million) of Chlorine residual in the water supply and shall be resistant to corrosion.

The water meter and accessories shall be manufactured from materials of adequate strength and durability. The materials, which come in contact with the potable water, shall not create a toxic hazard, shall not support microbial growth, and shall not give rise to unpleasant

taste or discoloration in the water supply. However, the spindle and bearings inside the hydraulic chamber shall be made of polished steel with hard metal tip and sapphire.

Furthermore the internal pressure cup should overlap the meter body. The lower case of the meter shall be painted with thermal painting internally and externally. The painting materials should be safe for human uses and not affect human health. (Health certificate should be included in the bidding documents). The painting colour shall be agreed on later upon order award.

Construction:

Meter shall be as per clause 9 of 779-1994 or relevant clause of ISO 4064-1. Each meter will be supplied with two cylindrical nipples or tail pieces with connecting nuts. Threads on the connection shall confirm to latest version of IS 2643(part1 to 3) or ISO 228-1. All meters shall be supplied with an easily removable tubular inlet strainer. The seal & sealing wire shall be rust proof material like engineering plastic.

16.1 WATER METER BOX (House Service Connection):

The Meter box consists of main body in rectangular shape with closing lid on top with plan dimension of 200 mm x 300 mm and height 250 mm. Lid should be press fitted to the body. No hinges should be used for opening /closing. Operational meter box should be provided with built in lock. The body has inlet and outlet windows through which the pipe of size upto 1" passes through. The material of construction of the lid and body of the valve box is weather resistant PP poly-propylene blue/black.

Reinforcement rips should be provided at the walls of the box. Base of the box should be designed in such a way that the box can be installed to the floor/wall using anchor Bolts / screws without grouting the entire base of the meter box. Provision for fixing Name plate showing the name of the Department must be made.

CHAPTER 17 – AMR METER

17.1 GENERAL SPECIFICATIONS

a) The technical specification for the work and details included in this bid are prepared with a broad view taking care of all items of work. However, all the supplemental items of works which are required for satisfactory completion and guaranteed performance of the system / projects are deemed to be included in the offer and no extra cost will be paid by CMWSSB.

   If a Condition /specification /clause is mentioned at more than one place and is having different implication / meaning , the most stringent favoring the employer shall be adopted for operation of the contract agreement.

b) The bidder shall extend full cooperation and interaction with other agencies at site, if involved.
c) The bidder must have service facilities to maintain the equipment installed.
d) The work shall be carried out with good workmanship following standard engineering practice.
e) The successful bidder shall take utmost care not to cause any nuisance due to noise, welding operations etc. all the proper precautions shall be taken by them in this respect.
f) The bidder shall submit. "Identity card" to all the work force at site.
g) Quantity of supply and installation of AMR water meters listed in 'Schedule 'A' Bill of Quantities' is for estimate purpose and this may vary. However, the payment shall be made on actual basis i.e. Number of AMR water meters supplied, installed commissioned & maintained satisfactorily.
h) All the submitted documents should be paginated, indexed and signed.
i) All the documents and certificates submitted shall be in English language only.
j) Authorization certificate from water meter manufacturer in original shall be submitted.
k) The bidder, in case of authorized dealer, shall submit copy of certificate of **d**ealership from manufacturer of the make quoted in the tender.

The authorization giv**e**n by the manufacturer shall be of direct nature or through dealer.

17.2. Technical Specification of Consumer AMR Water Meter

Multijet AMR water meters are required with wireless system utilising Long range gateways for meters of various sizes ranging from 15mm to 100mm. All meters must be equipped with AMR system and must interface with CMWSSB head office server equipment as specified in the Detailed Technical Specifications below.

17.2.1 Detailed Technical Specification

The Domestic / Commercial AMR water meters of size from 15mm to 100 mm diameter as per schedule should be Class B, Magnetically coupled, dry dial, having hermetically sealed register with Stainless Steel Cup / Glass Encapsulation confirming to IP 68 screwed end connections, manufactured as per ISO 4064 standards & have European Economic Council (EEC) or international Organization of Legal Metrology (OIML)/MlD pattern approvals & shall bear

EEC marking on dial of water meter for each size and must have register having inbuilt bidirectional wireless communication and remote reading. The Software module installed at CMWSSB data centre shall manage the AMR meters. The meter should adhere to the following specification

1. Dry Dial with IP68 protection.
2. Magnetically driven mechanical register.
3. The entire meter with the AMR should be IP 68 rated. No damages should occur even under the condition of continuous submersion under water.
4. The water meter should have the latest MID approval with conformance to IS-779 as well as ISO 4064 and should comply to OIML R49-1.
5. The water meters shall be CE and OIML marked.
6. Meter body should be made of Copper alloy / Stainless steel / brass. Meter should be electro statically epoxy painted. The firm shall specifically mention in the offer, the metal used in manufacturing. Material that come in contact with the water supply shall withstand at least 2 ppm (parts per million) of chlorine residual in the water supply and shall be resistant to corrosion.
7. The water meter should withstand a pressure of 16 bar.
8. A integral strainer is required.
9. A integral NRV is required.
10. Tamper proof against electromagnetic fields (Class E1 as per ISO:4064)
11. Vibration proof and Humidity proof as per class C ISO : 4046.
12. Maximum head loss as per ISO:4064.
13. Volume indicated in m3
14. Totalizer shall read a maximum of 99999m3. 3 digit pointers shall show flow in litres.
15. Totalizer shall be suitable for test on an electronic test bench with optical reading.
16. The meters shall be supplied complete with GI fittings, brass nuts and brass nipples, Strainer sealing shall be provided as per relevant IS provision.
17. The internal pressure cup shall be made of low-ferrous brass not exceeding 0.02% Fe contents / Engineering plastic. Furthermore, the internal pressure cup should overlap the meter body. The lower case of the meter shall be painted with thermal painting externally. The painting materials should be safe for human uses and not affect human health (Health certificates should be included in the bidding documents). The painting color shall be decided in consultation with the department after award of the contract.

17. Variation in weight of the meter will be permissible to +/- 5% of the weight indicated by the bidder in his technical bid.

18. Each meter should be supplied in separate individual box with its accessories and test certificates and guarantee card for free repair / replacement for duration of 5 years.
19. The bidder shall provide specific details of materials used for various parts of the meter which must meet the specifications for the material of construction of the individual parts of the meters as per IS 779: 1994 (latest amendments) or ISO 4064.
20. The water meter and accessories shall be manufactured from materials of adequate strength and durability. The materials, which come in contact with the potable water, shall not create a toxic hazard, shall not support microbial growth, and shall not give rise to unpleasant taste or discoloration in the water supply. However, the spindle and bearings inside the hydraulic chamber shall be made of polished stainless steel with hard metal tip / sapphire.
21. Supply shall be made strictly as per the sample meters produced for testing.

The supply and installation is to be done in Chennai City (India). The bidder shall provide all necessary technical support and indicate locations for installation of meters. The bidder shall

provide three years maintenance support. It shall include annual cleaning of the strainer, calibration of meter once in two years, repairing the out of order meter within 3 days, calibrating it and relaxing it, fixing a standby meter till that time and assuring Zero down time. The bidder shall transfer the monthly reading of meters to CMWSSB server for generating consumer bills which is compatible with CMWSSB server. The recovery is not in the scope of the bidder.

17.2.2 Description of the Requirements of AMR WATER METER

The water meter should be fitted with an AMR unit either integrated or attached with proper seal. The AMR unit should be able to transmit data to a gateway to take readings automatically in a fixed wireless network. However, if there occurs any communication lapse in getting the readings automatically through the wireless network, readings have to be taken by walk by method using a Hand held Unit using Wireless MBus protocol.

1. The AMR system shall have bidirectional data communication.
2. The line of sight range of the transceiver module to a gateway shall not be less than 10Km.
3. The meter should be able to communicate to a gateway to take readings automatically in a fixed wireless network and also to a handheld unit if necessary. The range of communication distance (Line of sight) to a Hand held unit shall be minimum 500m. Wireless MBus shall be the protocol for communication to the Handheld Unit.
4. The range of communication to a gateway shall be suitably arranged to transmit all the meter readings to the CMWSSB server.
5. The AMR modules along with the gateways shall form a simple star network. The AMR unit should be capable of communicating to a gateway.
6. The system should be capable of storing the following parameters
    a) Instantaneous reading of consumption.
    b) Daily consumption for the past 2 years.
    c) Periodic data stored for water audit and analysis.
    d) Tamper / Alarm records.
7. The meters should report an alarm to the server as and when they arise.
8. The meter shall have anti magnetic properties / immunity as specified in ISO: 4064 when tested with 400 gauss magnet. The AMR electronics and communication shall not be affected by the magnet.
9. The module enclosure is an integral part of the water meter and shall have IP 68 protection.
10. The water meter should be readable under submerged conditions with metal lid on top of a concrete chamber.
11. All water meter readings should be time stamped.
12. The AMR should have the capability to detect and record reverse flow in a separate totalizer.
13. The AMR should be capable of the following
    a. Leak detect
    b. No flow detect
    c. High flow detect
14. The AMR should operate even in electrically noisy environments with electromagnetic interference. The AMR should function even in the presence of high voltage power lines.
15. The battery life of the unit shall not be less than 7 years. Battery usage has to be indicated at the server. Provision should be provided to replace batteries if required.
16. The water meter scale should be readable when the AMR module is installed.
17. The meter should withstand extreme weather conditions.

a. Temperature from -10 to +55 Deg C
b. Relative humidity from 5% to 95%
c. Submerged conditions

18. Ability to operate in environment with radio frequency interference including those emanating from activities of the communication system frequency.
19. The number of gateways shall not exceed 1 per square km.
20. The communication shall be encrypted to avoid tampering.
21. The handheld should be able to retrieve all data from the meter.
22. The AMR module should be configurable either using from the server or the handheld unit.
23. Loss of communication should be indicated in the server within 24 hours.
24. The transmit power level shall not exceed 20 db.
25. Receive sensitivity should be better than 130 db.

2.3 Markings on the Body of the Meter:

(a) **Marking on dial / cap.**

i. Class “B”
ii. Multijet / Model
iii. Magnetic Type
iv. As per IS 779-1994 OR ISO: 4064-1993
v. ISI OR EEC or MID/OIML Code No,
vi. Make / Brand
vii. Sl.No. / Year of Manufacture.
viii. CMWSS Board

(b) **Embossing/ engraved on meter body.**

i. Size in mm
ii. Direction of flow of water on both sides of the body of meter.

17.2.4 The Totalizer and Totalizer Shield:-

The totalizer shall be designed in such a way that if the totalizer protective glass is broken for areas on or another the totalizer CMC not be removed from its place. The totalizer protective cover shall be made of sturdy glass and shall have a thickness of not less than 5mm and shall pass specified tests. Sturdy glass is defined as the ability of the counter protection glass to withstand, without damage, a free fall of a metal ball weighing 27.2 grams from a vertical distance of not less than 70 cm or sturdy Engineering plastic window subject to clear visibility till end of contract period guaranteed by bidder may be allowed.

Totalizer:-

a. It shall be of straight reading type.
b. The totalizer shall register in cubic meter units.
c. The totalizer shall consist of a row of minimum five on-line consecutive digits to read at least 99,999 m3.
d. Another three digits or pointers shall register flows in litres and be of a different colour.
e. The totalizer should be of closed type.
f. The totalizer must be suitable for test on an electronic test bench.

g. Totaliser shall be made of copper CMC having 5mm thickness mineral glass or any other suitable material required to maintain IP 68 protection class.

Meter will be provided with monolithic seal with copper wire.

AMR SYSTEM

1. The water meters shall have the anti - magnetic properties / immunity, as-specified in ISO: 4064 - 2005, when tested with 400 gauss magnet. The AMR system shall remain unaffected with application of 4000 gauss magnet as specified in ISO: 4064.

2. All meters shall be fitted with wireless remote trans-receivers for AMR. reading. It shall be either inbuilt or directly fitted on the water meter without wires. The water meter and AMR unit should be from the same manufacturer.

3. The wireless AMR trans-receivers shall have IP 68 protection class i.e. no ingress of water after submerging AMR water meter for 48 hours under 3 meters of water column.

4. The remote readings of AMR water meter should be obtainable by 'Walk by' / drive by methods if there is a problem in the direct transmission of readings through gateways to the server.

5. AMR shall be obtainable even under submerged conditions. The water meters fitted with A.M.R. shall have the facility to transmit reading in submerged condition & the remote readings should be obtained outside the meter chamber, with water meter in submerged condition & lid of the chamber closed.

6. Remote readings of different water meters shall be obtained with single command. The remote readings shall have instant reading facility. The remote readings and dial readings of water meters shall match at all the times. With single command all should be retrieved from AMR unit to unit, no separate command is required to retrieve the historical, Alarm Data.

7. All A.M.R. readings shall show the date and time of the reading recorded.

8. The AMR system shall have facility to record the reverse flow in water meters readings and it shall show the quantum & period of reverse flow on computer screen at CMWSSB Head office.

9. The AMR system shall have the facility to record the abnormalities like application of external magnetic effect, very high consumptions, water leakages etc. along with necessary alarms in software. Shall have (i) the ability to operate in a noisy electrical environment with electromagnetic disturbances (EMI) & (ii) the protection against current fluctuations and lightning according to international codes and requirements. The AMR water meter shall not get affected for its AMR functioning due to High Tension or High Voltage line concentration.

10. The battery life of AMR water meter shall not be less than 7 (seven) years from successful installation of said AMR water meter along with its AMR system, the battery life shall be calculated by considering the monthly remote reading. During remote reading the battery life of AMR water meter shall be displayed indicated.

11. If the AMR communication frequency is using / operating on paid frequency band, then the AMR water meter manufacturer has to produce the valid copy of license issued by Govt. of India / Dept of Telecom (DOT), for using the said operating frequency band. The cost of the same will be presumed as included in the quoted rates. If the AMR communication frequency is using operating on free frequency band, then the AMR water meter manufacturer has to produce the valid copy of license issued by Govt. of India / Department of Telecom (DOT) stating that the said operating frequency lies in the free band.

12. Wireless / Receiver must read the water meter in a more precise manner as per IS 779.

13. Wireless /Receiver must be able to diagnose fluctuations in the dial as a result of fluctuations in the water flow by reliable reading method.

14. The AMR device of the water meter shall be tamper proof. Wireless transmitter/Receiver must have a robust structure that is as resistant as possible to vandalism. End units must be sealed, have an antenna and should be an integral part of the water meter register

15. The manner in which Wireless /Receiver is installed must not cause any hindrance to reading the water meter scale. The scale must be readable in the same manner and convenience as prior to the installation of the end units.

16. Receiver must be resistant to extreme weather conditions, including the following:
    a. Temperatures ranging from 5°C to 60°C.
    b. Relative humidity from 5% to 95%.
    c. Rain

17. Ability to operate in an environment with radio frequency interference (RFI) including those emanating from the activities of the communication system wavelength.

18. It will be mandatory for the successful bidder to provide the demonstration of his remote AMR water meter reading and the bill preparation scheme to the CMWSSB staff & appointed officers as and when required during the said project.

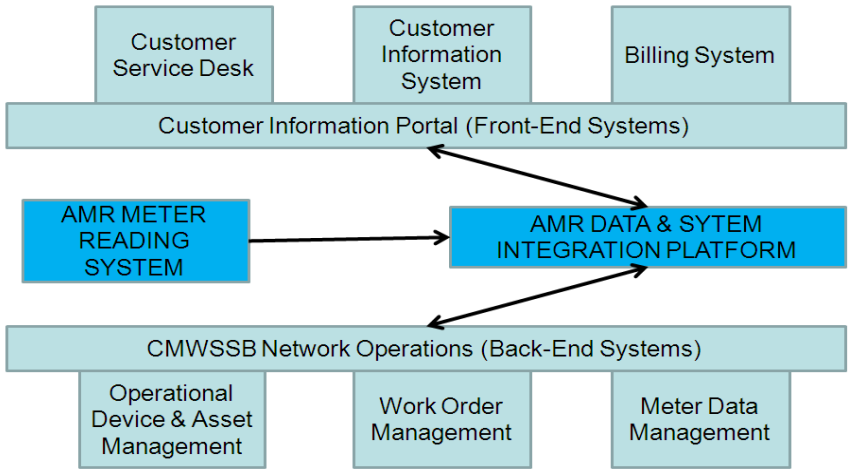
17.3 SOFTWARE

System Integration Requirements

The success of all AMR project implementations and rollout are dependent on a high availability and high performing Integration platform to support the orchestration of data and business process integration within the utility organization. The typical portfolio of systems within an utility organization can be broadly categorized into Front-End Systems that are accessible by its

customers and Back-End Systems that support the day-to-day business operations and are accessible to its internal staff members. The Integration platform is a critical layer that controls the information flow and process orchestration between the Front-End systems and Back-End Systems.

AMR SYSTEM INTEGRATION SCHEMATIC



The typical list of front-end and back-end applications and systems are as follows:

17.3.1 Front-End Systems

- **Billing** - Makes sure that the monthly meter reading should be exported to CMWSSB server so as to raise consumer's consumption bills at right time with accurate reading.
- **Customer Information System**
  Includes the customer database and takes care of customer communication

The bidder shall develop compatible data transmitting system to transfer the monthly reading of meters to CMWSSB server for generating consumer bills so that consumers to get feedback on consumption, see their bills, report issues/complaints etc through web based portal.

Integration Gateway – Use of standards based integration using Service oriented Architecture as part of Enterprise Application Integration platforms that support industry standards like Web services, Web API using XML, CSV or TSV based data formats with well-defined schemas and API's

17.3.2 Backend Systems

- **Meter Data Management**
  Meter data management Central repository for meter data that can be accessed by other systems. Interface between meter values and corporate applications to

effectively manage meter data. Used for balance settlements and calculations if value for billing is missing.

- **Operational Device and Asset Management**

  Single point of storage for meter identification data (i.e. meter and device register) and meter management.

- **Work Order Management**

  Manages work orders that cannot be handled remotely for field crew.

The Integrated Solution should meet the following requirements (functional and non-functional have been identified):

17.3.3 Integration Functional Requirements

The proposed AMR System should provide standard data integration interfaces to the following main systems:

Meter Asset Management

- Store and maintain metering devices and AMR communication equipment's
- Store and manage warranty status of all AMR meters
- Track and Manage defective AMR meters and returned to the manufacturer for repair or replacement
- Track and manage firmware versions and configurations of AMR meters
- Track and manage meter asset location

AMR Meter Data

- Provide Receipt of reads
- Provide Receipt of interval, or flow profile, data
- Provide reads and interval data
- Provide Receipt of real-time and historical events and alarms
- Validate the correct provisioning of the AMR meter by verifying the proper measurements and data and, based on configurable rules and validations,
- Configuration of rules for the validation and estimation of reads from the AMR meters.
- Configuration of interval data from the AMR meters
- Ability to generate reports or dashboard to summarize AMR meter reading performance, real-time status and issues.
- The bidder should provide source code / meter protocol to interface with the back end and front end system.

AMR CIS and Billing

- Deliver meter data for the purposes of scheduled, or periodic, billing.

AMR Event and Alarm Management

- Ability to receive, process and store all metering events supplied by the AMR.
- Ability to identify specific meter events, or combination of events, and create emails or To-dos for follow up and resolution.
- Ability to configure reports or dashboard to view event status and issues.

AMR Non-Functional Requirements

- Must support, where appropriate, OMS based standards for integration with external systems.
- Must validate and demonstrate the implemented configurations and integrations meet the performance requirements of CMWSSB's business processes.
- Must allow easy integration with engineering and distribution applications, such as Flow Management and Flow Analysis, for the purpose of extraction in support of the distribution network analytics for the purpose of planning and operations.

AMR System Integration Solution Services Requirements

CMWSSB requires the following professional services to be provided in addition to the implementation of the AMR:

Program Management and Administration

- Develop and maintain a detailed project plan and controls for the implementation and acceptance of the AMRSI Project and all integration necessary to fully integrate with the AMR technology after award. This includes implementing procedures for project control, project tracking and reporting of progress
- Scope and change management
- Issue and problem management, including escalation as necessary
- Cost and budget managements
- Risk management
- Manage project resources and identify external resource requirements and issues.
- Project meetings and reporting to review overall project status, milestones, issues, problems, accomplishments, schedule, resources, action items, and provide other relevant observations and advice regarding critical milestones.
- Assist in the ordering and sizing of any applicable servers and databases required to support CMWSSB's Project requirements. Recommend configuration, and provide acceptance of the proposed server environment and associated networking and storage systems. This includes all hardware and system software required to support the development, test, training, production (high availability), and possible disaster recovery environments within specified service levels and a schedule of upgrades to the environment to support various stages of the development effort leading up to production operation.
- System recovery and redundant system
- **Assist in setup and configuration of Test and Production environments**. CMWSSB requires the creation of a test environment of the hardware client and server software configuration at CMWSSB's facilities. The QC environments will emulate the ultimate production system. The respondent must be able to assist CMWSSB in specification and creation of the test and QC environments. CMWSSB will acquire and configure these environments.
- **Testing**. CMWSSB requires on-site system and acceptance test conducted on the Test environment. The objective of these tests will be to validate that the AMRSI integrations and configurations meet the defined CMWSSB requirements. All CMWSSB systems will utilize High Availability configurations and the testing should

support this configuration. The Bidder must provide and support the performance of test procedures, any applicable simulation and monitoring methods to demonstrate proper functioning of the MDM, ODM and SGG with CMWSSB's systems through both QA testing and actual live production. Such support will include the development of the test plans and test scripts, supply of any test harnesses and test data sets, regular testing status reports, final test report, defect tracking and resolution, on-site assistance during the testing to ensure troubleshooting and knowledge transfer that occurs in a timely and efficient manner.

- **Release Management:** CMWSSB will be responsible for release management and Bidder will support, as necessary, CMWSSB with Release Management. Bidder will be responsible for coordination of releases and upgrade with the parallel projects.
- **Component testing:** Bidder must create and submit a test strategy for conducting component level testing to validate the proper configuration and integration of the systems. Bidder must develop all test scripts and test data and execute all component testing. Bidder must document test results and review the testing and test results with CMWSSB.
- **Integration testing:** Bidder must create and submit for approval a test strategy for conducting integration testing. Bidder must develop all test scripts and incorporate additional test scripts requested by CMWSSB after review of the test strategy and test scripts. Bidder must develop the test data sets and conduct, with cooperation of CMWSSB, the integration tests. Bidder must document all test results and review the testing and test results with CMWSSB.
- **Acceptance testing:** Bidder must create and submit for approval a test strategy for conducting acceptance testing. Bidder must submit suggested test scripts to CMWSSB for inclusion into CMWSSB's overall test strategy. CMWSSB will conduct user acceptance testing with support from Bidder as necessary to complete the testing.
- **Performance testing:** Bidder must develop all test scripts and incorporate additional test scripts requested by CMWSSB after review of the test strategy and test scripts. Bidder must develop the test data sets and conduct, with cooperation of CMWSSB, the performance tests. Bidder must document all test results and review the testing and test results with CMWSSB.

- **Training and documentation**. Bidder must provide appropriate "As Built" documentation for the configurations and integrations. Bidder must provide a plan to properly train specified utility internal personnel how to maintain and operate the AMR system. Bidder should include a description and syllabus for all available and future training courses. A training and education program (the training plan) will be developed and delivered to CMWSSB for approval. The approved education program shall be delivered to all users of the system, including primary, secondary, and casual users. Successful Bidder staff delivering training must be very knowledgeable with the pertinent AMR solution products. A trainer with no prior product expertise to deliver this training is not acceptable. This may be accomplished using a combination of delivery methods, including classroom training courses, computer based training, personal practice time, Internet based training, etc.

- **Go Live Support.** Successful Bidder must develop and submit a work plan and schedule covering the go-live weekend and subsequent support activities to support the rollout shall be developed. This plan/schedule identifies all of the business and technical activities that must occur leading up to Production Cutover and all of the business and technical activities that must occur after Production Cutover. The plan identifies dependent tasks and assigns responsible resources and shall be verified by the Successful Bidder utilizing a desk walkthrough process.

- **Warranty Support. A** stabilization period of 12 months is anticipated. During this stabilization period, the system is in production operation. The Bidder shall be focused on fixing production problems with the AMR Integration and Configuration Project. Monitoring system use and how well the new business processes are executed is also expected during this period. A successful stabilization period shall occur prior to Final System Acceptance.

17.3.4 System Administrator, Operator

i. The system administrator must have full access and implementation rights for allocations and system configuration.

ii. System administrators will have permissions for authorization of other users including passwords.

iii. Allotting authorizations to users (operators) must be modular so that Authorization can be granted for performing certain actions according to the administrator's decision.

iv. Despite flexibility and required openness the system must be protected using accepted information protection mechanisms that will be approved by the client which will prevent unauthorized-penetration of the system.

v. Protection must include protection against penetration by unauthorized persons to equipment such as Server, end units, and the various programs. The information security system must prevent penetration by unauthorized persons via communication lines and various data and via the working stations and the computer network itself.

vi. Users/operators/meter readers must be identified when performing various operations such as reading meters dealing with malfunctions, evaluating consumption, changing meters, etc.

vii. The Application software system must be web based fine program must be designed in such a way that any user can login to the web based application and can perform all tasks. Moving from one task to another must be simple, user-friendly and quick. The system program must enable maintenance operations to be performed as well as everyday operation by users, including:
    i. Adding/deleting lists (including definitions of water meters, buildings, areas, and consumers) Defining reports, inquiries, and graphs
    ii. Backup

The Application can be assessable from web to all the users through standard web browsers Interfacing to the CMWSSB Computer System

All proposed software must be updated to the most recent production series and versions that exist on the market at the beginning of implementation. All this must be done at no additional cost.

a) The system shall be providing allow grouping of meters together for consumption analysis of zone metering.

b) The system shall provide capability of exporting data by a group of meters and/or individual meters to facilitate sharing of information with other stakeholders.

c) The system shall provide automatic recover of any missing daily data for up to 62 days in case there is a communication failure.

d) The system shall provide a summary report of successful transmission of all meters.

e) The system shall provide a summary of alarms occurred in the last 24 hours for a quick analysis of the performance of the system and to identify potential problem meters.

f) The system shall display the date and time of peak-flow events to facilitate the identification of the source of the issue.

g) The system shall display the percentage of meters installed that have been successfully read.

h) The system shall be able to display the actual read index of meter to enable billing of the end user from the system and to ensure legal compliance.

i) The system shall be providing a means to facilitate comparison between different meters

j) The system shall be providing means to facilitate comparison between different time periods.

k) The system shall be capable of displaying historical consumption information (minimum two months period).

l) Individual meters should be configurable independently of other meters in order to take into account individual consumption parameters

m) The system shall permit that all configuration parameters for similar meters CMC be updated in one time.

n) The software will include advanced tools to deal with replacing water meters in the middle of the billing period, reading in the middle of the billing period for account closing purposes, producing consumption estimates in case of malfunctions etc. All the above will be fully synchronized with the existing CMWSSB billing software in order to avoid double entries

and/or missing data.

o) The software will be based on a common standard commercial program for dealing with databases.

p) The software will allow several users to work on the same database simultaneously.

q) The software will allow several users to work in several databases simultaneously.

r) The software will include mechanisms for protecting data quality.

s) A high survival rate is required that will ensure that hardware malfunctions and communication failures will not harm the databases: no data with erroneous or partial information will enter the database, or damage the database or files.

t) The system administrator must have the possibility (and authorization) to rewrite data.

u) The database CMC is updated by the firm user.

v) The database will have an SQL that will enable inquiries and commands in Oracle from other programs while the system is operating. The database program to be used is SQL.

w) All necessary hardware, servers, printers would have to be quantified at CMWSSB's head office with the clear system architecture.

x) Alternative design using data concentrators using any technology should also be considered.

17.3.5 Bill Generation and Printing

The connectivity fee and its subsequent renewal fee for the above during the entire contract period have to be included in the price quoted. The Successful bidder / Contractor has to bear the entire cost of Annual Maintenance charges for the machines, consumables and GPRS connectivity (SIM) required for Billing. No extra payment will be made.

17.3.6 Lab Testing

The lab testing shall include the following tests as per IS 779 (Latest) / IS 2373 (Latest), ISO: 4064:2005 class 'B' standards which will be conducted at FCRI/NPL/NABL Accredited labs.

i. Accuracy testing of water meters at Qn.
ii. Accuracy testing of water meter at Qn after clamping the magnet on the water meter.
iii. IP 68 testing of water meter& AMR system
iv. Remote reading of water meter in dry i.e. open air condition.
v. Remote reading of water meter in submerged condition i.e. under water with under variable water depth conditions.
vi. Remote reading with different tamper alarms for back flow, magnet and physical damage, etc.
vii. Response time of AMR reading.

viii. Visual inspection of AMR water meter and its AMR system along with its software.
ix. Real Index test i.e. all the time electronic index of the water meter shall match with mechanical index.
x. Demonstration of uploading of readings from unit to PC and vice versa.
xi. Life cycle and endurance test.

17.3.7 DESCRIPTION OF AMR METERING SYSTEM ACTIVITIES

17.3.7.1 Data Collection:

Readings from the water meters will be collected following consumption and/or at permanent intervals. All readings must be identified by a water meter code, the value of the reading and sampling time.

17.3.7.2 Processing Information:

Information will be processed in the control center concerning the received data. Calculations and consumption balances will be calculated from the level- of each individual meter. The control center Software Module will allow management of water consumption and water meters replacement. In addition, interfacing to the existing information system in the CMWSSB is required.

17.3.7.3 Identifying and Reporting Malfunctions and irregularities

The system will conduct inspections and calculations in order to identify and locate hydraulic and technical irregularities and malfunctions on all levels, such as:

a) Suspicion of continuous leaks/consumption over a lengthy period of time / excessive use of water / suspicion of a stopped water meter / vandalism /water meter turning in reverse

b) Suspicion of leak/ excessive use of water / cutoff/ at the consumer/building/ or compound level.

c) Calculation and warning of a large decrease in water on a local (branched), regional/neighbourhood level.
Malfunction in end units or between the end unit and control centre.

17.3.7.4 Billing - Interfacing to the CMWSSB billing system

a) Meter Reading system must be interfaced with the CMWSSB Revenue Billing System (RBS). The data structure, data quality inspections, essence, manner and rate of data transmission must be completely compatible with the CMWSSB revenue Billing system so that no contradictions or duplications are created between the Remote Meter Reading system and the CMWSSB billing system. The successful bidder shall make arrangements to export and import the data from the CMWSSB database & enable exchange of the customer billing data, during said period of project.
b) Alternative technology based on lowest cost of ownership should also be tried.

17.3.7.5 General Guidelines and Requirements

a) The system and all its components: The method of communication, computerization system, logging volume, memory, databases, etc must be able to deal with minimum 100,000 water meters.

b) The reliability of the readings must be high with no more than 2 errors per 1,000 readings. A reading error will be defined as a deviation between the value that appears in the Remote Meter Reading and the mechanical display on the meter.

c) All layers of the system should support the process of watt meter replacements (dismantling and installation).

d) All tasks described, including the process of accumulating information, quantity calculation, and producing reports, must be performed without flaw in case the defective water meters are replaced.
e) All installed equipment must not hide the existing display on the water meter and allow the meter to be read conveniently.

f) The entire system the field to the control center will operate continuously under all weather conditions.

g) An equal time-base must be created for all system components: the hour and date must be synchronized for all system components within a range or precision of at least 1 minute.
h) The system will learn the consumption profile for each consumer for identifying irregularities and malfunctions.

i) The computer system will enable updating and rewriting of data initiated by an authorized user.

j) For example: updating the condition of water meters and monthly quantities of water.

k) Communication Procedures

The following are details regarding several basic procedures for communication.

a) Popup messages
A popup message should be from the end units and upward, when an irregular event such as a leak, Malfunction/vandalism to the end unit is identified.

b) Initiated inquiry

The control centre will be able to initiate inquiries for data of the end units. When an inquiry is made the latest log data in the end unit will be received.

c) Identifying Malfunctions in the Remote Meter Reading system (System Alarms)

The system will include routine checks to ensure flawless operation of communication and equipment including Water meter malfunction, End unit malfunction.

17.3.7.6 The Control Center

a) A control center will be established in the CMWSSB data centre All communication. Collecting and processing information, as well as the interfacing with the computer system and information in the CMWSSB will be implemented in Data center within the CMWSSB.

b) A control center within the CMWSSB will have the following:

   i. A Server installed in CMWSS board with management software to manage all AMR meters

   ii. Work stations for operation and/or handling terminals and/or diagnostics and system maintenance

17.3.7.7 Technical specification of the Test Bench

Water Meter Test Bench to be designed for-measuring the accuracy and pressure losses of water meters of DN 15mm- 100mm in accordance to the standard ISO 4064 or equivalent standards. The test bench should be manually operated, with pneumatic meter clamping system and electro pneumatic testing automated stop system. Three independent adjustment lines each equipped with a variable area flow meter, allow easy adjustment of flow rate. The measurement errors of the meters under test at various flow rates are calculated by comparing the volumes read by the meters against two calibrated stainless steel tanks of maximum volumes of 10 litres and 100 litres.

CHAPTER 18 – ELECTROMAGNETIC FLOW METER

18. Technical Specifications for Full Bore Electromagnetic Flow Meters

18.1. General

The Electromagnetic Flow Meters shall be installed in chambers/open pits or buried for indication of flow rate and total consumption of water in a transmission or distribution pipe network of city's water supply system.

The Electromagnetic Flow meters shall withstand maximum working temperature of about 600°C and working pressure of 10 kg/cm2 (1.0 Mpa), unless specified otherwise.

18.2. Electromagnetic Flow Meter

Full bore electromagnetic flow meters should be designed, manufactured and calibrated according to **ISO/IEC-17025 standard**. The flow meter shall be capable of measuring bi-directional flow.

18.3. General Specification

Electromagnetic Flow Meter shall be a velocity sensing electromagnetic type, microprocessor based signal converter, sealed housing, flanged tube meter for 1.0 Mpa working pressure. The meter shall be manufactured to highest standard available for mag-meters. The meter shall be equipped with minimum six digit digital totalizers, reading in units of kiloliters and shall be accurate within 0.5% of true flow. The accuracy should be inclusive of linearity, hysterisis, repeatability, temperature and pressure effects. The meter assembly shall operate within a range of 0.3 m/sec to 4 m/sec and be constructed as follows:

(i) **Meter Tube (Sensor)** shall be fabricated from stainless steel tube and use class PN10 flat face carbon steel flanges in accordance with IS 1538. The internal and external of the meter tube shall be blasted to near white and lined with hard rubber preferably by SBR or EPDM.

Meter tube shall have a constant nominal inside diameter offering no obstruction to the flow.

(ii) **Coil Housing** shall be fabricated from stainless steel (SS304) / Die cast Aluminum/ carbon steel with anticorrosive paint for corrosion resistance and welded to the tube providing a completely sealed environment for all coils, electrode connections and wiring harness capable of submerged or buried operation with IP68 protection.

(iii) Signal Converter shall be pulsed DC coil excitation type with auto zeroing. The signal converter shall be remotely mounted away from the meter.

The converter shall indicate direction of flow and provide a flow rate indication and a total of flow volume for both forward and revere directions.

The converter shall provide an isolated 4-20 mA output into minimum 600-ohm load and a frequency output of a maximum of 0-10 KHZ and a scaled pulse output.

The microprocessor based signal converter shall have a self-diagnostic test mode and a backlit display that continuously displays 'Rate of Flow' and 'Total Volume'.

The converter shall be compatible with Microsoft Windows and other software programs with built in terminal communication capabilities of RS 485, HART or other protocols for interface.

The converter shall be remotely mounted maximum up to 200 m from the sensor, and shall be supplied with all calibration complete for desired requirements.

Converter shall be supplied with a programmable low flow drop out and empty pipe zero return. The signal converter housing should be die-cast aluminum with glass window.

The converter cum transmitter should be fully programmable from the front facia.

The programming should be user friendly, self-prompting menu driven.

18.4. Volumetric Testing

Volumetric testing of all meters must be performed and approved prior to shipment. The complete meter assembly and signal converter must be wet accuracy tested and calibrated as a unit near minimum, intermediate, and maximum specified flow ranges of the meter (full range of flow).

The overall uncertainty of the calibration rig should be at least three times better than the uncertainty of the full bore electromagnetic flow meter.

The competent Government authority such as FCRI/NABL must certify the test facility. All the meters shall be calibrated for a minimum of 3 point.

The manufacturer should have an ISO 9001 certification. The magnetic flow meter should perform within the required accuracy of measured value without being affected by change in pressure due to demand fluctuation.

The length of the sensor should be strictly as per ISO up to DN 600 mm and for other sizes it should be as per the manufacturer's standard. Only, one manufacture shall make all meter sizes and styles required for this contract.

The maximum distance between flow sensor and the signal converter/transmitter should be at least 200 mtrs.

Supplier should have in-house calibration facility and should give calibration certificate for all the flow meters. The flow meter should have grounding rings only. Calibration of each Meter shall be tested at in house facility of manufacturer for the sizes for which manufacturer has this facility. The test bench of such manufacturer should be certified by a reputed government organization like FCRI or NABL.

If manufacturer has no in house facility for calibration than each meter shall be tested from FCRI. Wet calibration of all the flowmeters shall be witnessed by the purchaser or it's nominated inspection agency at FCRI Palghat, in case the supplier/Manufacturer does not have the testing facility.

Supplier must have test facilities, spare parts, and personnel to maintain, instruct, train or whatever is necessary to assure that meters shall be maintained throughout the guarantee/maintenance contract period.

The Bidder should submit data sheet of Full bore Electromagnetic flow meter to be supplied along with the proposals. After award of contract, the contractor shall submit the work plan, quality plan and different check lists to the concern SE/CE for approval and after approval 3rd party inspection should be called.

18.5. Technical Specification

A) Process Liquid			
a.	Liquid Type	:	Potable water/raw water
b.	Type of solid	:	Silt particles
B) Operating Condition			
a.	Operating pressure	:	Max. up to 1.0 Mpa
b.	Operating temperature	:	0° C to 50° C.

C) Flow Sensor			
a.	Type	:	Pulsed DC excitation
b.	System	:	Separate with cable output
c.	Power supply	:	230 V AC, 50 Hz
d.	End Connections	:	Flanges of Carbon Steel PN 40 –from Size 25 mm to size 80 mm PN 16 – from size 100 mm to size 150 mm
e.	Flange Rating	:	PN10 – from size 200 mm to size 1000 mm PN 6 -from size 1200 mm to size 2000mm
f.	Electrode material	:	SS 316 (Stainless steel) /Platinum /Tantalum
g.	Meter tube	:	SS 304 (Stainless steel)
h.	Electrode type	:	Round head electrodes
i.	Lining material	:	Hard Rubber (SBR or EPDM)/ Poly-urethane (PU)
j.	Protection category	:	**IP 68**
k.	Measuring accuracy	:	Measuring accuracy **+/-0.5%** of Measured Value inclusive of Linearity, repeatability, Pressure Effect and Hysterics between 0.3 - 4 m/s velocity.
l.	Coil Housing	:	SS 304 with fully welded construction
m.	Connection / Junction Box	:	SS 304
n.	Earthing	:	Grounding Rings in SS 304(Gr Electrodes are not Acceptable)
o.	Fluid conductivity	:	> 20 μ Siemens/cm
p.	Marking	:	Direction of flow with arrow, size, Sr. no, make

D) Flow Transmitter/Converter

a.	Type	:	Microprocessor based, Modular Design, remote mounting
b.	Display language	:	English
c.	Ambient temperature	:	-2^0 C to $+60^0$ C
d.	Display	:	Min. 2 line back lit LCD for indication of actual flow rate, forward, reverse, sum totalizes
e.	Outputs	:	One Current output (4 – 20 mA) One scale able pulse output One Status output Two replay output.
f.	Protection Category	:	IP 67
g.	Enclosure	:	Die Cast Aluminum with polyurethane finish with glass window
h.	Programming	:	Through Key /keypad on front facia /optical touch key
i.	Power Supply	:	230 V AC, 50 Hz
j.	Cable Gland	:	½" NPTF (4 glands of double compression type)
k.	Mounting	:	Remote /Wall mounted/Panel Mounted
l.	Interface	:	RS 485, based on EIA R 422/485 standard, or HART
m.	Power failure mode	:	Provision of RAM/PROM to store parameter entered and measured flow data during power failure
n.	Max. Separation	:	Up to 200mtrs. between sensor & transmitters
o.	Terminals	:	Shock – Hazard – protected push lock terminals
p.	Error Identification	:	0/3.6/22 m Amp
q.	Interchangeability	:	Fully interchangeable with all sizes of flow sensors
r.	Safety classification	:	General purpose certification
s.	Flow Indicator Totalizes	:	Internal, 5 mm high, LED display with 8 digit LCD / electromechanical Totalizer

CHAPTER 19 - HOUSE SERVICE CONNECTIONS

Providing House service connections on DI pipe

Providing house service connection by providing clamp saddles for tapping from DI mains during execution of water supply mains.

i) Clamp saddles for service connection from water distribution mains shall be wrap around design, wide skirt and wide straps support , which shall reinforce the pipe while providing excellent stability to the saddle non corrosive plastic body moulded with stainless steel threaded metal insert for tapping outlet with underneath projection for alignment of main pipe outlet. Threading size and dimension shall confirm to IS 554. The body shall have retaining cavity housing for internal and external retention of the elastomeric seal. Straps shall be made of Engineering plastic strap. Saddle strap – Virgin compounded PE 100 (HDPE) polymer. The grade of polymer used for body must be certified by WRAS, UK for type test as per BS 6920 from their Certified Laboratories like NSF International Ltd., UK. Stainless steel type 304 NC rolled thread. Tightening torque for ½" (M12) nut bolt 14-15 Kg.m. and for 5/8" (M16) nut bolt 21-23 Kg.m. Inclusive of VAT and Labour cess, Excluding CED etc. Providing House service connections to house hold upto house edge of the street including laying, jointing etc. Including all taxes, transportation and other levies.
ii) Brass ferrule
iii) Compression adaptor with one side compression end to suit ½" (20mm OD) MDPE pipe and other side with female threaded with SS-304 material inserts of sizes ½" BSP threads, Body, Nut and cap of Polypropylene, Clip ring of POM (Accetylic resin) and "O" ring of NBR materials, as per ISO 14236-2000 Standards with pressure rating PN 16-2 Nos.
iv) MDPE PE 80 Blue pipe of 4 metres length as per ISO 4427 Rev 1. for conveyance3 of potable water. The pressure rating of ½" (20mm OD) will be PN 16. Certificate for compliance of testing these fittings and pipe as per BS-6920 by designated laboratories to be produced.
v) Installation work of the above items
vi) Civil works like cutting trench for the above job and back filling

A. MDPE Pipes

a. <u>General</u>

Medium Density Polyethylene Pipes(MDPE) Blue Pipes are to be used for House Service Connections in sizes ranging from 20 mm to 32 mm dia (OD) confirming ISO specifications (ISO 4427) for carrying potable water. The Polyethylene material used for making the MDPE pipes

conforms to PE 80 grade and the MDPE pipes when used for conveying potable water does not constitute toxic hazard and does not support any microbial growth. It does not impart any taste, odour or colour to the water.

b. Raw Material

The pipes shall be manufactured from polyethylene containing only those antioxidants, UV Stabilisers & Pigments necessary for Manufacture of pipes conforming to this specification and for its end use. The minimum required strength for the PE 80 grade shall have 8 Mpa.

c. Pressure Rating:

The Pressure rating of MDPE Blue PE 80 Pipes shall be confirming to Clause 4.1 of ISO 4427: 1996 and shall be as per the table given below:

Nominal Dia of MDPE Pipe (mm)	Pressure rating
20	PN 16
25	PN 12.5
32	PN 12.5

d. Dimensions:

The pipe dimensions shall be as per latest revisions of Clause 4.1 of ISO 4427 : 1996 and pipes upto diameters 32 mm shall be supplied in Coils. The internal diameter, wall thickness, length and other dimensions of pipes shall be as per relevant tables of ISO 4427:1996. Each pipe shall be of uniform thickness throughout its length.

The wall thickness of the PE 80 Pipes shall be as per the table given below:

Nominal Dia of MDPE Pipe (mm)	Wall thickness
	Minimum
20	2.3
25	2.3
32	3.0

The dimension tolerances shall be as per ISO 4427 clause 4.1.3

b. Performance requirements

The Pipe supplied should have passed the acceptance test as per ISO 4427. The manufacturer should provide the test certificates for the following tests:

1. Melt Flow Rate
2. Density,

3. Oxidation and Induction test,
4. Hydrostatic Test ,
5. Pigment dispersion Test,
6. Longitudinal Reversion Test.

f. Effects on Water Quality:

The MDPE PE 80 Blue Pipes shall confirm to Clause 3.5 of ISO 4427 for Conveyance of Water for Human consumption. Also the Pipes intended for conveyance of Potable Water for Human consumption to be tested to comply with BS 6920 specifications in any of the laboratories like DVGW/ KIWA/SPGN/ WRc-NSF and certificate of compliance to be produced for the following parameters:

1. Odour & Flavour of Water
2. Appearance of Water
3. Growth of Micro Organism
4. Extraction of substances that may be of concern to Public Health (Cyto Toxcity)
5. Extraction of Metals

g. Marking:

MDPE pipe shall be clearly marked in inedible ink/ paint as per clause 8 of ISO 4427 at every 1 m with the following information.

a. The manufacturer's name and trade mark
b. Dimensions (nominal OD X, Nominal Wall Thickness)
c. Designation of the pipe as per ISO 4427 (PE 80)
d. Nominal pressure
e. Lot number / Batch number
f. Employer / Client name (CMWSSB)
g. Manufacturing standard (ISO 4427).

B. COMPRESSION FITTINGS.

Compression Fittings used for House service connection comply as per ISO 14236

a. Material of Construction

Compression fittings material shall confirm to ISO 14236 . Clause -5.

a) Body- Polypropylene
b) Nut / Cap- Polypropylene.
c) Clip Ring – POM (Acetylic Resin)
d) Packing Bush – Polypropylene.
e) "O" Ring – NBR

b. Pressure Testing

The pressure Rating of Compression Fittings as per clause 8 of ISO 14236 which shall be PN 16

c. Dimensions:-

The Dimension of Compression fittings shall be as per clause 7.1 of ISO 14236

d. Performance Requirements

The compression fittings shall be Tested as per ISO 14236. Following Test Methods shall be performed.

Clause 8.2.1 - Leak tightness Under internal Pressure
Clause 8.2.2 - Resistance to Pull Out
Clause 8.2.3 - Leak tightness Under Internal Vaccum
Clause 8.2.4 - Long Term Pressure Test for Leak tightness for assembled joint
Clause 8.3.2.1 - MRS Value as per ISO 9080
Clause 8.3.3.1 - Resistance to Internal Pressure

e. Effects on Quality of Water

The Compression fitting for Conveyance of Water intended for conveyance of Potable Water for Human consumption to be tested to comply with BS 6920 specifications in any of the laboratories like DVGW/ KIWA/SPGN/ WRc-NSF and certificate of compliance to be produced for the following parameters:

a. Odour & Flavour of Water
b. Appearance of Water
c. Growth of Micro Organism
d. Extraction of substances that may be of concern to Public Health (Cyto Toxcity)
e. Extraction of Metals

C.STOP COCK (BALL VALVES).

Stop Cock used for House service connection comply as per ISO 4422

Material of Construction

Stop Cock material shall confirm to as per Clause 4 of ISO 4422

a. Body – UPVC
b. Ball seat- PTFE/PE
c. Ball - UPVC
d. “O” Ring- NBR
e. Compression Nut / Cap – Polypropylene
f. Clip Ring – POM (Acetylic Resin)

Pressure Rating

The pressure Rating of Stop Cock as per ISO 4422 shall be PN 16.

Dimensions:-

The Dimension of Stop Cock shall be as per Table 3 of ISO 4422

Performance Requirements

The Stop Cock shall be Tested as per ISO 4422. Following Test Methods shall be performed.

Clause 7.1 - Resistance of Valve bodies to Internal pressure
Clause 7.2 - Crushing Test
Clause 7.3 - Endurance Test
Clause 7.4.2 - Seat and Packing TEST
Clause 7.4.1 - Operating Torque Test

Effects on Quality of Water

The Stop Cock intended for conveyance of Potable Water for Human consumption to be tested to comply with BS 6920 specifications in any of the laboratories like DVGW/

KIWA/SPGN/ WRc-NSF and certificate of compliance to be produced for the following parameters:

a. Odour & Flavour of Water
b. Appearance of Water
c. Growth of Micro Organism
d. Extraction of substances that may be of concern to Public Health(Cyto Toxcity)
e. Extraction of Metals

CHAPTER 20 – TOPOGRAPHIC SURVEY OF ASSETS AND UTILITIES USING RTK METHOD

Topographic Survey of assets and utilities of CMWSSB using the latest technology and DGPS/DGNSS Instruments, establishing Temporary Benchmarks (TBM) within the Area of Interest (AOI), furnishing “as built drawing with geo referenced Assets and Utilities” in (.shp) file format and the attribute data in FDGB/ PDGB format for incorporating into the GIS platform of CMWSSB.

Where the Site has already been surveyed and maps available in UTM Zone44 coordinate system with TBM available on ground or coordinates of other assets available on Ground.

The Contractor must obtain the existing Static GCP points from CMWSSB which should be considered as the control point with known coordinates X, Y and Z.

Survey consultant to ensure the closing error is within permissible limits (SoI Standards) while transferring the levels from the existing Static GCP points and the same to be presented as a report. The same process shall be adopted for random verification of positional accuracy of points established using the PBMs as base.

As built survey for every sewage and water pipeline and other assets must be done using DGPS based RTK method by transferring the coordinates from the nearest Static GCP of CMWSSB.

Where there are signal interruptions for the RTK method, Total Station can be used. The coordinates from the static GCP shall be transferred to the Total Station by RTK method and the co- ordinates of the assets can then be captured by Total Station.

All the features, attributes of all the assets, utilities captured shall be Geo referenced as per standard Coordinate reference system (WGS 84 UTM Zone 44N).

The final base map with assets and utilities shall be furnished in (.shp) format. The geo referenced assets and utilities along with the attributes (as specified by the GIS Wing, CMWSSB) shall be converted into proper geo database (FGDB / PGDB) with the attributes.

One set Hard and Soft Copy of all the CMWSSB assets and utility has to be prepared category wise network wise in A0 Print for verification in a print scale of 1:1000 in A0 plot, with standard legends in international and NUIS standards and should be legible and three sets of final Hard Copy in A0 print

Utilities pertaining to water supply scheme (WSS)

(1) Underground Assets

(i) Line

a. Pumping main / conveying main
b. Transmission main
c. Distribution main
d. Feeder main
e. House service connection
f. Dedicated main
g. Encasing pipe(used for Trenchless Technology)

(ii) Points

a. Specials
b. House Service Connection Pipe
c. Tapping Point
d. Receiving Point

(2) surface Assets

(i) Line

a. Pipe carrying Bridge

(ii) Point

a. Electro Magnetic Flow meter
b. Fire Hydrant
c. Valves
d. House service meter / Water meter
e. Filling Post
f. Pump Motor
g. DG Set

(iii) Polygons (Boundary)

a. Head works
b. Filling Station
c. Over Head Tank
d. Under Ground Tank
e. Water Treatment Plant (WTP)/ SWRO
f. Water Distribution Station (WDS)

General features for the Surface Assets

a. Bore well
b. Tube well
c. Open well
d. HDPE Tank
e. IM – II Pump
f. Public Fountain
g. Rain Water Harvesting Structure

Note : Minimum of 20 attributes to be filled for each feature / assest as directed by the Site Engineer

CHAPTER 21 – Remote Terminal Unit

Reputed manufacturer's Remote Terminal Unit, RTU/PLC in IP65 enclosure having modular PLC (Plug and play type) for control & monitoring with Modular Controller and should have modular communication. The PLC should be able to communicate to the master controller on an open protocol such as PROFIBUS and MODBUS for III party etc. with high speed desired. The communication should be suitable for integration in the Central Monitoring SCADA and should not require any additional cards or gateways. It should be possible to view, control & troubleshoot the PLC without requiring any software, from any PC, using web based protocols. Data logs should be stored inside the RTU and should be downloadable in CSV format using a web browser. It should be possible to increase the I/O handling capacity of the PLC. Maximum number of devices that shall be controlled by a single RTU shall be 5 or less. The RTU shall communicate to the central monitoring station on GPRS / GSM. The RTU shall be programmable with the HMI and it should also be possible to remotely program the RTU from the control room.

RTU shall be tested to work in a temperature range of 0 degree to +45 degree Celsius. The RTU shall have integrated non-volatile memory capacity suitable for storing the data for a period of one month. All must be complied with IEC-611131-03 and IEC 61158(4-20Amp). Suitable industrial grade AC to DC Power Supplies shall be mounted inside each RTU with battery backup for a period of 4 hours. Each RTU shall have separate power supplies for electronics and field. Both the power supplies shall be redundant.

Surge Protection Device shall be provided inside each RTU shall as per the following, to safeguard against transient & lightening surges. -Class B + C on mains input - Class D, for 24 V DC Supply.

Each RTU shall be interconnected suitably to control 5 nos. starters of the pump sets / valve actuators, as required.

The RTU equipment shall be housed in a properly sized, weather-proof panel, Housing of RTUs' in protection standards like IP65 box etc.

PREFERRED MANUFACTURERS

The bidders can use equivalent makes provided its quality on par with preferred Makes.

Table - I

Sr. No	Item	Manufacturers
1.	Pumps (submersible, dry pit & grit)	KSB / KISHOR / GRUNDFOS / AQUA/ XYLEM-STEADY/ ANDRITZ / FLOWMORE / JASCO / DECCAN / KARVEL
2.	Metering equipments like C.T.P.T. and Trivectometer	GYRO/ IMP/ GEC/ UNIVERSAL / SIMCO / HPL SOCOMEC / HAVELLS
3.	Switch & Fuse Unit	SIEMENS/ L & T/ JYOTI / GEC/ ELECTRIC CONTROL GEARS PVT. LTD., / CROMPTON GREAVES, CONTROLS & SWITCH GEAR / STANDARD / HPL
4.	L.T. & Control Cables	CCI, ICC, ASIAN, GLOSTER, UNIVERSAL., OMEGA, HAVELLS / HPL
5.	Cables (660 V Grade)	ASIAN/ UNIVERSAL/ GLOSTER/ TROPODUR/ FINOLEX/ INDIAN CABLES/ INDUSTRIAL CABLES, HAVELLS / HPL
6.	PVC Insulated Cu.wire	PHILCO / SANDEEP / HPL
7.	H.G. Conduit Pipes	NATIONAL/ KHANDELWAL/ SUPREME/ ECW.
8.	L.T. Panel Board	GEC/ JYOTI/ SIEMENS/ KIRLOSKAR ELECTRIC/ EASUN/ CROMPTON GREAVES / POWER TECH / ENPRO ENGINEERING / SPACE AGE SWITCHGEAR / VOLTECH
9.	Capacitors L.T.	VOLTAS/ BHEL/ ABB / ENERGY CAPACITORS / HAVELLS / EPCOS.
10.	Electrical Motors,	ABB / KIRLOSKAR/ JYOTI/ NGEF/ SIEMENS/ AEC/ BHARAT BIJLEE/ CROMPTON/ BHEL
11.	Starters.	L.T./ LK/ SIEMENS/ CUTLER HAMMER/ CROMPTON GREAVES / INNOVATIVE TECHNOMICS / POWER BOSS
12.	Switchgear with HRC Fuses	ENGLISH ELECTRIC/ SIEMENS/ L&T/ JYOTI/ SYSTEM CONTROLS/ HAVELLS / HPL
13.	ACB/M.C.C.B./MCB	ENGLISH ELECTRIC/ CROMPTON/ L & T/ STANDARD/ C AND S LTD / ANDREW-YULE SPACEAGE SWITCHGEAR/ HAVELLS / HPL
14.	MCB Distribution Board	MDS/LOADSTER & LOADKONTAKT/STANDARD / HPL

Sr. No	Item	Manufacturers
15.	PVC 5A and 15A Switches	ANCHOR/ PRECISION/ MK/ CPL
20.	PVC 5A and 15A Sockets	ANCHOR/ PRECISION/ MK/ CPL
21	D.G.SET ENGINE	KIRLOSKAR / ASHOK LEYLAND / CATER PILLAR / CUMMINS
22	ALTERNATOR	KEC / NGEF / CROMPTON / JYOTHI
23.	GLS/ HPSV/ HPMV/ Floure-scent Tubes/ other type lamps.	Philips / Crompton / Bajaj Mysore Lamps / Sylvania-hazman / Osram/ WIPRO/ HAVELLS
24.	Luminaires	Philips / Crompton / Bajaj Lumex, GEC/ WIPRO/ HAVELLS / HPL
25.	Ceiling / Exhaust / FANS Air Circulators.	Crompton / Bajaj/ Khaitan Polar / Rallis / Almonard Orient / Usha/ HAVELLS.
26.	Switches, SFV	Anchor / Radart / Khosla / Vinay / Pointer / MK / CPL.
27.	Emergency Lights	Prolite / Elite / Instalite.
28.	PVC Power and control cables, Flexible and house wiing cables.	Universal / Asian / Finnolex / Torrent / Uniflex /Tropodor / Jhonson / HMT Cable corporation / OMEGA / HPL
29.	Steel Tubular poles; caps and brackets	ITC,RUBIT,UNIFAB, B.T. & P. Co.
30.	HT Switchgear - VCB, RMG, Unitised Substation, Load Break Switch, LA, CT, PT, HRC Fuses	SEIMENSES / BIECCO LAWRIE LTD/ CONTROLS & SWITCH GEAR / ESWARI ELECTRICALS
31	Power Transformers	INDOTECH, KIRLOSKAR, BHEL, ALSTHOM, CROMPTON GREAVES, VOLTECH, WPDT-WILSON
32	Sluice Valve, Non-Return Valve, Butterfly Valve	AUDCO, KIRLOSKAR, FOURESS, DURGA, JUPITER, IVC
33.	Electro mechanical valve actuators, Valves, Dampers	ROTORK, AUMA, SDTORK.
34.	Double walled corrugated pipes	ALOM / POLICECO / RELIANCE / PIPELIFE.
35	Hydraulically operated Diaphragm Valves (Pressure reducing / pressure relief / Surge / Flow rate / Altitude valves	SINGER / ARMAS / FLOMATIC NY / LA TIS SERVICE.

Schedule of Particulars

General Notes

At the time of bidding, the Bidder is required to furnish the relevant details for each pumping station with respect to all the plant and equipment proposed to be installed as required in the schedule- I below. Furnish additional details any separately.

Particulars given in these Schedules will be binding on the Contractor and may not be varied, except with the consent in writing of the Engineer. The approval or otherwise of the particulars given, shall be deemed in no way to relieve the Contractor of any of his obligations under the Contractor.

SCHEDULE - I

S.No.	Description	Unit
	Pumping Station -	
	Submersible pumps	
1	Manufacturer	
2	Model No.	
3	Maximum flow	lps
5	Total head at Maximum flow rate	m
4	Guaranteed efficiency of pump at duty point	%
5	Impeller size	mm
6	Solid handling capacity	mm
7	Full load current	Amp
8	Motor speed	rpm
9	Thermistor fitted	Y/N
10	Cable length attached	m
11 a b c	Material: - Casing - Impeller - Shaft	
12	Continuous Motor rating	KW
13	Type of thrust bearing Type of journal bearing	
14	Pump Performance Curves supplied (Q vs H, P, n & NPSH)	Y/N

Description	Unit
Pumping Station -	
MV Panel	
Make	
Capacity	
Make of Components used	
Capacity of Switchgear	
Current Transformer	
Make	
Type	
C T Ratio	
Voltage Transformer	
Make	
Type	
Ratio	
Over voltage vector	
Power Capacitor	
Make	
Type	
Capacity of the Bank	kVAR/MF
Capacitor element	
Type of insulation used	
Automatic power factor correction unit installed	Y/N
DG Set	
Engine	
Make	
BHP	
Alternator	
Make	
Capacity	

APPENDIX – A

WATER PIPE LINE PRESSURE TEST REPORT

CHENNAI METROPOLITAN WATER SUPPLY AND SEWERAGE BOARD

CONTRACT :

CONTRACTOR;

WATER PIPE LINE PRESSURE TEST REPORT

PIPE NUMBER

PIPELINE ROUTE

LENGTH TESTED FROM CHAINAGE OUTSIDE DIAMETER (mm)

FROM METER METRES TO CHAINAGE

SOAKAGE PERIOD (24 HOURS MINIMUM) AT OPERATING PRESSURE

From Hours to hours on (date)

Report to Events:

Reading	1	2	3	4	5	6	7	9
Time								
Pressure								

This pipe is passed
Ready for test

Inspector's
Signature

Date

PRESSURE TEST FOR 1 HOUR AFTER 1 HOUR PUMPING AT TEST

TEST PRESSURE	BARS Time from	DATE Hrs. to hrs.
ALLOWABLE WATER LOSS		Litres
MEASURED WATER LOSS		Litres

This pipeline has passed the pressure test

Signed for Contractor Singed for Engineer

CHAPTER 23 - SMARTMETERS

Detailed Specification of Ultrasonic Smart Water Meters

i. Water Meter shall be manufactured as per ISO 4064 Standards, IP 68.
ii. Water Meters of domestic sizes shall be equipped with GSM, GPRS based AMR/AMI Technology, Ultrasonic Smart water meters.
iii. Water Meters shall be, Dry Dial with IP 68 Protection as per ISO4064/ IS standards. The meter should be Humidity Proof, Vibration Proof, Tamper Proof against electromagnetic fields.
iv. Water Meters shall have the Pressure Rating; Working Pressure of >16 Bars, and have the Environmental Temperature;0-degree C to 50-degree C.
v. Water Meters of each size should have been duly tested and passed as per the relevant standards and specifications from any NABL accredited labs or Fluid Control Research Institute (FCRI) Kerala for life cycle test and performance test, supported with test certificate.
vi. Water Meters must be able to retain their accuracy, when installed in either horizontal, vertical or inclined planes.

APPLICABLE STANDARDS (UPDATED/LATEST AMENDMENTS)

- IS779
- IS6784
- ISO4064:2014

The meters shall be supplied complete with all the accessories; fitting material, nuts and nipples. All Water Meters shall be protected and covered with Poly-Propylene (PP) meter protecting box.

Material of Construction:

- The manufacturer shall provide specific details of materials used for various parts of the meter which must meet the specifications for the material of construction of the individual parts of the meters as per applicable standards.
- The body of the meter shall be of Brass/Bronze/Engineering Plastic. The firm shall specifically mention in the offer, the metal used in manufacturing. Material that come in contact with the water supply shall withstand 2 ppm (Parts per Million) of Chlorine Residual in the water supply and shall be resistant to corrosion.
- The water meter and accessories shall be manufactured from materials of adequate strength and durability. The materials, which come in contact with the potable water, shall not create a toxic hazard, shall not support microbial growth, and shall not give rise to unpleasant taste or discoloration in the water supply.
- The painting material used should be safe for human uses and not affect human health (Health Certificate should be attached /provided).
- Each Water Meter should be supplied with its accessories and Test Certificates and Guarantee Card.
- Sampling Criteria for Accuracy Test.
- Supply shall be made strictly as per the sample meters including the weight, as approved by FCRI.

- Markings on the Body of the Meter:
  - Make/Brand

- Size/Nominal Dia.
- S.No./Year of Manufacture
- Ultrasonic/Model
- Direction of Flow Unit of Measurement
- Class "C" or equivalent.

ITEM	SPECIFICATIONS
a) Measuring Principle	A battery operated inline GSM/GPRS based AMR/AMI Technology, Ultrasonic Smart water meters with no moving parts.
b) Power Supply	Power-Supply-Battery operation for complete meter including AMR with battery life of more than 5 years.
c) Meter Lifetime	More than 10 years.
d) Protection Class	Must comply to IP68 Standard for indoor and outdoor operation, including fully submerged installations
f) Accuracy	+/-1% typical operating range and temperatures. The Electromagnetic water meter should maintain its accuracy over its lifetime.
i) Material	The water meter body shall be made of Brass/Bronze or Engineering Plastic.
j) Pressure Rating	Pressure rating shall be ≥ PN16
k) Environmental Temperature	0 °C to 50 °C
l) Data Protection and tamper proof	The meter should be tamper proof with suitable data protection of calibration and revenue parameters.
n) Access to information	Display with 28 digits for main information. Index, menu and status symbols for dedicated information
o) Measuring Units	The measuring units should be m^3 for volume and m^3/h or l/h for flow rate.
p) Facility for Remote Communication interface	The Ultrasonic smart water meter should be configured with battery operated remote reading capability to cloud via 2G/3G/4G
q) Indicators/Alarms	Tampering, Reverse Flow, Leakage etc.
r) Data storage and transfer	The hour wise data from smart water meter has to be stored and Data transfer from device has to be once a day to the server
s) Reports	The day wise reports or historical reports should have hour wise data.

CHAPTER 23

Annexure C- O&M Schedules (CPHEEO Manual Part B)

Contractor should follow good practices in Operating & Maintaining the water supply assets in the best working conditions. Contractor should prepare the detailed Operation and Maintenance plan, Standard Operating Procedures (SOP) taking in to account best international practices and guidelines given in the CPHEEO: Part B: Manual Operation & Maintenance and submit for the approval of CMWSSB.

1. Underground & Overhead Reservoir Maintenance

The maintenance procedures shall include a step-by-step procedure for every equipment in reservoirs, such as pipes inside the tank (chambers, screens, inlets, outlets, washouts, overflows), valves, specials, and flow meters, following the procedures as per the manufacturers' catalogues.

- Clear Water Reservoir (CWRs) have to be inspected regularly as per the schedule.
- Leakage from the structure, pipes and valves have to be attended to on priority. It is advisable to resort to pressure grouting to arrest leaks from structures, and sometimes an additional coating of cement mortar plastering is also done using a waterproof compound to arrest leaks from the structure.
- Maintenance is mainly concerned with protection against corrosion both externally and internally. Corrosion of roof slab of RCC reservoirs due to the effect of chlorine is also common. Internal corrosion is prevented by cleaning and painting at regular intervals. Only food-grade paints are to be used for painting the interior surface of CWRs. Anti-corrosivepainting (epoxy) is also done to the interiors when corrosion due to chlorine is expected.
- External protective coating (painting, epoxy, etc.) of overhead steel tanks as and when required with waterproof cement paint for exteriors of RCC tanks once in 5 years is usuallydone. The inside of the painted CWR shall be disinfected before being used for a sufficientperiod to give chlorine residuals of at least 0.2 mg/L. Manhole covers and vent pipes shallalways be properly placed and maintained.
- The air vent helps in the easy circulation of air in the tank. Ventilation windows should beprovided with wire mesh so that entry of rodents, reptiles, etc., inside the tank can be stopped, and also periodic check has to be done.
- Water level indicators, level gauges/flowmeters be inspected regularly and repairs are carried out.
- Inspection of RCC ceiling, columns, etc., can only be accomplished by performing in situ tests on the structures in addition to visual inspection. The rebound hammer test, ultrasonic pulse velocity (UPV) test, pull-out and pull-off tests, core sampling and testing,carbonation test, and cover survey are all commonly used to evaluate existing concrete structures. Necessary steps should be adopted for strengthening of the RCC structure, ifnd dilapidated. All the pipe fittings should be leak-proof, any leakage nearby reservoirmay affect the safety of the reservoir.
- The overflow pipe should be connected with the distribution system after the sluice valve is installed on the delivery pipeline to avoid the wastage of overflow water.

- A concrete platform as protection work shall be provided around the CWR, if not provided,so as to safeguard the reservoir foundation from any leakages/overflow of water. All valves should be inspected and regulated regularly at a specified frequency of inspection.
- Valves spindles that develop leaks should be repacked.
- Rust and sediment in the valve are removed with proper caution.
- Valve chambers of the SR also require maintenance to ensure that the interiors of chambers are not silted up and also ensure that the covers are in good condition and properly positioned.
- The sluice valve chamber shall not be waterlogged by ensuring proper drainage and disposal of water from the chamber.
- Lubricate the packing gland and soften the packing.
- The valve supports should also be checked for any structural cracks, exposure of reinforcement, etc., and repaired.

1.1 Cleaning of Clear Water Reservoirs

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with the water level lowered to about half or less. Alternatively, a detailed inspection can be made after draining the tank and then cleaning or washing. The best time of the year to take up cleaning of the reservoir is during theperiod of lowest water consumption.

The following activities are normally involved in the cleaning of a tank:

i. Make alternate arrangements for water supply to consumers served by the reservoir.
ii. Close the inlet line before commencing cleaning of the reservoir.
iii. Draw the water from the reservoir till 200–300 mm water depth is left in the reservoir.
iv. Close the outlet valve so that no water will be used while the tank is being cleaned.
v. Collect a sample of water and silt/mud accumulated in the tank and get the biological analysis for the presence of snails and worms. If snails and worms are found, find the source and eliminate it.
vi. Drain and dispose of the remaining water and silt.
vii. Wash the interior of tank walls and floor with a water hose and brushes.
viii. The floor should be cleaned off into the scour sump and all solids should be removed by wet vacuum and disposed of appropriately.
ix. Inspect the floor, inlets, and outlets for any depression, pits, vegetation, etc., and seal such pits with rich concrete after removing loose material and vegetation and consolidating the floor below the pit.
x. The frequency of cleaning of SR depends on the extent of silting, development of biofilms, and results from water quality monitoring.
xi. Care should be taken in avoiding contamination of drinking water reservoirs in an area where there is faecal contamination from farmland.
xii. In order to facilitate smooth and safe working during the cleaning process, arrangements for proper lighting, personal protective gears, air blower, oxygen cylinder, first aid, alarm, or hooter system should be made available to avoid health hazard.
xiii. Proper office procedure or standard operating procedure should be followed.

1.2 Disinfection of Clear Water Reservoirs

After cleaning, reservoir should be disinfected before taking in the service for which qualified operator(s) wearing the appropriate personal protective gears should be allowed to perform disinfection of the reservoir. The following are some of the different methods of reservoir disinfection:

- Sodium hypochlorite/chlorine should be injected into water to give a free residual chlorinein the range of 25 to 35 mg/L to spray the internal surfaces of the reservoir. The residual chlorine should not be below 6 mg/L after a period of 24 hours.
- All outlets should be closed off during the procedure to prevent highly disinfected water entering in the distribution network.
- Disinfected water should be kept for at least 24 hours in the reservoirs. The water shouldthen be drained completely and the reservoir refilled with drinking water.
- Entire reservoir should be filled with chlorinated water (10 mg/L) for a specified period (6 to 24 hours) and then emptied completely (AWWA, Standard C652, Disinfection of StorageTanks).
- Fill 5% of the reservoir with chlorinated water (50 mg/L) for 6 hours minimum, and then fillthe reservoir with treated water (i.e., with normal levels of chlorine) to overflow level for 24 hours and then use this water (AWWA, Standard C652, Disinfection of Storage Tanks).
- Reservoir water should be put back into service only when the water analysis results are in compliance with the drinking water standards.
  Reference: EPA: Drinking Water Advice Note No. 10 (Service reservoir inspection, cleaning, and maintenance), 2011.

1.3 Recommended Schedule for maintenance of reservoirs:

Daily or Weekly

- Check storage tank for signs of security breaches – damaged fences, open gates, graffiti,vandalism, etc.
- Check water level indicator – functioning, adequate amount of stored water, excessivewater use.
- Check the overflow line, vents, ladder access locks, roof access hatches, and controls thatare readily visible from the ground for damage, vandalism, or other conditions.
- Check storage tank and site after any adverse weather conditions – high winds, heavysnow, ice, rains, etc.

Monthly

- Verify all openings are protected from surface runoff, windblown contaminants, insects,birds, and animals.
- Check tank overflow lines for signs of damage, such as screens, flapper valves, checkvalves, splash plates, etc.
- Check the area for excessive vegetation or dangerous conditions – uncut grass, brush,dead trees, fire hazard, etc.
- Check control valves for proper positions, open or closed, damage or leaks.

Quarterly

- Inspect the tank's exterior and roof for signs of damage, corrosion, degradation, leakage, or structural problems, focusing on all openings into the reservoir (reservoir roof and sidewall vents, access hatch, overflow outlet, and so on).
- Check for leakage of water due to non-functioning of appurtenances or structural failure.
- Check tank-supporting structure for signs of damage, corrosion, degradation, or structuralor seismic inadequacy.
- Check tank foundation for signs of damage, corrosion, degradation, and structural inadequacy.
- Check that there are no signs of damage near tank ladders, including corrosion, degradation, structural issues, or vandalism.
- Check the tank area for water ponding, poor drainage, excessive vegetation, unhealthy trees, fire hazards, etc.
- Check that the tank area is free from combustible storage, trash, debris, brush, or othermaterial that could present a fire hazard.
- No accumulation of material on or near parts possibly resulting in accelerated corrosion orrot.
- Tank and support free of ice build-up.
- Check earth embankments for erosion, burrowing animals, improper drainage, and leakage.

Annually or Seasonally

- Check storage tank structural, seismic, and sanitary integrity – leaks, corrosion, cracks,supports, warping, etc.
- Inspect storage tank interior for pitting, concrete spalling, rot, corrosion, rust, water levelsensors, biofilm build-up, etc.
- Exercise valves and make repairs as needed.
- Document inspection and maintenance activity as part of an O&M programme.
- Inventory and evaluate storage facilities capacity, condition, replacement costs, and plan for improvements.
- Evaluate stored water for clarity, sediments, floating materials or films, unusual odours,insects, birds, or animals.

2. DISTRIBUTION SYSTEM:

The distribution system is the most important part of the water supply, delivering treated and disinfected water to the customers with adequate residual pressure. The water is supplied through a well-articulated network of pipelines with various appurtenances including valves, collectively called as the water distribution system (WDS), which involves operation of network spread over a large area. Contractor should develop operating procedures to ensure that the overall system can be operated satisfactorily, function efficiently, effectively. Contractor should also develop and get approval from CMWSSB the Routine and Emergency operating procedures.

Normal Operations:

1. District Metering Area (DMA): District Metering Area (DMA) concept may be adopted for continuous/intermittent supply of piped drinking water.
2. Storage, Transportation, and Distribution: The distribution system shall have storage reservoirs located at key points to take advantage of natural physical topography, or for reasons of balancing supply and demand, or for emergency situations. In the absence of an advantageous natural topography, critical points shall be selected in a given distribution system for monitoring of pressures by installation of pressure recorders and gauges. These pressures are either measured manually and transmitted to the control station or automatically measured and transmitted by telemetry to control station. Pumping stations or booster, if necessary, shall be provided to maintain adequate pressure throughout the distribution system. Valves and meters and other appurtenances shall be installed throughout the distribution system as control devices and for water audit. Water supplier/utility shall maintain a documented procedure for the same.
3. Water Audit: Water audit shall be conducted Quarterly/annually and documented. The report shall be submitted to CMWSSB for review and further necessary action. All components of the water balance shall be quantified over the same designated period and expressed in KLD or MLD.
4. Metering: The water supplier/utility shall provide bulk water meters in the water distribution system to ensure water audit. Provision may also be made to have a functional/automatic/smart meter at household level, which shall support in water audit. Automatic/smart meters shall be preferred over conventional meters for DMA.
5. Water Quality, Sampling & Monitoring: Contractor shall plan and implement control and monitoring systems as specified in the scope of works, the water supplied should meet the water quality standards of CPHEEO manual. Wherever contamination of water is suspected, random sampling shall be done by Contractor or on demand by the customer. The details of control being exercised by water utility/services shall be documented. The advisory/guidelines issued by the Government of India from time to time shall be followed by the water supplier/utility.
6. Customer Satisfaction: CMWSSB shall monitor customers' perceptions of the degree to which their needs and expectations have been fulfilled. Contractor shall conduct surveys, obtain feedback on the services provided, meetings with customer to monitor customers' perceptions of the degree to which their needs and expectations have been fulfilled. Contractor with approval from CMWSSB shall determine the procedure for obtaining, monitoring, and reviewing this information.
7. Analysis and Evaluation: CMWSSB shall analyse and evaluate appropriate data and information arising from monitoring, measurement, and evaluation. Contractor shall document performance indicators to assess and improve the services. A minimum performance parameter should be met to claim the performance remuneration and avoid penalties for poor quality of services and maintenance of the assets.

2.1 Distribution Net Work - O&M Schedule

An effective strategy for efficient O&M has to be in place, and following actions are to be taken for designing an efficient operations schedule:

2.1.1 Preparation Studies

2.1.1.1 Mapping and Inventory of Pipes and Fittings in the Water Supply System

Availability of updated distribution system maps with contours, location of valves, flowmeters, and pressure gauges or taping points is the first requirement for preparation of operation schedule. Contractor should set up routine procedures for preparing and updating the maps and inventory of pipes, valves, and consumer connections. Any addition of valves, connection, or tapping should be recorded and updated in the map. The maps shall be exchanged with other public utilities agencies to contain information on other utility services like electricity, communications, etc.

The activities involved in mapping are as follows:

2.1.1.1.1 Establishment of consultative process with the management of other utility serviceslike electricity, communications, etc.

2.1.1.1.2 Definition of maps such as layout, scale, representation of pipes, valves,connections, etc.

2.1.1.1.3 Establishment of procedures for storage and retrieval and updating of maps andinventory information including intersections.

2.1.1.1.4 Setting up procedures for collecting map information in the field i ncluding field verification for compliance of the as-built drawings with design.

2.1.1.1.5 Setting up procedures for updating maps when any changes are made in thedistribution system.

2.1.1.2 Procedure for Preparation and Updating of Maps

a. Contents of Maps

Comprehensive maps prepared for a scale of 60 m/cm to 120 m/cm are used for O&M of distribution system. They provide an overall view of the system with location of reservoirs, pumping stations, valves and hydrants, etc. Valve location maps apart from indicating their location also show the direction to open the valve, number of turns toopen, make of valve, and date of fixing of valve. At times, plan and profile drawings are also available which show the depth of pipe, pipe location vertical and horizontal,and distance from reference point. Hydraulic gradient contour maps are also prepared to indicate the pressures in the system in peak demand period. They can be used for identifying high pressure or problem areas with low pressures.

b. Field Survey

Existing maps are used or conventional survey is employed for preparation and updating the maps. As an alternative to traditional survey and map preparation, “Total Station method” is gaining popularity. Total station instruments can be used for survey and mapping of towns where data is not readily available.

c. GIS Maps in demanded by CMWSSB

GIS is a computer programme that combines mapping with detailed information on physical structures with geographic areas. GIS has also compatibility with AutoCAD design systems. The remote sensing maps can be used to prepare base map of the utilities by using GIS. The GIS creates a database within a mapped area such as streets, valve chambers/manholes, pipe networks, and pumping stations. The attributes can be address, number of valve chamber/manhole, pipe length, diameter, invert and quadrant co-ordinates and can also include engineering information, maintenance information, and inspection information. The utility staff will get facility to update the maps and retrieve information geographically. These maps can be used to inform the maintenance crew to locate the place of work. The utility can use a work order system for new/repair works so that after the completion of work, such as a line is added, a valve is fixed, or a new connection is given, the work order can be used by the map unit for updating the map and its attributes. These maps are used to indicate layers of maps for water lines, sewers, power cables, telecom cables, etc.

2.1.2 Routine Operations of the Water Supply Distribution System

The efficiency and effectiveness of a water supply system depends on the operating personnel's knowledge of the variables that affect the continuity, reliability, and quantity of water supplied to consumers. The operational staff should be able to carry out changes in the hydraulic status ofthe system as required depending on those variables promptly and effectively. Routine operations shall be specified, which are activities for adjusting the valves and operation of pumps to match the prevailing conditions (flows, pressures, levels, and operation of pumps). Valve and pump operations will have to be controlled as per schedule. The schedule shall contain procedures for operating the distribution system. It should contain procedures to obtain, process, and analyse the variables related to water flows, pressures, and levels as well as the consequences of manipulating control devices, such as operation of valves and pumps, so thatthe hydraulic status of the system can match the demand for water. Flow of information such as closure of a valve for repair or maintenance purpose, any unscheduled activity started in an ongoing shift, etc., should be exchanged while switching over the shift for better O&M.

2.1.3 Operation under Emergency Conditions

Contractor should develop and get the approval from CMWSSB for emergency operations. Operations other than routine, viz., during breakdowns and emergencies have to be specified and should be carried out in specific circumstances when normal conditions change, i.e., when flows, pressures and levels, and operation of pumps change. A standard operating procedure for valves should be prepared and emergency conditions should be considered into it.

The objective of developing a programme for managing in times of shortage of water is to reduce the excessive use of water particularly when the source is limited due to adverse seasonal conditions.

The water managers play an important role in managing the water supplies during emergencies. Their role can be fulfilled by:

(i) Giving an emergency condition notification so that people could get aware

(ii) Defining new policies to balance the demand and supply of water so that at least basicneeds of every person can be fulfilled

(iii) Water quality should be monitored properly by the water managers so that water shouldbe safe

(iv) Water managers must see that emergency response plan includes a well-preparedcommunication strategy

(v) A proper vulnerability assessment of every affected area should be done

(vi) Special monitoring, vigilance, and response action team should be made to reduce thewastage and equitable distribution of water and verify that the policies made are properly followed

2.1.4 Alternative water sources available near the affected area must be looked into Monitoring of Flows, Pressures, and Levels

It will be necessary to monitor regularly operational data concerning flows, pressures, and levels to assess whether the system is functioning as per requirements. Analysis of data may reveal over withdrawal of water to some reservoirs and/or bulk consumers. At such places appropriateflow control devices may be introduced to limit the supplies to the required quantity. A list of priority points in water supply system have to be identified such as installation of meters to measure flows, pressures, and levels. A detailed map showing location for each measuring pointhas also to be prepared. The degree of sophistication of the devices used at each measuring point with regard to indication, integration, recording, transmission, and reception of data depends mainly on the skills of O&M personnel available with the agency and affordability of the agency.

2.1.4.1 Evaluation of Hydraulic Conditions

A continuous evaluation of the hydraulic conditions of the water supply system can be done by the O&M personnel after obtaining the data on water volumes and flows at various points in the system, the water pressures and levels in the reservoirs and comparing withexpected performance. This evaluation shall lead to identification of operational problemsand/or system faults. Depending on the type of problems, action have to be initiated to ensure that the system functions as per the requirement.

2.1.4.2 System Pressures

Maintenance of a continuous positive pressure at all times (during supply timings) to consumers is the main concern of O&M. Negative pressures can cause contamination ofwater supplies especially in intermittent supplies. Very high pressures may damage the pipelines and valves, which can be corrected with pressure reducing valves (PRVs). Complaints from consumers about low pressures have to be promptly investigated, if necessary, by measuring pressures with pressure gauges. Low pressures may be under the following circumstances:

- Purposefully or accidentally a line valve is left closed or partly closed or blockage due to any material causing loss of pressure.
- Too high velocities in small pipelines.
- Low water levels in SR.
- Failure of pumps/booster pumps (either due to power failure or mechanical failure)feeding the system directly.

2.1.4.3 Sampling for Quality of Water

Contractor operating the water supply system is charged with the primary responsibility of ensuring that the water supplied to the consumer is of an appropriate quality. To achieve this objective, it is necessary that the physical, chemical, and bacteriological tests are carried out at frequent intervals. Samples should be taken at different points on each occasion to enable overall assessment. In the event of epidemic or danger of pollution more frequent sampling may be required, especially for bacteriological quality. For each distribution system, a monitoring programme has to be prepared showing the location of sampling points. Based on historic records of a system it will be possible for the manager of the system to decide locations for bacteriological sampling and residual chlorine testing.

Online monitoring system like pH, turbidity, chlorine sensors can be installed in the pipeline which can provide real time water quality data for analysis and quick rectification.

2.1.5 O&M of DMA's and Operational Zones

The entry of DMA is fitted with flowmeter to record the inflow. With the addition of consumer meters, the amount of water billed to the consumer in the area can be measured against the amount of water supplied to the DMA. The difference between the two figures represents the water volume not accounted for NRW. This helps in localising the leakage. Prompt repairs to the leakage should be arranged. Replacement of damaged pipelines should be scheduled. Theflowmeters should be calibrated in regular intervals. Pressure zones should be created with pressure monitors like pressure probes inserted in the pipe at certain critical points. This can be done to avoid pipes in lower ground having higher pressure than needed, and pipes in higher elevations having insufficient pressure to satisfy consumers.

Proper DMA operation helps in longer-lasting pipelines, lower energy consumption and fewer pipe bursts. In addition, due to the increase in data obtained from zoning, operational efficiency and asset management are also improved. These data-driven analytics can give timely alert in case of leakage.

2.1.5.1 Ensuring/Confirming DMAs are Hydraulically Discrete

A district metered area (DMA) is defined as a discrete area of a WDN usually created by theclosure of isolation valves in which the quantities of water entering and leaving the area are metered. In other words, DMA is a sub-division of a large network, created by closingisolation valves interconnecting the surrounding network and thus isolating area, called DMA. DMA receives water from separate pipeline coming from SR and supplies continuous water through 100% metering of consumers.

2.1.5.2 Check for Losses

For effective control of water losses, NRW of every DMA is to be determined by dividing Operating Zones (OZs). WDS divided into number of OZs which are further divided into number of sub- zones called as DMAs. Each DMA is then critically studied for different demand patterns, leakages, and unaccounted for water. Thus, the problem is divided into sub-problems andeffective control measures are taken to provide effective solution for each sub-problem tosolve the problem in total. The measures for reduction of both apparent and real losses inthe WDNs are (i) pressure management, (ii) active leakage control, (iii) improved system management, and (iv) improved response time for leak repairs. Each DMA is discrete in terms of WDN usually by creating isolation valves the losses in each DMA can tackled separately.

2.1.5.3 Re-configuring of DMA

For re-configuring of DMA, the unutilized water due to excessive capacity of existing Service Reservoir (SR) should be utilized by increasing the spread of OZ and if the SR is suffering with low waterlevels, then it can be balanced by decreasing the range of OZ. All this balancing of SR canbe done by distribution of areas based on elevation and demand of water in an area.

2.1.5.4 Equitable Flow and Pressure

Design of OZ and DMA is made by the approach of whole-to-part and is coupled with demand management by 100% consumer metering and telescopic tariff. The whole-to- part approach is explained below with use of PRVs and flow control valves (FCVs),

however, PRVs should be used only when required. Maximum head that comes on pipes in the distribution system is the difference between FSL of SR and minimum ground elevation in the OZ of that SR. Class of pipe should be so chosen that working pressure of that pipe is more than the maximum head coming on the pipes in that OZ. Good water supply is achieved by whole-to-part approach, in which two stages are involved: (a) from MBR to SRs and (b) from SR to DMAs.

2.1.6 System Surveillance

Surveillance of distribution system is done to detect and correct. Routine surveillance shallreveal:

- sanitary hazards;
- deterioration of distribution system facilities (to detect);
- encroachment of distribution system facilities by other utilities such as sewer and stormwater lines, power cables, telecom cables, etc.; and
- damages of the system facilities by vandalism (detecting and correcting).

In addition, checks are carried out under special circumstances for assessing damage of the system after flooding of streets following a heavy storm. All these checks are done for above groundwater facilities such as valves and valve chambers or exposed pipelines. Some less frequent inspection of underground pipelines will also be required, wherein critical areas of the distribution system should be patrolled routinely so that the water

utility can watch out for early warning of any adverse conditions of the distribution system. Any activity or situation that mightendanger the water facility or water quality shall be investigated and corrective action is to be taken. Surveillance shall also include looking for unauthorised construction activity on or near the utility's pipelines, which may pose a physical threat to the mains. Any digging, excavation, or blasting near the mains shall be closely supervised by the utility staff.

2.1.7 Distribution Maintenance Schedule

Maintenance schedules can be designed considering points summarised below:

2.1.7.1 General

A maintenance schedule is required to be prepared to improve the level of maintenance of WDNs and house connections through improved co-ordination and planning of administrative and fieldwork and through the use of adequate techniques, equipment, andmaterials for field maintenance.

- The schedule has to be flexible so that it can achieve team action with the availablevehicles and tools.
- Co-ordination of activities is required for spares and fittings, quality control of materials used, and services rendered.
- Training of maintenance staff shall include training to achieve better public relationswith consumers apart from the technical skills.

2.1.7.2 Activities in Maintenance Schedule

Following activities are to be included in the schedule:

- Establishment of procedures for setting up maintenance schedules and obtaining and processing the information provided by the public and the maintenance teams.
- Formation of maintenance teams for each type of service with provision for continuous training.
- Establishment of repair procedures for standard services.
- Specification of appropriate tools.
- Allocation of suitable transport, tools, and equipment to each team.
- Establishment of time, labour, and material requirements, and output expected;time required and other standards for each maintenance task.
- Monitoring the productivity of each team.

2.1.8 Preventive Maintenance Schedule

A preventive maintenance schedule for servicing valves and maintenance of valve chambers, maintenance of the pipelines may include tasks, set priorities, issue of work orders for tasks to be performed, list of scheduled tasks not completed, record of when the tasks are completed, andmaintaining a record of tools, materials, labour, and costs required to complete each task.

2.1.8.1 Servicing Valves

Seating of valves which are subject to operations several times is likely to become leaky orpass the flow downstream even after closing tight. Periodical servicing will be required forvalves on hydrants and public taps, flowmeters, and pressure gauges. Corrosion of valves is a main problem in some areas and can cause failure of bonnet and gland bolts. Leaks from spindle rods occur and bonnet separates from the body. Stainless steel bolts canbe used for replacement and the valve can be wrapped in polyethylene wrap to prevent corrosion.

2.1.8.2 List of Spares

A list of spares required for the distribution system maintenance shall be prepared, procured, and kept for use. The list should indicate the minimum level at which action for replenishments should be initiated. The list of probable spares to be kept in stock may include the following: spare check nuts, spindle rods, and assorted bolts, nuts and washers for the flanged joints, gaskets for flanged joints for all sizes of sluice valves installed in the distribution system, spare manhole covers and consumables like the gland rope, grease,cotton waste, spun yarn, pig lead and lead wool, O-rings, mechanical joints and fittings, etc.

2.1.8.3 List of Tools

The necessary tools to properly repair and correct both the routine problems and for facilitating repairs and replacements in a distribution system have to be identified and provided to the maintenance staff. Some of the tools for the maintenance work in a distribution system are: key rods for operation of all sluice valves, hooks for lifting manhole covers, pipe wrench of appropriate sizes (200, 300, or 450 mm), double ended (DE) spanner set, ring spanner set, screw drivers, pliers, hammers, chisels, caulking tools for lead and spun yarn, ladles and pans for melting and pouring lead joints, excavation tools such as crow bars, spades, iron baskets, buckets, and dewatering pumps.

2.1.8.4 Maintenance of Valve Chambers for Appurtenances

Valve chambers are generally filled with leakage in the glands, shafts, etc., and the stagnant water if not drained properly can be sucked into the distribution system. Hence, these chambers required robust drainage arrangement and regular maintenance to keepthem clean and hygienic.

Valve chambers shall be checked to ensure that they are not damaged, nor filled up with earth nor buried in pavement. Covers of valve chambers are stolen or broken up by vandalism or by accident resulting in damage to the valves or may lead to accidental fall of a person into the open valve chamber, such situations have to be corrected on priority.Road improvement works require constant attention of water utility staff since the valves may be lost or at times the valve chambers in the roads have to be reconstructed to matchthe renewed road surface.

Precaution shall be taken to provide the valves where absolutely essential because maintenance of valve chambers is a herculean task in the distribution system. These valvechambers are becoming dustbins and point of contamination of the water. Alternatively, valve chambers can be constructed based on the essentiality (access required for regularoperation) otherwise, can be buried after inserting a pipe or similar type of any special above the spindle so that O&M team can access wherever there is requirement.

2.1.9 Maintenance Schedules of Pipelines

Maintenance schedules of pipelines are summarised as below:

2.1.9.1 Main Breaks

Pipeline bursts/main breaks can occur at any time and the utility shall have a plan for attending to such events. The repair plan must be written down, disseminated to all concerned and the agency must always be in readiness to implement the plan immediatelyafter the pipe break is reported. After a pipe break is located, a decision is to be taken as towhich valve is to be closed to isolate the section where the break has occurred. Every consumer (some important consumers may be having an industrial process dependent onwater supply which cannot be shut down as fast as the water supply lines are cut off) shouldbe notified about the break and informed about the probable interruption in water supply and also the estimated time of resumption of water supply. After the closure of the valve, the dewatering/mud pumps are used to drain the pipe break points. The sides of trencheshave to be properly protected before the workers enter the pit. The damaged pipe is removed, and the accumulated silt is removed from inside the pipe and the damaged pipeis replaced and the line is disinfected before bringing into use. After every pipe break, a report shall be prepared in regard to the cause of such break, the resources required for rectification and the time and cost required for repairing, etc., so that the agency can follow up with measures for avoiding such breaks and also modify their plan to address such breaks in the future.

2.1.9.2 Deterioration of Pipes

Pipes deteriorate on the inside due to corrosion and erosion on the outside due to corrosion from aggressive soil and water/moisture. Depending on the material of pipes, these are subjected to some deterioration, loss of water carrying capacity, leaks, corrosionand pitting, tuberculation, deposition of sediment and slime growth. Preventive maintenance of distribution system assures the twin objectives of preserving the bacteriological quality of water in the distribution system and providing conditions for adequate flow through the pipelines. Incidentally, this will prolong the effective life of the pipeline and restore its carrying capacity.

2.1.9.3 Flushing of Pipelines

Flushing is done to clean the distribution lines by removing impurities or sediment that may be present in the pipe. Routine flushing of terminal pipelines is often necessary to avoid taste and odour complaints from consumers. It is advisable that

a programme for flushing is prepared and followed so that water mains are flushed before consumers startcomplaining. The routine for flushing can be prepared by taking into consideration the consumer complaints and type of deposits found while cleaning. Since in distribution system, flushing is not the only solution for water quality problems; proper operation of treatment process and cleaning of SRs supplying water to the distribution system shall also be planned along with the flushing of distribution system. Flushing is usually done during low water demand, when the weather is favourable. This is very essential in flat terrain with low pressure otherwise the silt particle settles in the pipe and create frequent contamination of water. Prior planning and good publicity with public will allow the flushing to proceed quickly and without confusion.

2.1.9.4 Cleaning of Pipelines

Mechanical cleaning devices such as swabs and pigs are sometimes used if flushing doesnot improve the water quality. Scrapers or brushes are used in pipelines with hardened scales or extensive tuberculation. Sometimes scrapers and brushes are used before taking up lining works.

2.1.9.5 Cement Mortar Lining

The present trend is to use cement mortar lined ductile iron (DI) pipes or mild steel (MS) pipes so that they will not lose their carrying capacity with use and age. Still many new pipelines are proposed with unlined metallic pipes and there are several existing pipelines with bare metal surface such as CI or MS. With passage of time, these pipelines deteriorate and require rehabilitation. Cement mortar stifles corrosion through its ability to develop high alkalinity. The application of cement mortar lining to pipe in place is done bya lining machine, containing a device that projects cement mortar against the pipe wall. Directly behind this device are mechanically driven rotating trowels, which give the surface smooth finish. In situ cement mortar lining of existing metallic water mains has been beneficial where:

- pipe carrying capacity may reduce due to tuberculation;
- water quality is affected due to release of corrosion products from the pipes to thewater; and
- leaks occur through joints and pipe walls.

2.1.10 Leakage Control

Wastage of water in the system and distribution network occurs by way of leakage from pipes, joints, fittings, reservoirs, and overflow from reservoirs and sumps. The objective of leakage control programme is to reduce the wastage to a minimum and minimise the time that elapses between the occurrence of a leak and its repair. The volume of water lost through each leak should be reduced by taking whatever action is technically and economically feasible to ensurethat the leak is repaired as quickly as possible. To achieve this, the organisation shall prescribe procedures for identifying, reporting, repairing, and accounting for all visible leaks. It will be beneficial for the agency if the procedures involve the conscious and active participation of the population served by the agency apart from its own staff. The management has to process the data and evaluate the work on

detection and location of leaks and for dissemination of the results and initiate actions to control the overall problem of water loss. Interim measures for reduction/control of leakage can be initiated by controlling pressures in the WDS where feasible.

A pipe replacement programme in a distribution system is a proactive approach to ensure the efficiency and longevity of the water supply infrastructure. This programme involves identifying old and deteriorating pipes in the distribution network and replacing them with new ones. The primary objective of this programme is to improve the water quality, reduce leaks, and ensure uninterrupted water supply to customers. In addition, the replacement of old pipes can also reduce maintenance costs and mitigate the risk of water contamination. The programme typically involves a comprehensive assessment of the distribution network, including pipe material, age,and condition, to identify the areas that require urgent attention. It is an essential aspect of water management and a significant investment in the long-term sustainability of the distribution system.

7.6.10.1 Step Test

Step testing is an effective, flow-based method of localising water loss within a zoned distribution system. It is particularly suited to identifying areas of high leakage and to use on plastic pipe materials, where leak noise is absorbed, and conventional acoustic methods are less effective.To perform a step test the inflow into a zone must be monitored. This can be achieved by deployinga data logger upon the inlet water meter to automatically transmit flow data to the operative in the network. Alternatively, an additional operator can be left upon the inlet meter to manually record flow and network activity. Once a method of monitoring has been established, then valves are closed to cut off sections of the zone known as “Steps”. This demonstrates how much wateris consumed in each step. Each step has an estimated customer consumption which is comparedto the drop in flow at the inlet meter. If the difference between the actual drop in demand and estimated consumption is significant, this provides an indication to the operative that leakage iscontained within that step. Step tests should be carried out when demand is at its lowest. This tends to be at night time between the hours of 01:00–04:00. This helps contributes to a more accurate step test as fluctuations in demand are minimised. Before a step test is implemented all valves required must be located on site. Once located then the integrity of the valve must be tested. This will include ensuring the valve is accessible and operable. A zero pressure test (ZPT) can conclude if the valve can be closed completely without passing any water, this helps contributes to further reassurance of an accurate step test. There are three types of valves whenoperating a step test:

(1) Valves that are permanently shut to create a zone. These can sometimes be called boundary valves or zone valves.

(2) Valves that need to be shut before the start of the test in order to create “Steps” that can be closed off during the test with a single valve, as sometimes it is not possible toshut off a section by using only one valve closure. These valves are only shut for the duration of the test and re-opened once the test is completed. They are sometimes known as circulating valves.

(3) The final type of valve is one that isolates a step from the zone. They are numbered accordingto the order that they need to be shut in during the test. Step 1 is typically the “Step” that is the farthest away from the meter and the last step closure is the one nearest the meter.

To evaluate the level of leakage in the DMA, it is required to calculate the system’s Net Night Flow (NNF). The value of NNF is then obtained by subtracting the Legitimate Night Flow (LNF)from the Minimum Night Flow (MNF). The MNF is the lowest flow into the DMA over a 24-hour period, which generally occurs at night when consumption is minimum (Ranhill NRW Manager'sHandbook, 2008).

Precautions to be Taken before Test

Before conducting a STEP test, ensure that the DMA is perfectly hydraulically discrete. This canbe ensured by conducting the “*zero pressure test*” keeping all valves including the inlet are closed and checking if the pressure in the DMA drops to zero. It confirms the water entering from the other area if the pressure does not drop to zero (Yukun Hou, 2018). It is used to check whether a particular DMA is watertight. The procedure is as follows:

1) Indicate the boundary valves with different colour.
2) Inform the consumers about the test and arrange the test at night, say between 1 am to4 am.
3) Plans of DMA boundary, boundary valves, and the DMA inlet valve should be kept ready.
4) Set up a pressure gauges at key locations within DMA.
5) Close the DMA entry valve to isolate the DMA.
6) The pressure at the pressure gauge will drop. If the drop of pressure is immediate, the DMA is isolated perfectly.
7) If the pressure does not fall, then inspect the boundary valve and find the culprit valves.
8) Faulty valves should be replaced.
9) After the test is over, and water supply is restored, pressure gauge should indicatecorrect pressure.
10) If there is zero water pressure through the DMA, it means the boundaries of that area arewatertight.
11) The isolation valves to be used for making segments must be tested for its functioning, they should be leakage proof.

DMA is divided into small sections by closing valves. Each small section is shut off at night. Before any valves are closed, the MNF is recorded. It is called as “START” MNF value. Then, aseach valve is closed systematically, this is called a “STEP” and the new MNF is recorded. The difference between the start and the new flow is the “STEP” value which is approximate NRW value.

7.6.10.2 Isolation Valve System

The mechanical reliability of WDNs is a relevant technical and scientific issue. During

planned maintenance or unplanned interruptions, the affected area must be isolated by valves shutdown. This operation involves the alteration of the network structure, i.e., the domain of the hydraulic system, and for this reason the isolation valve system (IVS) plays a central role. Some studies started to consider the presence of the IVS in WDNs reliability analysis.

The IVS is a crucial element in WDNs because it activates segments, i.e., isolated portions of the network, when pipe failures occur, or maintenance is required. During the repair time, the failed pipes are hydraulically isolated from the rest of the network. Shutdown modifies the WDN connectivity structure, then the IVS is closely related to the mechanical reliability of WDNs. This means that for the reliability assessment of WDNs, the IVS analysis is mandatory. In many reliability studies, pipe failure is modelled by removing individual pipes from the network, i.e., by assuming the presence of two isolation valves at the ending nodes of each pipe (Walski et al., 2006). This assumption is not quite realistic because the isolation valves are usually smaller in number and, generally, they are designed to activate segments when one or more pipes need to be repaired. Then the real position of the valves has to be considered in the analysis. Many researchers already studied reliability analysis using graph theory, considering the classic modelling, where links represent pipes and nodes represent vertices. This representation cannot describe the real effect of a pipe failure, since the presence of the IVS entails that many pipes are isolated when failures or ordinary maintenance occur. To account this fact, Walski (1993) introduced a new representation of the network using the segment graph, i.e., a graph where the isolation valves represent the edges, and the vertices represent segments activated by the IVS.

There are several different variations on the approach depending on the technology available, whether it is important to maintain supply and the configuration of the network.

I. Leakage Through House Connections

Leakage can be controlled at the point of house connection and in the consumer pipe by adopting correct plumbing practices and improving the methods used for tapping the mainand giving house connection and strict quality control on the pipe material used for houseconnection. An analysis of leaks in house connections and an investigation into the reasonsfor leaks in the house connections shall be carried out to initiate action on reducing the leakage through house connections.

II. Procedures for Reporting Visible Leaks

The water utility has to establish procedures whereby the population served by the agencycan notify the visible leaks. The agency staff can also report visible leaks found by them while carrying out other routine works on the water supply system. Utility has to establish procedures for prompt repair of leaks and for attending efficiently and accurately to the leaks. Critical areas where leaks often occur have to be identified and appropriate corrective measures have to be implemented.

III. Procedures for Detecting Invisible Leaks

Establishment of procedures for detecting and locating non-visible leaks shall be compatible with the technological, operational, and financial capability of the

agency. Selection and procurement of equipment for detection and location of leaks must take into account the cost-effectiveness and the financial capability of the organisation.

This detection can also be carried out by testing residual chlorine simultaneously over a grid around the compliant spot. A team of trained staff were deployed with handheld chloroscopes. This gives an idea of the origin of pollution entry when a sudden drop in residual chlorine is detected. Thereafter, the grid is narrowed down and further narrowed and the location of pollution is identified. Thereafter, simultaneous testing in all the houseends is tested and this shows the actual ingress of pollution. All these are non-invasive. The observation of late-night flow can also be a useful method for detecting leakage in a WDN. This method is based on the fact that during the night when water demand is low, theflow rate in the distribution network should also be low. If there is a significant flow duringthis time, it could be an indication of a leak.

However, it is important to note that there could be other reasons for increased flow ratesduring the night, such as unauthorised use of water or operational reasons, so further investigation is required to confirm the presence of a leak. The observation of late-night flow can be a valuable tool for detecting leaks in a WDN, but it should be used in conjunction with other methods to confirm the presence of a leak and to identify its location.

IV. Active Leakage Control

Following steps are implemented for active leakage control:

(i) Locate the failure.

(ii) Close all related isolation valves.

(iii) Ensure safety for working using appropriate signs, barriers and trafficdiversions.

(iv) Excavation of failed pipe sections with ensuring workers safety and avoidingfurther damage to the pipe.

(v) Drain out the water, solids, and sludge by use of an extractor pump.

(vi) Repair the failed pipe section using an appropriate method.

(vii) Ensure that the exposed and new sections are carefully cleaned anddisinfected.

(viii) Open slowly one or more of the closed isolation valves as well as hydrant or valveto allow air to escape.

(ix) Ensure that all isolation and scour valves opened or closed are reinstated to theircorrect state.

(x) Flush the section using a hydrant in order to ensure the contaminants and solidsare removed.

(xi) Inspect the repair of leaks once the section is under pressure.

(xii) Reinstate the pipe bedding, blanket, and backfills using appropriate placing andcompaction methods and materials.

(xiii) Complete the pipe repair reports including an analysis of likely cause of the

failureand keep the report for future actions.

For detection and control of leakage, refer subparts of Section 4.4.4 of Chapter 4: “Transmissionof Water” and Section 11.8 of Chapter 11: “Water Audit, Monitoring and Control of NRW” in PartB of this manual shall be referred.

2.2 Monitoring System Performance

Normally, the managers of O&M of water utilities monitor levels in SRs, pressures, and flows inthe distribution system and operation of pumps such as hours of pumping, failure of pumps and monitor water quality by measuring residual chlorine. The manager usually uses telephone lineor wireless unit to gather the data, maintain records analyses, uses his discretion gained with experience and takes decisions to ensure that the system is operating with required efficiency. Manual collection of data and analysis may not be helpful in large undertakings if water utilities

have to aim at enhanced customer service by improving water quality and service level with reduced costs. In such cases, monitoring system performance can be done with the use of Telemetry and SCADA and Digital Twins.

I. Quality of Pipe Material for House Connection

The water utility shall ensure that the connection and communication pipe from the streetmain up to the consumer premises is laid as per correct plumbing practices and adopt improved methods for tapping the main. Strict quality control is required on the pipe material used for house connection. The bye-laws shall lay down rules for defining the ownership and responsibility for maintaining the point of connection and the communication pipe. In several utilities, the communication pipes are leaking since they are corroded; however, these are not replaced by the consumer or by the utility particularly where the O&M responsibility for consumer pipe rests with the consumers.

II. Contamination Through House Connection

While laying the consumer connection pipes, there is a need to avoid contamination of water supplies. This can be achieved by maintaining horizontal and vertical separation betweenthe water supply communication pipe and the sewer/drain. In some instances, a sleeve pipe may be required to be provided to the consumer pipes crossing a drain. It is always recommended to provide a non-corrodible pipe material for the consumer connection. Contamination by possible backflow can also be prevented by ensuring provision of double check/non-return valves at the consumer end.

III. Rules for Consumer Connections

The water utility shall formulate rules for sanction of consumer connection. Tapping the branch line and laying the connection piping. At no circumstances, a consumer connectionis permitted from the mains. On unavoidable circumstances, a separate parallel pipeline/rider pipeline has to be drawn from the nearby existing distribution system. Waterutility shall undertake inspection of the consumer premises before

releasing the connection to ensure that the internal plumbing system of the consumer conforms to the National Building Code. Water utility shall supervise the process of drilling/tapping of the main for giving connection and laying of the consumer piping. The process of submission of applications for connections by consumers and carrying out the connection work throughlicensed plumbers is also prevalent in some utilities. In such cases, the utility shall formulate procedures for licensing the plumbers including the qualifications to be possessed by the plumber, facilities, and tools to be available with the plumber for the work to be undertaken by the plumber. The utility shall closely observe the quality of materials used and works done by him and he should act as per procedures laid down in the bye- laws for approval of the connection works, renewal, or cancellation of the plumbers' licenses or any other requirement depending on their performance or non- performance. For all the service connections, ferrule should be provided/fixed with saddles and compression fittings to avoid leakages from the connection joint.

2.3 Records and Reports

I. Record System

A record system has to be developed which should be realistic and apply to the operatingproblems involved in the distribution system. Management must be clear as to why the data/information is collected, as to who will review the data, and who will respond to the results of review. The most efficient way to keep records is to plan what data is essential and then prepare the formats followed by the persons concerned for filling of the data, frequency, and to whom the record is to be sent for review and report. The agency shouldmake a repository of real time data at the discretion of the authority in managing and taking an appropriate decision of the system. Sample records to be maintained are given belowfor guidance:

- Updated system map.
- Pressure and flow readings at selected monitoring points.
- Persistent low pressure or negative pressure areas.
- Age of pipes/quality of pipes.
- Pipelines to be replaced.
- Presence of corrosive water in the system.
- Water budget for each zone served by one SR.
- Number of connections given.
- Number of meters out of order.
- Status of fire hydrants and public taps.
- Quantity measured at outlet of reservoir.
- Quantity distributed/measured or billed.
- Source of leaks and persistent leak points.
- Status of bulk meters – function or not.
- Status of consumer meters.
- Facilities for repairs of consumer meters.
- Number of unauthorized connections.

- Residual chlorine levels at the pre-selected monitoring points.
- Bacteriological quality of the water sampling points.
- Persistent areas where residual chlorine is absent/where bacteriological samplesare unwholesome.
- Record on carrying out repairs on the following works and its cost:
  - The pipeline leaks or replacement of pipes.
  - Change of gland ropes of the valves in distribution system.
  - Replacement of parts.
  - Replacement of manhole covers.
- Record on man-hours spent on routine operations in the distribution system in the previous year and the cost thereof.
- Record on total cost of repairs and replacements in previous year along with break- up of material cost and labour cost with amount spent on outside agencies for repairsand replacements.
- Record on when the exposed piping was last painted and the cost of materials and labour cost thereof.
- Record on the unserved areas – extension of pipelines – need for interconnections.

II. Reports

With the accumulation of all essential data a report can be prepared evaluating the O&M of the facility. The report can identify the deficiencies in the system and its appurtenances,and then plan future repairs to the network or valves and other equipment or for replacement of defective valves or other equipment or additions and extensions to the distribution network.

III. Computerized Maintenance Management System (CMMS)

Computerized Maintenance Management System (CMMS), also known as Computerized Maintenance Management Information System (CMMIS), is a software package that maintains a computer database of information about an organization's maintenance operations.

This information helps in maintenance of the system by determining which component (pipes, machinery, instruments, chemicals, manpower, etc.) requires maintenance and where the spare parts are. The CMMS also keeps track of all the maintenance work involved by generating work orders, procurement orders, vendor orders, stores inventory, as well as the cost involved in all the activities thus help to accurately calculate the budgetneeded for O&M.

CMMS also allows to keep record and geotagging of the components in the system whichcan be linked to GIS and network model, which in turn helps to analyse and keep track ofvarious maintenance works.

2.3.1 Checks to be Carried Out

A programme has to be prepared for each zone of the distribution system which shall contain procedures for routine tasks, checks and inspections at intervals, viz., daily,

weekly, quarterly, semi-annually, or annually. This plan shall fix responsibility, timing for action, ways and means of completing the action as to when and who should take the action and mention the need to take these actions. Simple checklists for use by the managerial staff can be prepared to ensurethat the O&M staff has completed the tasks assigned to them as shown in the below Table.

Table 7.2: Sample Checklist

Sl. No.	Checks required/undertaken	Status	Suggested frequency of reporting
1.	Check whether the operation of valves is smooth without any abrupt stoppage during closure or opening.	OK/Not OK	Daily
2.	Check whether closure of a valve results in complete stoppage of flow or if any flow passes the valve	OK/Not Ok	Daily
3.	Check for status of scouring and then proper closure of washout valves.	OK/Not OK	Daily
4.	Check for leaks through pipes.	Yes occurring/Not Occurring	At every pressure/flow drop
5.	Check for leakage through valves at gland, bolts, or any other place.	OK/Not OK	Daily or at every pressure/flow drop
6.	Check for leaks at the appurtenances.	OK/Not OK	Daily or at every pressure/flow drop
7.	Check for any signs of corrosion of pipelines.	OK/Not OK	Yearly
8.	Check for the status of manhole covers over the chambers; are they corroded.	OK/Not OK	Yearly
9.	Inspect for any possibilities of pollution of the distribution system water stored.	OK/Not OK	Monthly
10.	Status of out-fall drain for scour and overflow.	OK/Not OK	Daily or at every such instance
11.	Assess the need for painting of the piping work.	Required/not required	Every 3 years
12.	Check for availability of spares for valves, pipes, and jointing materials.	Available/not available	Check monthly bill of quantity
13.	Preparation of water budget for each OZ/DMAs.	Y/N	Annual (yearly)
14.	Number of connections given.	No./Nil	Monthly
15.	Number of meters out of order.	No./Nil	Monthly
16.	Status of hydrants and PSPs.	Working/ Not working	Yearly

Sl. No.	Checks required/undertaken	Status	Suggested frequency of reporting
17.	Status of OZ and DMAs.	OK/Not OK	Yearly or on every addition/removal of connection
18.	Review of hydraulic conditions.	OK/Not OK	At pressure/flow drop
19.	Water quality.	OK/Not OK	Daily
20.	Identify source of leakage.	OK/Not OK	At pressure/flow drop
21.	Metering.	OK/Not OK	Monthly
22.	Status of bulk metering and consumer	OK/Not OK	Monthly
23.	Review facilities for repair of consumer meters.	OK/Not OK	Monthly or on abrupt billing/reading
24.	Unauthorized connections if any.	Yes/no	Monthly
25.	Status of fire hydrants and PSPs.	OK/Not OK	Yearly
26.	Availability of updated system map.	Yes/no	On every addition/alterations
27.	Need for any interconnections.	Yes/no	For balancing when abnormal pressure/flow fluctuations noticed

Annexure D:

A. Electromagnetic full bore type flow meter.

If not provided with the flow meter, the flow indicator and integrator shall be provided.

Sl. No.	Details	Parameter
1	Principal of working	Faradays law of electromagnetic induction
2	Type	Full Bore Type with integral flow transmitter
3	Size	100 mm dia. and above
4	Signal out put	4-20 mA DC
5	Time contact	1 second to 20 second adjustable
6	Pulse out put	10 – 18000 pulses per hour a) Output to drive external electromagnetic counter of 12 V / 24 V DC directly
7	Maximum load Resistance	1000 Ohm
8	Local display	3.5 Dijet LCB
9	Ingress Protection	IP 65
10	Flow velocity	0.25 m/sec to 10 m/sec
11	Accuracy	+/- 2.0 % of actual flow at reference condition
12	Repeatability	+ or – 0.15% of span
13	Power supply	Normal 240 Volt AC + or – 15 % 50 Hz
14	Media pressure	As per requirement
15	Power consumption	Maximum 20 W
16	Materials	
a)	Liner	Neoprene /Polyurethane
b)	Pipe	SS316
c)	Flanges	SS316
d)	Coil housing	SS
e)	Transmitter	Cast Aluminum epoxy painted

1.8 Flow Indicator and Integrator

Type	:	Microprocessor based
Display	:	Digital, seven segment back lit LCD/LED display
Digit Height	:	14 mm or Higher
No. of Digits for		
Flow indicator	:	5 Digits
Flow integrator	:	6 Digits
Input through analogue signal multiplier	:	4-20 mA DC (Isolated) from flow transmitter
Zero and span Adjustment	:	Required
Manual Reset Facility for flow integrator	:	Required (shall be key operated)
Engineering units for		
Flow rate indicator	:	Cum/Hr
Flow integrator	:	ml
Battery backup for Integrator	:	Required

Notes:

1. Necessary power supply arrangement for EMF should be made

2. Digital flow indicator and flow integrator shall be a combined unit
3. Data logger has to be provided at each location for data storage.
4. Provision should be made for data transfer to the control room server through electronic mode.

B. Pressure Sensor & Transmitter

Sensor	:	Diaphragm Sensor 2 wire type
Wetted parts material	:	SS 316
Range	:	Adjustable over full span
Zero & Span Adjustment	:	Required
Output signal	:	4-20mA, DC
Enclosure Protection	:	IP 65 of IS 13947 (Part I)

C. Display Unit:

Remote display Unit Digital panel meter with 3½ digit backlit LCD/LED, ±0.25% accuracy, high and low alarm set point, input 4- 20 mA D.C.

Quality Standards Physical & Chemical Standards of Potable water shall be as under:

Sl. No.	Characteristics	Acceptable	Rejection
	i) Physical		
1.	Turbidity (units on JTU scale)	2.5	10
2.	Colour (unit on platinum cobalt scale)	5	25
3.	Taste	Nothing	Disagreeable
4	Odour	Nothing	Disagreeable
	ii) Chemical		
5	Ph	7.0 to 8.5	Less than 6.5 or greater than 9.2
6	Total dissolved solids in mg/lit	500	1500
7	Total hardness (as CaCo3) in mg/lit	200	600
8	Calcium (as Ca) in mg/lit	75	200
9	Magnesium (as Mg) in /lit	30	150
10.	Iron (as Fe) in mg/lit	0.1	1.0
11.	Manganese (as Mn) in mg/lit	0.05	0.5
12.	Copper (as Cu) in mg/lit	0.05	1.5
13.	Zinc (as Zn) in mg/lit	5.0	15.0
14.	Chlorides (as Cl) in mg/lit	200	1000
15.	Sulphates (as So4) in mg/lit	200	400
16.	Phenolic Substances (as phenol) inmg/lit	0.001	0.002
17.	Fluorides (as F) in mg/lit	1.0	1.5
18	Nitrates (as No3) in mg/lit	20	45
	iii) Toxic Substances		
19.	Arsenic (as As) in mg/lit	-	0.05
20.	Chromium (as Hyxavalent) inmg/lit	-	0.05
21.	Cyanides (as CN) in mg/lit	-	0.05
22.	Lead (as Pb) in mg/lit	-	0.1
23.	Selenium (as Se) in mg/lit	-	0.05
	iii) Bacteriogical Examination		
24	Total coliform,MPN/100ml		
25	E Coli,MPN/100ml		

a) Standards for Bacteriological Quality shall be:
   - Water entering the distribution system: Coliform count in any sample of 100 ml should be zero.

b) Water in the distribution system shall satisfy all the three criteria indicated below.
   - E Coli count in 100 ML of any sample should be zero.
   - Coliform organisms not more than 10 per 100 ML shall be present in any sample. Coliform organisms should not be detectable in 100 ML of any two consecutive samples or more than 50% of the samples collected for the year.
   - Individual or small community supplies. E coli count should be zero in any sample of 100 ML and coliform organisms should not be more than 3 per 100 ML

c) Standards for Biological Quality shall be

- 0.50mg/lit free chlorine residue for one hour is sufficient to inactivate virus.
- The disinfection of potable water is almost universally accomplished by the use of chlorine compounds, because of the limitations of other procedures, for example ozone, ultraviolet light, chlorine dioxide etc. Chlorine is easy to apply, measure and control. It persists reasonably well and it is relatively in expensive.

d) Maintenance of Chlorination Equipment
   - Prepare daily schedule for
   - Check chlorine leakage by ammonia torch.
   - Check of exhaust fans working.
   - Check rotary meter functioning.
   - Carry out physical verification of stock and position of tonners.
   - Check position of safety equipment.
   - Check vacuum of chlorinator.
   - Quantify the work.
   - Use of work permits system. A written work permit system is essentially a document which identifies the plant to be worked on and details precautions to be taken before a work can start. It predetermines the safe procedure and is a clear record of the hazards that have been anticipated defining the appropriate precautions to be taken to avoid them. It is also a statutory requirement.

e) Keep equipment record i.e. history cards.
f) Forecast yearly & monthly maintenance program.
g) Prepare check lists for different types of preventive maintenance.
h) Set up a man power control.
i) Set up a preventive maintenance program.
j) Use budgetary control yearly & monthly budget.
k) Provide material control.
l) Always use recommended spares.
m) Plan plant shut downs.
n) Establish major overhaul procedures.
o) Develop standard practices.
p) Improve efficiency of the equipment's.
q) Train the supervisors.
r) Train the maintenance staff.
s) Analyses performance and cost.

CHAPTER 24 ABBREVIATIONS AND ACRONYMS

C.I.	Cast Iron
C.M.	Cement Mortar
Cm	Centi metre
CMWSSB	Chennai Metropolitan Water Supply & Sewerage Board
Cum	Cubic metre
Dia.	Diameter
D.I.	Ductile Iron
Km	Kilometre
M.H.	Machine hole
M.S.	Mild steel
m	Metre
mm	Milli metre
R.C.C.	Reinforced Cement Concrete
sq.cm	Square centimeter
W.C. (ratio)	Water Cement (ratio)