Asian Development Bank (ADB) Assisted
Delhi Water Supply Improvement Investment Program

BIDDING DOCUMENT

For

Procurement

of

DWSIIP/ 01: Distribution Network Improvement in UGR Command Areas C-02 and C-03 Targeting Continuous Pressurized Water Supply and DMA Based NRW Reduction and Providing House Service Connections

Under International Competitive Bidding

(Following ADB's single stage two envelope bidding procedure)

Technical Bid -Volume 3

PARTICULAR SPECIFICATIONS

Executing Agency:

Delhi Jal Board,
Varunalaya
Jhandewalan
Karol Bagh
New Delhi-110005
INDIA

Consultant/PMC:

NJS Consultants Co., Ltd.
In Joint Venture with
ICRA Management Consulting Services Limited
TATA Consulting Engineers Ltd. &
NJS Engineers India Pvt. Ltd.

6.2.2.1
Particular Specifications
(Civil Works)

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Technical Standards and Regulations

All works, materials, workmanship, testing, designs, safety, etc. shall satisfy the specifications and provisions of BIS Standards and in general comply with specifications and provisions of CPWD, IRC, MOST/MORTH, etc. Reference may be made to Handbooks (CPWD's Repair and Rehabilitation, Guidelines and Standards for Disabled and Aged, Handbook of Landscape, DSR, PAR, etc.) and Aids published by BIS or similar reputed organizations, subject to Employers approval. There should be compliance to the mandatory requirements related to environmental controls and clearances.

In the absence of any specifications or IS code, equivalent International Standard Specifications or Manuals may be referred to by the contractor, as approved by the Employer.

All standards and specifications, whether national or international, applied and used shall be with latest amendments / correction slips (up to the date of submission of bid or later).

In event of conflict, generally the more conservative specifications shall be adhered to, as directed/ approved by the Employer.

In referring to the Standards, Specifications, Manuals, etc. the some of the following abbreviations are used:

1)	IS	:	Indian Standard
2)	BIS	:	Bureau of Indian Standards
3)	ANSI	:	American National Standards Institute
4)	API	:	American Petroleum Institute
5)	ASME	:	American Society of Mechanical Employers
6)	ASTM	:	American Society of Testing and Materials
7)	AWS	:	American Welding Society
8)	AWWA	:	American Water Works Association
9)	ISO	:	International Organisation for Standardisation
10)	JIS	:	Japanese Industrial Standard
11)	DIN	:	Deutsches Institute fur Normung
12)	BS	:	British Standard / European Standards
13)	JWWA	:	Japanese Water Works Association
14)	IEC	:	International Electrotechnical Commission
15)	IEE	:	Institution of Electrical Employers
16)	IEEE	:	Institute of Electrical and Electronic Employers
17)	NEMA	:	National Electrical Manufacturers Association
18)	AGMA	:	American Gear Manufacturer's Association
19)	IP Ratings/IP code	:	Ingress Protection Ratings
20)	MORTH/MOST	:	Ministry of Road, Transport and Highways
21)	EN	:	European Standards
22)	ACI	:	American Concrete Institute
23)	NZS	:	Standards New Zealand
24)	AS	:	Standards Australia

All materials used in the works shall be new, unless otherwise approved by Employer. All plant and equipment shall be new / rehabilitated / modified to suit the requirement and materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area, as approved by the Employer.

All details, materials and equipment supplied and workmanship performed shall comply with these specifications. If Contractor offers inputs to works to other standards, the same should be equal or

superior to those specified and full details of the difference shall be supplied, and shall be subject to approval by the Employer.

Any makes listed in the specifications are for general guidance as to the quality of the products expected. In case of every product/ material/ application the data sheet cum specification shall be submitted for the prior approval of the Employer before incorporation in the works.

1.1 Structural requirements

1.1.1 Design Submissions

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures (new and rehab), masonry structures and structural steel works. However, structures shall be designed for the satisfactory performance of the functions for which the same are being constructed.

Design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted. The contractor shall be responsible for the safety of structures, structural strength, stability, soundness, water tightness, accuracy, adequacy of design, workability and performance even after the approval of the same by Employer. The general design criteria (design basis report) and typical details drawings shall be submitted for approval.

Only approved materials and designs shall be incorporated in the works. Any approval conveyed to the contractor will neither relieve the contractor of its contractual obligations or its responsibility for the correctness of the performance, designs, dimensions, material of the construction, weights, quantities, design parameters, assembly, its performance, particulars, conformity of the supplies with Indian statuary laws as may applicable nor will it limit the DJBs rights under the contract.

The Contractor may refer to the available soil investigations, topographical survey and NDT reports. The contractor has to undertake confirmatory soil investigations and other surveys, including for underground services to ensure that no damage is done to existing infrastructure. The required re-routing and re-location of the services, as required will be done by the Contractor after approval of the proposals for the same by the Employer with no extra cost. The Contractor is liable for any damage and disruptions caused to the works and he should repair & make good all such damage and disruptions at his cost to at least the specifications to which the original works were constructed or as directed by the Employer.

1.1.2 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the loads/stresses as specified including during testing and under working conditions and shall at least be as per IS: 875 and other relevant codes. The loads considered shall include dead load, live load, wind load, seismic load, or any other loads expected over structures including stresses due to temperature changes, shrinkage and creep in materials, dynamic loads, differential settlement and uplift pressure, etc.

i) Dead Load

This shall comprise all loads as specified in codes and weight of all permanent construction including foundations, walls, floors, columns, roofs, partitions, stairways, fixed service equipment and other items of machinery. In estimating the loads of equipment all fixtures and attached piping (with likely retained liquid) shall be included. The following minimum loads/ unit weights shall be considered in design of structures:

(a)	Weight of water	:	10.00 kN/m^3
(b)	Weight of saturated soil (irrespective of strata available at site and type of soil used for filling etc.). However, for checking stability, actual minimum weight of soil as determined by field test shall be considered.	:	22.00 kN/m^3
(c)	Weight of plain concrete	:	24.00 kN/m^3
(d)	Weight of reinforced concrete	:	25.00 kN/m^3
(e)	Weight of brickwork (exclusive of plaster)	:	22.00 N/m^2 per mm thickness of brickwork
(f)	Weight of plaster to masonry surface	:	18.00 N/m^2 per mm thickness
(g)	Weight of granolithic terrazzo finish or rendering screed, etc.	:	24.00 N/m^2 per mm thickness
(h)	Weight of sand filter media	:	26.0 kN/m^3

ii) Live Load

The following minimum loads shall be considered in the design of structures:

(a)	Live Load on Roofs.	:	1.50 kN/m^2
(b)	Live Load on Dome.	:	2.50 kN/m^2
(c)	Live Load on floors supporting equipment such as pumps, blowers, compressors, valves etc. (weight of equipment to be considered separately)	:	10.00 kN/m^2
(d)	Live load on all other floors walkways, stairways and platforms.	:	5.00 kN/m^2
(e)	Toilet	:	2.00 kN/m^2

In the absence of any suitable provisions for live loads in I.S. Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Employer prior to starting of the design work. Apart from the specified live loads, any other load due to material stored, any other equipment load, possible overloading during maintenance/ erection/ construction shall be considered and shall be considered over partial or full areas whichever causes the most critical condition. Any such loading condition must be incorporated in design calculations with supporting documentation for approval.

iii) Wind Load

Wind loads shall be conforming to I.S. 875.

iv) Earthquake Load

Earthquake loads and designs shall be conforming to I.S. 1893 considering seismic Zone IV for Delhi Importance factor shall be taken as minimum 1.5. Designs shall comply with the requirements of other relevant codes such as IS 13920 and 4326. Dynamic loading of tanks shall comply with recommendations of IITK for GSDMA or as in Part 2 of IS 1893.

v) Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, and other machinery, etc. shall be considered in the design of structures as per codal provisions and recommendations of the vendors, etc.

vi) Vehicular Load

IRC Class AA/ Class A (wheeled vehicle) loading shall be considered for design of structures under or by the side of roads.

vii) Temperature Load

All structures will be designed for a temperature variation of minimum plus minus 5 deg. Celsius along with other loads. Parts of structures prone to thermal exposure/ cracking, etc. shall be designed for a temperature variation of minimum plus minus 10 deg. Celsius. Structures similar to Digesters, etc. should be designed for a differential temperature of minimum plus minus 15 deg. Celsius.

viii) Joints

Movement joints such as expansion joints, complete/ partial contraction joints and sliding joints shall be designed to suit the structure requirements. Position and design of construction joints should be predetermined keeping in view the convenience in construction. All joints should be tested for water tightness and must be leak proof. The material used in the joints like bonding agents, joint filers, water bars, sealing compounds and other such materials should be resistant to chemical and biological action and require approval of Employer.

1.1.3 Design Conditions for Completely / Partly Underground Liquid Retaining Structures

All underground or partly underground liquid retaining structures shall be designed for the following conditions. These conditions may apply to other structures as applicable. The relevant considerations for design life (minimum 50 years for new and 30 years for rehabilitated structures), durability, exposure condition, fire resistance, etc. should be fully taken into account.

i. Liquid retaining structures shall be designed as per the relevant codes and best practices. The limiting crack width will be 0.1mm for all liquid retaining structures. All likely loads and their combinations shall be considered to determine the direct and flexural stresses and their combination, shear, etc. As a design consideration to control crack and have sufficient strength and stability general requirements of IS 3370 and other codes (IS 456, etc.) shall be followed.

ii. Stability checks shall be made for the structures and the FOS shall not be less than those specified in the relevant codes. The worst combinations of loadings shall be considered while evaluating the same. Minimum FOS against overturning shall not be less than 1.2 without imposed loads for full water and no soil/ no water and full soil condition/ etc., against sliding it shall not be less than 1.4 and against uplift not less than 1.2. These stability checks shall be made for other structures and their foundations also.

iii. Structure filled with liquid: Liquid depth up to full height of wall, irrespective of the actual height of liquid in the structure: no relief due to openings, bypass and soil pressure from outside to be considered;

iv. Structure empty**:** full earth pressure and surcharge pressure, as applicable, to be considered. The coefficient of lateral earth pressure shall be considered for at rest condition but not less than 0.5. The unit weight of soil shall be maximum from soil report but not less than minimum specified above. Surcharge of minimum 10 kN/m2 will be considered wherever vehicular access is within 3m of the structure wall and wherever there is likelihood of fill.;

v. Partition wall between dry sump and wet sump**:** to be designed for full liquid depth up to full height of wall including free board – likelihood of leakage to be considered for dry sump.

vi. Partition wall between two compartments: to be designed as one compartment empty and other full;

vii. The design water table for uplift shall be considered at least 2m (seasonal variation) above that indicated by the Contractor's own investigation or that approved by Employer prior to design, whichever is maximum, but not less than HFL. No reduction Factor for the uplift forces shall be considered.

viii. The dead weight of the empty structure (ignoring any soil, etc. on any part of the structure or its foundation) should provide a safety factor of not less than 1.2 against uplift pressures during construction and in service;

ix. Walls shall be designed under operating conditions to resist earthquake forces from earth pressure mobilization and dynamic water loads;

x. Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below the base slab.

1.1.4 Design Conditions for Foundations

i. The Finished Ground Level shall be established for each structure depending on the slope management of the site as a whole to ensure proper drainage and no ponding taking place due to rain, etc. The slopes and top of road shall accordingly be kept higher as per codal provisions, the highest (crown) of the road to be generally 150 mm above the FGL.

ii. The minimum depth of foundations for all structures, equipment, buildings and frame foundations and load bearing walls shall be conforming to IS 1904. All structural foundations shall extend to a depth of at least 1.0 meter below virgin ground level or as per soil report.

iii. The foundations shall be placed on virgin soil and not on backfilled soil, though in exceptional cases the same may be undertaken after soil testing and approval of the Employer.

iv. The earth fill above virgin/natural ground level till formation level shall be taken as a surcharge load and shall be added in the loads coming on foundations appropriately.

v. Safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports and contractor's independent Soil Investigation Report, whichever is less. For the foundation depths and types of footings other than those mentioned in the geotechnical reports, the maximum safe bearing capacity shall be appropriately computed from the parameters given in the geotechnical reports and got reviewed and approved by the Employer. Condition of local inundation shall be considered in reducing/computing safe capacities.

vi. Care shall be taken to avoid the foundations of adjacent buildings or structures, either existing or likely to be constructed later. Suitable adjustments in depth, location, arrangement and sizes may have to be made depending on site conditions.

vii. Plinth/ FFL (finished floor level) level of all building structures shall be at least 500 mm above formation finished ground level (FGL). The top of walls of liquid tanks/sumps shall be minimum 500mm above FGL. Safety handrails shall be provided if the height of barrier is less than 1.0m. To account for relative settlement the foundations shall be modelled as elastic.

viii. If pile foundations are used, the contractor shall conduct the initial routine test as per IS 2911 at own cost, to determine the safe load bearing capacity of piles, and as directed by Employer. The capacities shall also be computed using the field investigated geotechnical parameters and lower of the two values to be used in design.

ix. Pressure release valves are not permitted (to provide any relief from the hydrostatic pressures causing uplift and other structural stresses).

x. Minimum reinforcement shall be provided on the top face of the footings also, even if the stress requirement is not present, this shall not be less than 0.06% of the gross section. The bottom/ stresses face reinforcement shall not be less than 0.12% of the gross section, as for

slabs, etc.

xi. Lap/ embedment length shall be full development length 'Ld' as computed for full stress, rather than actual stress; in general, this means that it shall be 50 times diameter of the bar. For direct tensile stress it shall be '2Ld' i.e. 100 times diameter of the bar. This shall also apply to buildings and other structures (hoop reinforcement, etc.).

1.1.5 Design Requirements

The Civil & Structural design shall be carried out in accordance with IS:456 and IS:3370 and other relevant Indian Standard Codes for the worst combination of all likely loads during construction and service.

The following are the design requirements for reinforced or plain concrete structures:

i. All blinding and levelling concrete shall be minimum 100 mm thick in concrete grade M10 for Building & other Structures and concrete grade M15 for water retaining structures, unless otherwise specified on the basis of soil characteristics.

ii. All structural reinforced concrete shall be with a maximum 20 mm stone aggregate size.

iii. The minimum grade of concrete shall be M25 for RCC structures other than liquid retaining structures (LRS), for which (LRS) minimum grade of concrete shall be M30 (including all other parts of the structure) or as given in requirements elsewhere. The reinforced concrete for all structures shall have a minimum cement content of 375 kg/m with a maximum 20 mm size aggregate and 350 kg/m with a maximum 40 mm size aggregate. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48. The minimum and maximum values will also be in accordance with provisions of the IS Codes as given in IS 3370, 456, etc.

iv. The minimum reinforcements in walls, floors and roofs of liquid retaining structures in each of two directions at right angles shall be at least 0.3% of (of the gross section) HYSD bars or more, as per relevant IS code. In this for computation of temperature steel (IS 3370) the value of T1 shall be 25 deg. celsius for all parts and T2 shall be 12 deg. celsius for all parts except for below ground base slabs for which T2 can be considered as be 6 deg. celsius. The coefficient of expansion shall not be considered less than 0.85E-05/deg celsius. Further specific requirements shall be as given elsewhere for different units.

v. Any pipelines crossing below roads shall be designed for IRC Class AA/ Class A (wheeled vehicle) loading or as classified by the respective authority. At least NP3 RCC pipe with encasing shall be used below roads inside/ outside the plant.

vi. All pipes and ducts laid below the structural plinth and road works shall be encased with concrete of grade M-20 of minimum thickness 200 mm or $1/4^{th}$ of outer diameter or as directed by Employer.

vii. Minimum sizes, reinforcement and cover to the reinforcement shall be provided as per relevant IS standards for appropriate exposure conditions and fire protection of at least 2 hours. Minimum reinforcement and cover to the reinforcement shall be provided as per relevant IS standards or as specified herein. Care to be taken regarding spalling, etc.

viii. Pressure release valves shall not be permitted.

1.1.6 Minimum Thicknesses and Covers of Reinforced Concrete Members

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

Walls for liquid retaining structures	:	225 mm
Bottom slabs for liquid retaining structures	:	225 mm
Wall foundation (at junction of base slab & wall)	:	300 mm
Roof slabs for liquid retaining structures	:	200 mm
Floor slabs including roof slabs, walkways, canopy slabs	:	125 mm
Walls of cables / pipe trenches	:	125 mm
Precast trench cover	:	75 mm

The minimum cover to the main reinforcing bars for different members for :

1. Non–liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	25 mm
Beams (Sides, Bottom & Top)	40 mm
Columns	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
i) Face in contact with earth	50 mm
ii) Interior face	40 mm
Foundations (Top, Bottom and sides)	50 mm
Lintels (all around)	40 mm

In no case they shall be less than those specified in the codal provisions.

2. Liquid retaining structures shall be as follows unless stated otherwise:

Walls - Face in contact with earth	55 mm
Walls - Face in contact with Water	55 mm
Base Slab in contact with Water	55 mm
Base Slab in contact with Soil	55 mm
Gutter Slabs	50 mm

In no case they shall be less than those specified in the codal provisions.

1.2 Particular Civil work Requirements

Unless otherwise specified, all the buildings and structure works shall generally comply with the following particular requirements and specifications. These requirements shall apply to other works as may be applicable.

1) All buildings and units shall be provided with 1000 mm wide plinth protection in M20 PCC of minimum thickness being 100mm and under layer of well compacted 150 mm brickbat or equivalent materials.
2) Plinth level of all new buildings and top of tank/ sump walls shall be minimum 500 mm above finished ground level around the buildings, with proper containment of the below flooring material.
3) For new construction the Parapet over roof shall be minimum 300 mm high in RCC or brick work for non-accessible roof and 1000 mm high in RCC for accessible roof. Care should be taken that no horizontal cracks appear at the base of the parapets over time for this wire mesh may be used below plastering, etc.
4) As per requirements, in buildings and pump houses, etc. RCC/ Stainless Steel staircases shall be provided to permit access to roof of the buildings, platforms and top of other structures.

5) All non-accessible roof tops of buildings and pump houses shall be provided with Stainless steel Cat ladder with safety cage, as per requirements.

6) All RCC staircases inside the buildings shall be in Granite (or as per architecture control with provisions for disabled) with prefinished nosing to treads of steps.

7) All elevated RCC platforms, walkways around and across the various units including along the channels and those connecting various units shall have flooring of chequered tiles of minimum 22 mm thick.

8) All uncovered staircases shall have flooring with chequered tiles of minimum 22 mm thick on risers and treads.

9) All elevated walkways, staircases, and RCC platforms shall be minimum 1200 mm wide (clear 1000 mm) and shall have SS 304 Hand railing, including around openings. The handrails shall be minimum 1.0 m high and shall be designed for twice the likely or as given in the codes loads. No section shall be less than 25mm in size and minimum 1.5 mm in thickness and the spacing of the posts shall not exceed 1.50m. Minimum two rails shall be provided along with a proper safety continuous SS toe guard plate of minimum 75x4mm section. The maximum number of steps between two landings shall normally be 12. The size of tread and rise shall be 250 mm and 175 mm respectively.

10) Steps/ ramps shall be provided at the entrance of the buildings for Pedestrian/ Vehicular, equipment entry. Minimum 1200 mm wide platform shall be provided in between entrance door and steps/ramps. Following dimensions of the steps/ramps shall be adhered to the following:
    a. Tread = 250 mm Minimum
    b. Riser = 175 mm Maximum
    c. Slope of Ramp = Generally, not steeper than 1:6, as per requirements. Ramp shall be finished with metallic hardener topping with anti-skid grooves at top surfaces.

11) All utility and control buildings including SCADA, etc. building shall be of RCC framed structure with brick panel walls. All brick walls shall be 230 mm thick, except for partition walls of toilets which may be 115 mm thick. All brick walls 230 mm thick shall be built in 1:4 cement mortar (1 cement: 4 coarse sand). Half brick (115 mm) thick walls shall be in 1:3 cement mortar (1 cement: 3 coarse sand) and shall be provided with 2 Nos. 8 mm dia. MS bars at every fourth course or as required by codes.

12) Transoms and mullions of minimum 115 mm x 230 mm size with four numbers 10 mm bars and 8 mm links at 150 mm c/c shall be provided to form panels not exceeding 3500 mm x 3500 mm in size in 230 thick brick masonry.

13) The area of windows and ventilators shall be 20% of the walls area of the building unless otherwise specified. Special attention to be paid to natural lighting.

14) The design of buildings shall be such so as to allow entry of natural light to the maximum possible extent and wall openings and all windows (and openable ventilators) shall be protected by weather canopies.

15) All doors, windows, rolling shutters shall have lintels with chajja in order to prevent the rain water splashing into the building. The minimum projection from the building wall of chajja from lintels for windows (and openable ventilators), doors and rolling shutters shall be 450 mm, 600 mm & 750 mm respectively and all grills should be Aluminium or as directed by the Employer.

16) Top exposed surfaces of chajjas / lintels / canopies shall be given required slope so that no water is allowed to stand on it. Waterproof screed maybe uses as in roof slabs.

17) All doors, windows, ventilators in all the new buildings including toilets shall generally be of Aluminium or as otherwise approved by Employer. All glass doors and windows at ground floor level shall be fitted with security grills. The contractor shall submit the shop drawings including details of material, framing members, anchors, accessories, elevations, colour, etc. to

the Employer for approval. The contractor shall fit and align the grill assembly including hardware; level and plumb, to provide smooth operation of windows. Alternatives as per architectural control may be made/approved by the Employer.

18) In line with Architectural Control and as directed by the Employer, the main entrance door of important buildings shall be made with decorative finish on both sides. Windows in such building, etc. may have insulating double glazed windows.

19) The new rolling shutters shall be of Galvanized material, as specified.

20) The fitting and fixtures shall be of heavy duty as approved by the Employer, durable and of type matching to the size and weight of the door/ window/ ventilator shutters. These shall operate easily without hindrance and jamming, secured properly and shall require nominal maintenance.

21) Emergency exit doorways shall be provided in all buildings in compliance with local and international safety regulations. All emergency exit points shall have extended paved path / areas for smooth escape of the people.

22) All buildings having reinforced concrete roofs, terraces and any such area/ locations as directed by the Employer these shall be made waterproof by laying APP (Atactic Polypropylene Polymer) modified prefabricated five layer 3 mm thick water proofing membrane system, with covering top of membrane with Geotextile, 120 gsm non woven, 100% polyester of thickness 1 to 1.25 mm bonded to the membrane along with top most layer shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 . The roof waterproofing shall in general also include the appropriate type of thermal insulation (such as puf slab, etc.). The finished roof surface shall have adequate slope to drain quickly the rain water to down take inlet points. The rain water inlet points near down take pipes shall have uPVC/ FRP/HDPE gratings. RCC roofs be finished with smooth slope so that there is no likelihood of seepage puddles. In instances of rehab work it is to be ensured that load of replacement or repaired waterproofing is not more than that of old treatment. Prior to waterproof treatment, top surface of concrete shall be prepared and sloped appropriately.

23) For roofing drainage, HDPE / uPVC rainwater down take pipes and as directed by Employer shall be provided. For roof areas up to 40 sq.m minimum two nos. 100 mm diameter down take pipes shall be provided. For every additional area of 40 sq.m or part thereof, at least one no. 100 mm diameter down take pipe shall be provided. Khurras's of size 45x45 cm shall be provided at roof over these locations.

24) False ceiling shall be provided in buildings such as SCADA as per specifications. Contractor shall submit drawings for approval of Employer prior to construction. Where required, false flooring shall be provided and height of structure adjusted for all functional requirements.

25) Plastering on brick / RCC work shall be as follows:

a.	Exterior surface	-	20 mm thick in CM 1:4 (1 cement: 4 coarse sand)
b.	Interior surface	-	12 mm thick in CM 1:4 (1 cement: 4 fine sand) for single brick thick wall
		-	12 mm thick in CM 1:3 (1 cement: 3 fine sand) for half brick thick wall
c.	Ceilings	-	6 mm thick in CM 1:3 (1 cement: 3 fine sand)

26) The contractor shall provide and erect PVC coated of 4mm GI wire chain link fencing of minimum height 1.8 m for fencing the transformers and other hazardous and restricted areas and will have stainless steel swing gates.

27) Wherever required expansion joint shall be provided using neoprene filler material / backer rods, PU sealant, sealing tape, adhesive, etc. or better equivalent all complete as approved by the Employer.

28) Exterior of all the buildings shall be painted with two or more coats of durable anti-fungal paint with anti-carbonation protective qualities which has assured performance warranty of at least 5 years.

29) The inner walls and soffit/underneath of platforms/ walkways (inside of all the liquid retaining structures) shall be provided with protective coating as specified herein.

30) Outer surface of all the RCC structures including underneath of platforms/ walkways shall be painted with two or more coats of water proofing cement paint, including projections and undersides. Appropriate cleaning and priming to be done as required. The paint used shall have assured performance warranty.

31) The ground floor of pump houses and other such structures shall generally be made of 150 mm thick concrete grade slab on 230 mm thick rubble soling/ 150mm thick PCC. The grade slab shall be provided with 8 mm reinforcement bars at 200 mm c/c both ways or as per the approved drawings.

32) Flooring of buildings shall be as follows:

a.	SCADA Building, etc.	:	Anti-Static flooring such as Vitrified glazed tiles of appropriate size.
b.	Pump Houses and other operation buildings, etc.	:	Cement concrete flooring with metallic hardener topping.
c.	Toilet	:	Matt finish ceramic tiles
d.	Corridors and other covered passages	:	Granite as per architectural controls and requirements.

33) Dado work in buildings shall be as follows:

Pump houses at pump installations and similar locations	:	Min. 2.1 m high or as per sump height from floor in Glazed (acid resistant) ceramic tiles of appropriate size.
Toilet	:	Will be up to full height of the wall
Pump house operational room at ground floor	:	Min. 0.9-meter-high from floor in Glazed ceramic tiles of appropriate size.

34) PVC encapsulated MS rungs shall be provided for access to the tanks, pits, sump, manholes etc. Stainless Steel ladders (cage) may be provided, as per requirement of safety, durability, etc.

35) Water bar shall be used as per requirement.

36) Minimum two white vitreous china laboratory sink of size 600 x 450 x 200 mm with two CP drinking water taps 20 mm long body, etc. complete shall be provided in laboratory, etc. as per requirements.

Toilets shall be provided as required functionally and as directed by the Employer. The minimum size of the toilet shall be 2m by 3m or as required. If required and so directed by Employer, separate ladies toilet shall be provided with appropriate facilities and utilities. The toilets shall be provided with all necessary fixtures (as indicated below). The waste from the toilets shall be disposed into the inlet chamber or similar unit as directed by Employer; if necessary, by pumping from a combined or separate sump.

a. The finished floor level of toilet shall be 25 mm below general finished floor level elsewhere in the building, with proper slopes for drainage.
b. At least one WC European or Indian type of approved size and shade as directed by Employer along with fittings, cistern, etc. all complete.
c. At least one white vitreous china wash basin of appropriate size with two C.P. brass pillar tap 15 mm and other fittings. One soap dispenser at each washbasin.
d. Two white vitreous china flat back half stall urinals of appropriate/ standard size.

e. One C.P. brass cock along with drain pipe at a separate location having connection with potable water supply line.
f. One mirror of superior glass of approved quality of rectangular shape of appropriate size , wall mounted type fitted over wash basin with proper framing and fixing.
g. Stopcocks, bib taps, valves and pillar cocks shall be heavy duty chromium plated brass in required numbers and as directed by Employer.
h. All fittings such as `P' or `S' traps, floor traps, vent pipes, down take pipes etc. shall be as directed by Employer.
i. One best quality polyethylene or better FDA grade/ approved MOC, storage tank of 1000 litre capacity shall be provided at the roof of the building / toilet along with internal water supply with PP-R or heavy GI piping, fittings and connections to the toilets and sinks.
j. Connection with water supply line and sewage disposal arrangement.
k. The sunk floor of the toilet shall be made sloping and be properly treated with water barrier layer/coat with appropriate admixtures prior to placing of pipes and filling with cinder, etc. Special attention shall be paid to the joints, bends, inlets and outlets. The flooring of the toilet shall be placed over an appropriate layer of PCC laid over the filling with proper slope and drainage.
l. In place of brass products of more durable and reliable material may be provided, only if and as approved by the Employer.

1.3 Civil Specifications

All materials including Cement and reinforcement/structural steel wherever to be used by the contractor shall confirm to the latest BIS/CPWD/MORTH/IRC specifications. All mandatory tests as required by BIS/CPWD/MORTH/IRC specifications shall be carried out and test certificates to be submitted to Employer. However, the contractor shall be fully responsible for required performances of civil/ structural work. Costs of such tests are to be borne by the contractor. In case of conflict, generally the more conservative specifications shall be adhered to or as directed by the Employer.

For testing of all materials, following shall be strictly adhered to -

a) All the tests shall be done in certified laboratories (preferably Government run or Shree Ram Testing Laboratories) approved by Employer. The contractor is required to take written approval from Employer, in this respect.
b) Cement and Steel shall be of a make approved by the Employer as detailed out in respective material sections of this document.

The contractor shall establish/ provide all infrastructure such as fully equipped site testing laboratory to enable testing of materials and products.

1.3.1 Earthwork

Unless otherwise specified all excavation shall be done by mechanical means and includes working in or under water and /or liquid mud and / or under foul positions.
No blasting is allowed for any type of excavation.

In case of excavations adjacent to existing structures, care should be taken to avoid damage/settlement to existing structure. Prior information, consultation and approval of Employer should be taken while carrying out excavation near existing structures / buildings.

Excavated material shall be dumped in regular heaps, bunds, riprap with regular slopes and levelling the same so as to provide natural drainage. Excavated material should be stored as directed so as to provide necessary access for functioning of existing structures conforming to client's requirements.

Rock/soil excavated shall be stacked separately as approved by the Employer. Topsoil shall be stock piled separately for later re-use.

Timber Shoring “closed” or “open” depending upon the nature of site and site conditions shall be carried out as directed by the Employer.

The contractor shall plan necessary drainage system at the site and ensure that the excavated areas shall not get filled / submerged in rain / surface water.
The earth and sand used for filling shall be free from all roots, grass, shrubs, vegetation, trees, sapling and rubbish.

No filling shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as per the approval of the Employer.

The back fill material has to be similar to the existing soil & as permitted by the Employer with similar Employering properties including permeability, bearing capacity, density, grading, etc. All filling to be done in the specified layers with proper compaction of each layer to achieve the required properties.

Anti-termite (and if directed; anti-weeds) treatment of soil beneath the floors & foundations and around the foundations shall be done with suitable insecticide/ chemicals as approved by the Employer.

1.3.2 Plain and Reinforced Cement Concrete Works

3.4.2.1 Materials

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.

Tolerances for all works shall be as per standards and specifications. Irrespective of the permitted deviations/tolerances, the fulfilment of all aesthetic and functional requirements of the works is the responsibility of the contractor.

The materials used in the works shall be of the best quality, as specified and from pre-approved sources. All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

All materials (cement, reinforcement, water, admixtures, etc.) incorporated in the works shall be as per the relevant BIS Standards and specifications. Manufacturer’s test certificates shall accompany all consignments and the same shall be submitted for approval prior to incorporation.

3.4.2.1.1 Cement

1) The Contractor shall procure ISI mark OPC (Ordinary Portland Cement) of suitable grade (Confirming to relevant IS codes) as required for the work only from the manufacturers as approved by Ministry of Industry, Government of India and holding license to use BIS certification mark for their product, whose name shall be got approved from the Employer before use. Supply of cement shall be taken either in silos or in 50 kg bags bearing manufacturer's name and BIS marking. Samples of cement arranged by the Contractor shall be taken by the Employer and got tested in accordance with provisions of relevant BIS codes. Cost of such tests shall be borne by the contractor. In case test results indicate that the cement arranged by contractor does not conform to be relevant BIS codes the same shall stand

rejected and shall be removed from the site by the Contractor at his own cost within one week time of written order from the Employer. Other cements that may be required to be used based on recommendations of the codes, such as sulphate resisting cements, the same shall also be in accordance with the above and relevant codes.

2) The cement shall be brought at site in bulk supply of approximately 50 tonnes from the manufacturer direct, or as decided and approved by the Employer, as the case may be.

3) The cement godown of the sufficient capacity should be constructed by the contractor and at all time it should have a stock of minimum of 3000 bags. The contractor shall facilitate the inspection of the cement godown by the Employer at any time. Storage of cement shall be as per CPWD specification.

4) Cement brought at site and cement remaining unused after completion of work shall not be removed from site without written permission of the Employer.

3.4.2.1.2 TMT Steel & Structural Steel

1) The contractor shall procure TMT steel reinforcement bars (Gr Fe 415D 500D, BIS code 1786) and structural steel conforming to relevant BIS codes from main producers such as SAIL, TISCO and RASHTRIYA ISPAT NIGAM LTD or as approved by Employer from the approved list of Ministry of Steel. The steel reinforcement, structural steel shall be brought to the site in bulk supply of 10 tonnes or more or as decided by the Employer. For small or occasional quantities of TMT steel reinforcement bars that less than 10 MT, the Employer may authorize the contractor to purchase the same from authorized dealers of the approved manufacturers. The contractor shall have to obtain and furnish test certificates to the Employer in respect of all supplies of steel brought by him to the site of work. Samples shall also be taken and got tested by the Employer as per the provisions in this regard in relevant CPWD/BIS codes. Cost of such tests shall be borne by the contractor. In case the test results indicate that the steel arranged by the contractor does not conform to CPWD/BIS codes, the same shall stand rejected and shall be removed from the site of work by the Contractor at his cost within a week's time after written orders from the Employer. In case of non- availability of steel reinforcement bars and structural steel with the above manufacturers, the Contractor shall procure the steel from reputed manufacturers as approved by the Employer.

2) The steel reinforcement, structural steel shall be stored by the contractor at site of work in such a way as to prevent distortion and corrosion. Bars of different sizes and lengths shall be stored separately. The reinforcement, if required, shall be provided coating to prevent corrosion.

3) For checking nominal mass, tensile strength, bend test, re-bend- test etc. specimen of sufficient length shall be cut from each size of the bar at random frequency not less than that specified below or as per the relevant IS/BIS/CPWD specifications : -

Size of Bar	For consignment below 50 tonnes	For consignment over 50 tonnes
Under 10 mm dia	One sample for each 25 tonnes or part thereof	One sample for each 40 tonnes or part thereof.
10mm to 16 mm dia.	One sample for each 35 tonnes or part thereof	One sample for each 45 tonnes or part thereof.
Over 16 mm dia	One sample for each 45 tonnes or part thereof	One sample for each 50 tonnes or part thereof.

4) Steel brought to site and steel remaining unused shall not be removed from site without the written permission of the Employer.

3.4.2.1.3 Quarry Materials

The Contractor shall be wholly responsible to identify the suitable sources for quarry materials required for the Works, such as earth, sand, stone, murrum, etc., and to make his own arrangements for collection and transportation of the materials irrespective of the leads and lifts required. The quarry thus identified by the Contractor should have proper license from the concerned Government Department. All materials supplied by the Contractor shall be tested, approved and satisfy the requirements set forth in the Specifications and shall be subject to the approval of the Employer-in-Charge. The Contractor shall take this into account while offering his rates and no claims whatsoever shall be entertained for extra costs on this account.

3.4.2.2 Formwork

Formwork shall be properly designed for various types of loads anticipated to be imposed during the construction process. The design should also take into account the effect of vibrations created during operation of vibrators. The forms shall be capable of producing a consistent quality surface as required in the contract without leakages of slurry, at joints, etc. with special attention being given to proper removal of formwork, without leaving any unacceptable inserts, voids, etc.

All the staging shall be of Tubular steel structure with adequate bracings or made of built up structural sections from rolled structural steel sections. Form work shall be steel or wood. Wooden form shall be made with 12 mm thick water proofing ply of approved quality.

For liquid retaining structures, securing formwork should not impair the water tightness of the structure.

Only tie bolts which avoid embedding any metal parts permanently within 50mm/ clear cover of the concrete surface shall be permitted. Voids remaining after the removal of all, or part, of each tie bolt shall be sealed using a non-shrink polymer modified cementitious / epoxy (LRS) compound with an appropriate bonding coat.

Release agents shall be such that they do not adversely affect the surface of the finished concrete or the quality of the concrete.

Striking out / removal of formwork shall be done as per the approval of Employer. The surfaces of the RCC/ concrete work obtained after removal of shuttering shall be smooth and without honey combing/ pin holes, undulations and shall be such that it does not require any plastering. If at all any pin hole/ undulations are required to be made good, this shall be done with cement mortar 1:2 using coarse sand and finished smooth with steel trowel or as directed by Employer. All works damaged through careless removal of forms shall be reconstructed within 24 hours. All damaged of improperly formed surfaces will be repaired using proper appropriate repair material. This will include necessary grouting with appropriate materials and additives in case of honeycombing. Repairs materials of this type of repairs shall in general be epoxy based.

3.4.2.3 Concrete

Nominal mix concrete may be used (as allowed by codes) for concrete of grade M 15 (or lower in accordance with proportions as per codes and conditions arising at site, subject to approval of Employer.

Design mix concrete shall be used for concrete of grade M 20 and above.

The mixing of concrete shall be strictly carried out in the batching & mixing plant for concrete. The contractor shall erect a concrete batching plant as per site requirement and as approved by Employer.

For small concreting works, mechanical concrete mixers may be used. Hand mixing of concrete shall not be permitted at all.

Ready mix concrete may be used for construction work from approved and certified sources. In the case of small quantities less than 6 cum, portable mixers (automated) may be used. The cement content in such cases may be increased by 5% depending on the type of mixer, as approved by Employer. Volumetric batch mixing shall be avoided. Nominal mix design for M15 and lower strength concretes shall be as per IS 456. The design mix shall be tested with trial mix testing prior to use in structures.

The contractor shall get the Mix design approved from IIT Delhi. The Contractor shall not alter the approved mix proportions or the approved source of supply of any of the ingredients without obtaining the approval of the Employer.

The contractor shall submit method statement describing work procedure to be carried before commencing the concrete work. The method statement shall be approved by the Employer. Routine quality control tests such as calibration, slump, cube strength, sieve analysis and any other mandatory tests as required by codes and as directed by Employer shall be done in the presence of Employer or its representative in the laboratory established by the contractor at site.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strengths, the Employer reserves the right to order the Contractor to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, etc. The Employer also reserves the right to ask the Contractor to dismantle and re-do such unacceptable work, at no cost to the employer.

Corrosion inhibiting admixtures may be used in the design mix concrete for improving the resistance to water penetration, abrasion resistance and durability. Admixtures for producing low water cement ratio high strength design mix concrete mix are permitted with prior approval of Employer. Other admixtures, as per the requirement of site, may be used for designing the concrete mix with prior approval of Employer and after establishing its use and advantages. However, the use of such admixtures or a combination thereof should not affect the workability and quality of concrete adversely and be in compliance with the requirements of the codes, product data sheet and shall only be used after necessary prior mix testing. Trial mixes shall be made with and without admixture(s).

3.4.2.4 Construction Joints

All construction joints shall be provided as recommended in BIS: 3370 and 6494 and as per minimum site requirement. However, contractor is allowed to reduce the number of construction joints as per best practices with sufficient justification. The position of construction joints should be specified by the structural designer & indicated on the drawings.

3.4.2.5 Other type of Joints

Expansion joints, where required shall be provided as per BIS: 3414 Code of practice for design of joints and installation in buildings.

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure.

Expansion joints of suitable gap at suitable intervals not more than 30m shall be provided in walls, floors and roof slabs of liquid retaining structures, etc.

3.4.2.6 Preformed Fillers, Joint Sealing Compound and Polyethylene Sheet

Preformed filler for expansion/ isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to BIS: 1838 Part I or BIS 1838 Part 2. Bitumen coat to concrete/ masonry surfaces for fixing the preformed bitumen filler strip shall conform to BIS: 702. Bitumen primer shall conform to BIS: 3384.

Sealing compound for filling the joints above the preformed bitumen filler shall conform to Grade 'A' as per BIS: 1834. Other organic solvents such as polysulphide based joint sealants to BIS: 11433 Part-I or BIS 12118 Part-I may be used with the approval of Employer.

If a layer of bond breaking material is required below the grade slab and lean concrete, it shall be polyethylene sheet of minimum 500 gauge or 0.125 mm thickness of make approved by the Employer.

3.4.2.7 Hydrostatic Testing Of Liquid Retaining Concrete Structures for New and Rehabilitated

The contractor shall make all arrangements including provision of water for hydro-testing of liquid structures as per IS: 3370, temporary bulk heads, pressure gauges, pumps, pipelines, etc. Hydro-static test for water tightness shall be done up to top level of structure, as may be directed by the Employer. This test shall be carried out preferably in dry season in accordance with the procedure given in the codes. Roofs shall also be tested. Clean water (IS 456) shall be used for tests. The below given conditions should generally also be satisfied:

The water tightness test shall be carried out when the structures are ready for filling. Before the filling operation is started, the structure shall be jointly inspected by the Employer and the Contractor's representative and the condition of surfaces of wall, contraction and expansion joints shall be noted and it shall be ensured that jointing material filled in the joints is in position and all openings are closed. The filling of the structure then shall be carried out gradually at the rate not exceeding 30 mm rise in water level per hour and shall preferably extend over a period of 72 hours. Records of leakages starting at different level of water in the structure, if any, shall be kept. The structure once filled shall be allowed to remain filled for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded again at subsequent interval of 24 hours over a period of seven days.

The total drop in surface level of a period of seven days shall be taken as indication of the water tightness of the structure, which for all practical purpose, shall not exceed 40 mm for open tanks & 20 mm for covered tanks or as specified in the relevant IS code – without any other signs of leakage/ seepage. If the structure does not satisfy the conditions of the test and a daily drop in water level is found, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory. Employer shall decide on the actual permissible nature of the drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has due to evaporation losses.

In case of structures whose external faces are exposed, such as elevated structures, 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.

Each compartment/segment of the structure shall be tested individually and then all together.
Backfilling of earth on the sides for underground or partly underground structures shall be withheld till the structures are hydro statistically tested and found leak proof to the entire satisfaction of the Employer. The hydrostatic tests shall be undertaken prior to protective lining works.

Any leakage that may occur during the hydro-test or subsequently during the trial run period shall be effectively stopped either by cement / epoxy pressure grouting, guniting or such methods as may be approved by the Employer. All such rectification shall be done by the contractor to the entire satisfaction of the Employer.

3.4.2.8 Embedment's / Inserts in Concrete Work

All the miscellaneous inserts such as bolts, pipes, assemblies, plate embedment's etc., shall be accurately installed in the building works at the correct location and levels, as detailed in the approved construction drawings. The contractor shall be responsible for the accuracy of dimensions, levels, alignments and centre lines of the inserts in accordance with the drawings and for maintenance of the same until the erection of equipment structure or final acceptance by the Employer.

The contractor shall ensure proper protection of all bolts, inserts, etc., from weather by greasing or other approved means such as applying white lead, putty and wrapping them in gunny bags or canvas by other means as directed by the Employer to avoid damage due to movement of his labourers, material, material, equipment etc., The contractor shall be solely responsible for any damage caused to bolts inserts etc., due to negligence and in case damage does occur it shall be rectified to the satisfaction of the Employer at the contractor's cost.

Requisite galvanizing and/or painting/ protective shall be provided to ensure proper durability along with additional 2mm corrosion allowance. In general no insert shall be less than 10 mm thick and base plate less than 12mm thick, all with appropriate anchorage/ lugs.

3.4.2.9 Grouting

All workmanship, material, equipment, accessories shall be as per best standards of the trade and shall meet the requirements set out in the relevant sections (2800, 2803, 2806, 2807, etc.) of MORTH/MOST specifications. In this care has to be taken that in case of active leaks it is better to grout with the tank filled, so that crack is open to the maximum, this then may first be plug grouted with appropriate material from outside or other side and epoxy or equivalently good materials be used to structurally plug the crack/ opening along with proximity areas which may be weakened to ensure other leaks do not appear in proximity. Special grouting materials with very low viscosity and other special properties may be proposed/ used.

3.4.2.10.1 Standard Grout

The proportions of Standard Grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. Surfaces to be grouted shall be thoroughly roughened and cleaned. All structural steel elements to be grouted shall be cleaned of oil, grease, dirt etc. The use of hot, strong caustic solution for cleaning purpose will be permitted. Prior to grouting, the hardened concrete shall be saturated with water and just before grouting, water in all pockets shall be removed. Grouting once started shall be done quickly and continuously. Variation in grout mixes and procedures shall be permitted if approved by the Employer. Appropriate admixtures/blends may be used to ensure shrinkage/creep/etc. is within permissible limits.

The grout proportions shall be limited as follows:

Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
a) Fluid mix	Under 25mm	One part Portland Cement to one part sand	0.44
b) General mix	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff mix	50mm and over	One part Portland Cement to 3 parts of sand	0.53

3.4.2.10.2 Non-Shrink Grout

Non-shrink grout where required as instructed by the Employer, shall be provided in strict accordance with the manufacturer's instructions / specifications on the drawings. Non shrink grout material properties shall comply with Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non shrink). Application of non-shrink grout shall be as per manufacturer instructions.

1.3.3 Building Works

Green and energy conservation building concepts should be incorporated in the layouts and detailing of the buildings while using environmental friendly concepts and products without compromising on Employering properties and specifications.

3.4.3.1 Brickwork

Unless otherwise specified bricks having a minimum crushing strength of 7.5 N/mm^2 shall be used. Mortar Mix proportion for one or more brick thick work shall be in 1:4 (1 cement: 4 course sand) for half brick thick work the mortar mix proportion shall be in 1:3 (1 cement: 3 course sand).

Generally only framed RCC structures shall be provided in the works. In exceptional case approved by the Employer; for resting RCC slabs, the bearing surface of masonry wall shall be finished on top with 12 mm thick cement mortar 1:3, and RCC/ steel beams resting on masonry wall shall be provided with M-25 reinforced concrete bed blocks of minimum 50 mm thickness, projecting 50mm on either sides of the beam.

Steel wire fabric of suitable size and thickness shall be provided at the junction of brick masonry and RCC before taking up plastering work.

The top most course of half or full brick walls abutting against either a deshuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element. Bricks for partition walls shall be stacked adjacent to the structural member on upper floor so as to pre-deflect the structural member (beam) before the brick wall is taken up for execution at lower floor.

Where the drawings prepared by the Contractor indicate that structural steel sections are to be encased in brickwork, the brickwork masonry shall be built closely against the steel section, ensuring a minimum of 20 mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating or better to the surfaces at the point of entry into the brick masonry. In general encasing shall be with RCC.

3.4.3.2 Damp - Proof Course

All the walls in a building shall be provided with damp-proof course cover at plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 50 mm thick cement concrete of 1:2:4 (1 cement: 2 coarse sand: 4 graded stone 10 mm nominal size) nominal mix with approved water-proofing compound admixture conforming to IS: 2645, 9103. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.

3.4.3.3 Doors, Windows and Ventilators

Aluminium sections, or as otherwise approved by Employer, are proposed for new and rehabilitation works. The best quality and warrantied materials and products shall be sourced from certified (ISO, BSI, etc.) sources which are primary producers using virgin materials in manufacture. Requisite test certificates shall be provided with each batch and necessary tests conducted as directed by the Employer. The workmanship shall be as per the best certified practices of the trade. The installations, along with that of accessories such as safety grills shall ensure that there is no loose or prone to be loosened fitting, jamming, hanging, misfit, leakage, etc. The installation and products should be warrantied for a reasonable service life (say 10 years) after installation and in general be maintenance free and appropriately resistant to exposure, etc. as required/ specified.

i) Aluminium Work

All works shall in general be in compliance with sub head (21) 'Aluminium Work' of the CPWD Specifications and the descriptions of items in the CPWD DSR, including compliance with all related IS Codes. Due to higher exposure anodizing shall be preferred and it shall be of grade AC 25. All works shall be warrantied against proper functioning and durability of at least 10 years. All accessories, fittings, screws, etc. shall be of stainless steel, hardened aluminium or other equally corrosion resistant material. All workmanship shall be as per the best practices by trained personnel. Special attention shall be paid to items prone to break down such as jambs, door closers, etc. All materials shall be durable and have the necessary resistance to insects, water and fire. All panels and shutters shall be fitted with the specified and equally durable materials and resistance to insects, water and fire. In very wet areas the shutters shall be appropriately coated with water resistant durable materials such as FRP which should be UV stabilized. In rare cases after prior approval (product and brand) of Employer heavy duty factory prefabricated frames and doors of solid composite materials like uPVC (interchangeably PVC) may be considered for specific requirements such as exposure to acids, etc.

ii) UPVC Extruded Sections

All profiles shall be made from uPVC (Unplasticised Polyvinyl Chloride) Type A material & only those additives are used that are essential in producing sound extrusions in accordance to BIS 7413:1991. No reworked material shall be used. The profile shall be a hollow 3 chamber (across depth) profile with a nominal 2.3 mm wall thickness, +/- 0.3mm of tolerance. The profile shall be uniform and free from foreign bodies, cracks or marks. The profiles shall be multi chambered, with a min. of three chambers. The central chamber, being for reinforcement, shall be fully sealed when main profiles are welded at joints. The colour of profiles shall be as decided by Employer.

All reinforcements for profiles shall be Galvanized Mild Steel. The reinforcement is secured to the profile so that it does not move or rattle and it maintains the structural integrity of the frame and satisfactory thermal separation. The structural frame assemblies must be capable of withstanding and accommodating satisfactorily wind loads and pressures in accordance with the requirements of relevant codes.

The door / window / ventilator units shall be designed with all corner joints, transom joints and mullion joints being mitred and fusion welded. The joints must be completely moisture resistant and not permit any penetration into the profiles either externally or internally. All excess material is to be neatly trimmed and neatly feature grooved to corner, transom and mullion joints. No polishing of any joints are permitted. There is to be no mechanical jointing of the profile unless the profile section is less than 350 mm long. The units shall be designed so that the route of drainage is prevented from passing through the reinforcement chamber. The dimensional tolerances on the finished outer frame height and width is +/–3mm.

All screws, nuts, bolts, rivets and other fastenings shall be of corrosion resistant or treated material, like stainless steel or ferretic steel, bi-chromate treated steel and be compatible with other metallic fixings used in the manufacture of the window, in accordance with relevant national / international codes. Fastenings be made from stainless steel 304 which has been finished by one of the following methods:-

a) Zinc plated and passivated.
b) Hot dip galvanized
c) Sprayed with metal coating.

Hardware and ironmongery fittings and fixings are to penetrate at least two thicknesses of the uPVC profile and/or penetrate the reinforcement by at least 2mm. The locking mechanism is to be a Shoot Bolt Locking System operated by a single handle. Gearbox is to be sealed to stop the ingress of swarf during manufacture and use.

Glazing shall be with clear (obscure in bathrooms/wc) float glass panes. The glass shall be free from bubbles, scratches and other flaws. The glass shall be retained by suitable UPVC snap-on beads matching existing frame. All glazing gaskets & weather strips shall be of EPDM rubber.

All windows and ventilators shall have float glass panes of minimum 5.50 mm thickness. Double glazing shall be done wherever the functional and utility requirements arise.

The uPVC door shutters shall be 30 mm thick shall be made of styles and rails of a uPVC hollow section of size 60x30 mm and wall thickness 2 mm (± 0.2 mm), with inbuilt decorative moulding edging on one side. The styles and rails mitred and joint at the corners by means of M.S. galvanized/ plastic brackets of size 75x220 mm having wall thickness 1.0 mm and stainless steel screws. The styles of the shutter reinforced by inserting galvanized M.S. tube of size 25x20 mm and 1 mm (± 0.1 mm) wall thickness. The lock rail made up of 'H' section, a uPVC hollow section of size 100x30 mm and 2 mm (± 0.2 mm) wall thickness fixed to the shutter styles by means of plastic/ galvanized M.S. 'U' cleats. The shutter frame filled with a uPVC multi-chambered single panel of size not less than 620 mm, having over all thickness of 20 mm and 1 mm (± 0.1 mm) wall thickness. The panels filled vertically and tie bar at two places by inserting horizontally 6 mm galvanized M.S. rod and fastened with nuts and washers, complete as per manufacturer's specification and direction of Employer.

iii) uPVC Sections of Rigid PVC Foam Sheet

The door frame shall be of size 50x47 mm with a wall thickness of 5 mm, made out of extruded 5mm rigid PVC foam sheet, mitred at corners and joined with 2 Nos of 150 mm long brackets of 15x15 mm M.S. square tube, the vertical door frame profiles to be reinforced with 19x19 mm M.S. square tube of 19 gauge, EPDM rubber gasket weather seal to be provided throughout the frame. The door frame to be fixed to the wall using M.S. screws of 65/100 mm size, complete as per manufacturer’s specification and direction of Employer.

The door shall be made of 30 mm thick pre laminated PVC door shutters consisting of frame made out of M.S. tubes of 19 gauge thickness and size of 19 mm x 19 mm for styles and 15x15 mm for top

& bottom rails. M.S. frame shall have a coat of steel primers of approved make and manufacture. M.S. frame covered with 5 mm thick heat moulded PVC 'C' channel of size 30 mm thickness, 70 mm width out of which 50 mm shall be flat and 20 mm shall be tapered in 45 degree angle on both side forming styles and 5 mm thick, 95 mm wide PVC sheet out of which 75 mm shall be flat and 20 mm shall be tapered in 45 degree on the inner side to form top and bottom rail and 115 mm wide PVC sheet out of which 75 mm shall be flat and 20 mm shall be tapered on both sides to form lock rail. Top, bottom and lock rails shall be provided both side of the panel. 10 mm (5 mm x 2) thick, 20 mm wide cross PVC sheet be provided as gap insert for top rail & bottom rail, panelling of 5 mm thick both side PVC sheet to be fitted in the M.S. frame welded/ sealed to the styles & rails with 7 mm (5 mm+2 mm) thick x 15 mm wide PVC sheet beading on inner side, and joined together with solvent cement adhesive. An additional 5 mm thick PVC strip of 20 mm width is to be stuck on the interior side of the 'C' Channel using PVC solvent adhesive etc. complete as per direction of Employer, manufacturer's specification & drawing.

iv) Galvanized Steel Rolling Shutters

Rolling shutter shall be provided in workshop, pump houses and other such buildings as directed by Employer. GI Sheets and Plates used for manufacturing the guide channels, brackets and lock plate should be of hot rolled steel of thickness not less than 18 gauge conforming to IS 5986. All components of rolling shutter to be hot dip galvanized with a zinc coating containing not less than 97.5% pure zinc. The galvanization of members shall conform to the requirements of IS 4759, IS 209, IS 2629, IS 2633 and IS 6745.

Rolling shutters shall conform to IS: 6248 and shall be suitable for fixing in position as specified i.e. outside or inside on or below lintel or between jambs of the opening. Shutters up to 10 sqm shall be on push and pull type and shutters with an area of over 10 sqm shall generally be provided with reduction gear operated by mechanical device with chain or handle. The crank handle shall be removable.

3.4.3.4 Soling under Floors and Foundations

Structural foundations shall be placed on virgin soil. In case of over excavation or where soft patches are encountered the same shall be excavated out and the areas shall be filled to the required levels with M 10 lean concrete. The same practice shall be followed for profiling slopes in multi-level foundations. The slope sides shall not be steeper than 1H:1V.

The work covered under this specification includes all type of soling works by rubble stones under floors / foundations, hand packed, complete as mentioned below and approved drawings. The rubble stone shall be of best quality of black trap / granite / basalt or other approved variety of stone available locally. Stones shall generally conform to the requirements stipulated in IS:1597 (Part I) and shall be approved by Employer.

Stones shall be of height equal to the thickness of the packing proposed with a tolerance of ± 10 mm. Stones shall not have a base area less than 250 sq.cm nor more than 500 sq.cm, and the smallest dimension of any stone shall not be less than half the largest dimension.

Under floors the interstices shall be filled with sand and as approved by Employer the fill under floors from NGL may be filled with compacted sand with proper side containment.

3.4.3.5 Base Concrete

Base concrete shall be provided as per the approved drawings. The surface of the base shall be roughened with steel wire brushes without disturbing the base concrete. The base concrete shall be in M-15 (1 cement: 2 coarse sand: 4 graded stone aggregate 10 mm size) and of minimum 40 mm thickness or as directed by Employer.

3.4.3.6 Flooring

i) Cement Concrete Flooring with Metallic Hardener Topping

Wherever floors are required to withstand heavy wear and tear such as in pump house floors, workshops, uncovered staircases etc. the metallic hardener topping flooring shall be used. The metallic hardener topping flooring shall be 60mm thick cement flooring with Metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m2. Including cement slurry and rounding off edges and making chequers of patterns approved by the Employer on steps, landings etc. Metallic Hardening Compound shall be of approved quality and screedable, iron aggregate cementitious system designed to provide a thin, high strength topping for applying over the concrete floors. The iron aggregates shall be free from non-ferrous metal particles, oil, grease sand, soluble alkaline compounds. Sample of the compound shall be got approved from Employer before use.

The flooring shall be laid in panels of uniform size and no dimension of panel shall exceed 2 m and the area of a panel shall not be more than 4 sqm. The border panels shall not exceed 450 mm in width and the joints in the border shall be in line with panel joints. Aluminium strips of 2 mm thick shall be provided at the junction of two panels.

ii) Chequered Tiles Flooring

Mainly these shall be used in walkways, landscaping, and parking space or as specified. The thickness of tiles shall not be less than 22 mm. The chequered tiles shall conform to IS: 13801. Colour/ shade of the tile shall be as approved by the Employer or indicated in approved drawings. Only approved BIS certified branded products of approved strength to be used.

iii) Ceramic Tile Flooring

Flooring

The tiles shall be of approved make and shall generally conform to IS: 15622. They shall be flat and true to shape and free from blisters, crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested in accordance with IS: 13630. They should be of the best quality suitable for the most demanding industrial category use (abrasion, strength, etc.).

The tiles shall be of nominal size such as 300 x 300 mm, 600 x 600 mm or as approved by the Employer. The thickness of the tiles shall be as specified by the manufacturer. The top surface of the tiles shall be glazed and the glaze shall be either glossy or matt finished or as directed by Employer. Samples of tiles shall be got approved from the Employer before bulk procurement for incorporation in the work.

Skirting and Dado

The tiles shall be of approved make and shall generally conform to IS: 15622 for dimensional tolerance, physical & chemical properties. The tiles shall be pressed ceramic covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. The thickness of the tiles shall be as specified by the manufacturer. Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when joined together (with 1 mm joint) match with dimensions of full tiles. They shall be fully compatible with the quality of the tiles used in the flooring and meet the special requirements of acid/alkali resistance, depending on the location of use.

iv) 3.4.3.6.4 Vitrified Tile Work – Flooring / Dado / Skirting

Material

The tiles shall be of approved make and shall generally conform to IS: 15622. They shall be flat and true to shape, free from cracks, crazing spots, chipped edges and corners. Unless otherwise specified, the nominal sizes of tiles shall be as under:

The tiles shall be of nominal sizes such as: 500 x 500 mm, 600 x 600 mm or approved by the Employer. All tiles shall be as specified for heavy duty use with high abrasion resistance and strength. The tiles may be of glossy or matt finish, as approved by the Employer.

Thickness shall be as per recommendations of the approved manufacturers. Technical specifications of the tiles shall be generally conforming to the following standards:

1.	Deviation in length	(+/-) 0.6%
2.	Straightness of sides	(+/-) 0.5%
3.	Rectangularity	(+/-) 0.6%
4.	Surface flatness	(+/-) 0.5%
5.	Water absorption	< 0.50%
6.	Mohs. Hardness	> 6
7.	Flexural strength	> 27 N / mm2
8.	Abrasion resistance	< 204 mm2
9.	Skid resistance (friction coefficient)	> 0.4

Samples of tiles shall be got approved from Employer before bulk procurement for incorporation in the work.

v) Granite Flooring

The stone slabs shall be of selected quality, smooth and of even surface without holes or pits, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and other flaws. Before starting the work the contractor shall get the samples approved by the Employer. This shall be repeated for all the lots supplied at site. Samples shall be tested in accordance with IS:1121, 1124, 1706, etc. Granite should comply with IS:14223 and other specifications.

The stone slabs of approved colour and finish shall be machine cut to the required sizes and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact it. All angles and edges of the slabs shall be true and free from any chippings thus giving a plane surface. Slabs shall have the top exposed surface machine polished before being brought to site, unless otherwise specified.

The thickness of the stone slab after it is dressed shall be at least 18 mm. Tolerance in thickness shall be ±2mm. In respect of length and breadth of slabs, tolerance of ±5mm for hand cut slabs and ±2mm for machine cut slabs shall be allowed.

The stone stones shall be laid over 20 mm (average) thick base of cement mortar 1:4 (1 cement:4 coarse sand) laid and jointed with grey cement slurry, including rubbing and polishing complete.

In lieu of Granite equally durable and aesthetic flooring may be used, as per architectural control & as directed/approved by Employer.

vi) Granite in Risers and Treads of Steps, Skirting and Dado

Granite slabs and dressing shall be as specified above under section "Granite Flooring". In lieu of Granite an equally durable and aesthetic material may be used, as per architectural control & as directed/approved by Employer.

3.4.3.7 Cement Plastering Work

The mixing of the cement mortar for plastering shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Employer. If so desired by the Employer, sand shall be screened and washed to meet the Employer's requirements. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re- tempered by adding water as required to restore consistency but this will be permitted only up to 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

Interior Plain Faced Plaster	-	This plaster shall be laid in a single coat of 12 mm thickness in cement mortar 1:4 (1 cement : 4 fine sand) for single brick thick walls.
	-	This plaster shall be laid in a single coat of 12 mm thickness in cement mortar 1:3 (1 cement : 3 fine sand) for half brick thick walls.
Plain Faced Ceiling plaster	-	This plaster shall be applied in a single coat of 6 mm thickness in cement mortar 1:3 (1 cement : 3 fine sand).
Exterior Plain Faced Plaster	-	This plaster shall be 20 mm thick in cement mortar 1:4 (1 cement: 4 coarse sand). This may be applied in two layers/coats.

3.4.3.8 False Ceiling

False ceiling shall be 15 mm thick densified tegular edged eco-friendly light weight calcium silicate false ceiling tiles of approved texture **Spintone/ Cosmos/ Hexa/ Armstrong/ equivalent** of size 595 x 595 mm in true horizontal level, suspended on inter locking metal grid of hot dipped galvanised steel sections (galvanising @ 120 grams per sqm including both side) consisting of main 'T' runner suitably spaced at joints to get required length and of size 24x38 mm made from 0.33 mm thick (minimum) sheet, spaced 1200 mm centre to centre, and cross "T" of size 24x28 mm made out of 0.33 mm (Minimum) sheet, 1200 mm long spaced between main 'T' at 600 mm centre to centre to form a grid of 1200x600 mm and secondary cross 'T' of length 600 mm and size 24 x28 mm made of 0.33 mm thick (Minimum) sheet to be inter locked at middle of the 1200x 600 mm panel to from grid of size 600x600 mm, resting on periphery walls /partitions on a Perimeter wall angle pre-coated steel of size(24x24X3000 mm made of 0.40 mm thick (minimum) sheet with the help of rawl plugs at 450 mm centre to centre with 25 mm long dry wall screws @ 230 mm interval and laying 15 mm thick densified edges calcium silicate ceiling tiles of approved texture (Spintone / Cosmos/ hexa/ equivalent) in the grid, including, cutting/ making opening for services like diffusers, grills, light

fittings, fixtures, smoke detectors etc., wherever required. Main 'T' runners to be suspended from ceiling using G.I. slotted cleats of size 25x35x1.6 mm fixed to ceiling with 12.5 mm dia and 50 mm long dash fasteners, 4 mm G.I. adjustable rods with galvanised steel level clips of size 85 x 30 x 0.8 mm, spaced at 1200 mm centre to centre along main 'T', bottom exposed with 24 mm of all T-sections shall be pre-painted with polyester baked paint, for all heights, as per specifications, drawings and as directed by Employer. The calcium silicate ceiling tile shall have NRC value of 0.50 (Minimum), light reflection > 85%, non - combustible as per B.S. 476 part IV, 100% humidity resistance and also having thermal conductivity <0.043 w/m 0 KC. All works shall at least be in compliance with as specified in IS codes and CPWD specifications & DSR as also detailed in sub-head 12 of Roofing.

3.4.3.9 Aluminium Cladding Work

The Designing, fabricating, testing, installing and fixing in position of Curtain Wall with Aluminium Composite Panel Cladding, with open grooves for linear as well as curvilinear portions of the building, for all heights and all levels etc. shall include structural analysis & design and preparation of shop drawings for pressure equalisation or rain screen principle as required, proper drainage of water to make it watertight including checking of all the structural and functional design. The contractor shall ensure best practices in sourcing/supplying, fabricating and fixing panels of aluminium composite panel cladding in pan shape in metallic colour of approved shades made out of 4mm thick aluminium composite panel material consisting of 3mm thick FR grade mineral core sandwiched between two Aluminium sheets (each 0.5mm thick). The aluminium composite panel cladding sheet shall be coil coated, with Kynar 500 based PVDF / Lumiflon based fluoropolymer resin coating of approved colour and shade on face # 1 and polymer (Service) coating on face # 2 as specified using stainless steel screws, nuts, bolts, washers, cleats, weather silicone sealant, backer rods, etc. The fastening brackets of Aluminium alloy 6005 T5 / MS with Hot Dip Galvanised with serrations and serrated washers to arrest the wind load movement, fasteners, SS 316 Pins and anchor bolts of approved make in SS 316, Nylon separators to prevent bi-metallic contacts all complete required to perform as per specification and drawings.

It shall include cost of all material & labour component, the cost of all mock ups at site, cost of all samples of the individual components for testing in an approved laboratory, field tests on the assembled working curtain wall with aluminium composite panel cladding, cleaning and protection of the curtain wall with aluminium composite panel cladding till the handing over of the building for occupation. The cost of the base frame work for ACP cladding is also part of the all-inclusive works.

All works shall be as per architectural drawings or as directed by Employer.

3.4.3.10 Guniting Spray Concreting Work

The works shall comply with the best practices of the trade and generally comply with specifications of MORTH/MOST and recommendations of IS 9012. The gunite material should be selected based on target strength at the target age, depending on available time of repair. In addition the required additives shall be provided that reduce the rebound, increase corrosion inhibition, increase water proofing/ permeability properties, necessary non-shrinkage and strength parameters. The design thickness will depend on the condition of the existing substrate. The minimum cover to the wire mesh should be 50 mm. At corners extra over lap and anchoring may be provided for likely negative moments and associated shears.

3.4.3.11 Epoxy Lining Work

The epoxy resin and hardener formulation for laying of joint-less lining work in floors and walls of concrete structures etc. shall be conforming to the requirements of IS: 9197 (Specification for epoxy resin, hardeners and epoxy resin composition for floor topping).

The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct for the epoxy resin. The hardener shall react with epoxy resin at normal ambient temperature. Contractor shall furnish test certificates for satisfying the requirements of the epoxy formulation approval of Employer.

The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces shall then be washed with dilute hydrochloric acid and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry before the commencement of epoxy application.

Just adequate quantity of epoxy resin which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for laying and jointing.

The minimum thickness of epoxy lining shall be 0.3 mm or as directed by Employer. It is essential that the concrete elements are adequately designed to ensure that water is excluded to permeate to the surface, over which the epoxy lining is proposed.
Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.
Final finish of epoxy lining should be non porous epoxy ceiling coat.

All lining works should have a warrantied long life of about 10 years and suitable for 'wet' surface conditions or with high moisture content of walls as may be encountered at site.

3.4.3.12 Sheet Roofing

The roofs of some buildings, sheds, etc. are to be provided with new/replacement sheeting. The same shall be as per the best products and accessories available for assured long life with minimal maintenance with appropriate designs in accordance with specifications for structural steel and/or other support members. All materials shall be approved Employer prior to incorporation in works.
The minimum requirements shall be: corrugated G.S. sheet (1.00 mm thick with zinc coating not less than 275 gm/m²) roofing including vertical / curved surface fixed with polymer coated J or L hooks, bolts and nuts 8 mm diameter with bitumen and G.I. limpet washers or with G.I. limpet washers filled with white lead, including a coat of approved steel primer and two coats of approved paint on overlapping of sheets complete (up to any pitch in horizontal/ vertical or curved surfaces). The works shall be complete in all respects including provision of compatible/ best ridges, hips, valleys, gutters, down take pipes, sky lights, etc.

1.3.4 Water-Proofing

All buildings having reinforced concrete roofs, terraces and any such area/ locations as directed by the Employer these shall be made waterproof by laying APP (Atactic Polypropylene Polymer) modified prefabricated five layer 3 mm thick water proofing membrane system, with covering top of membrane with Geotextile, 120 gsm non woven, 100% polyester of thickness 1 to 1.25 mm bonded to the membrane along with top most layer shall be finished with brick tiles of class designation 10 grouted with cement mortar 1:3 . The roof waterproofing shall in general also include the appropriate type of thermal insulation (such as puf slab, etc.). The finished roof surface shall have adequate slope to drain quickly the rain water to down take inlet points. The rain water inlet points near down take pipes shall have uPVC/ FRP/HDPE gratings. RCC roofs be finished with smooth slope so that there is no likelihood of seepage puddles. In instances of rehab work it is to be ensured that load of replacement or repaired waterproofing is not more than that of old treatment. Prior to waterproof treatment, top surface of concrete shall be prepared and sloped appropriately. Only certified water proofing compounds & admixtures used shall be conforming to IS: 2645, 9103, etc. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be conforming to manufacturer's instructions and as directed/approved by Employer.

1.3.5 Painting of Concrete and Plastered Surfaces

Paints and painting schemes shall be such as to provide the required protection for long warrantied periods and be sourced from the best reputed brands. Only procedures specified for each product shall be followed and extra thinning etc. shall be avoided. The products should be environment friendly such as low VOC, etc.

3.4.5.1 Surface Preparation

All RCC and plastered surfaces to be painted shall be made dust free, remove any type of loose material, oil, grease with chiselling (if required) or by grinding

.

Pot holes, crevices, honey combing, etc. on RCC surfaces shall be grouted / treated with Two component epoxy modified mortar. The same may generally comply with the following requirements: Solvent Free epoxy Mortar for high early strength with compressive strength (As per ASTM C881) of 50 N/mm2 in 7 days, bond strength (as per ASTM C881) of more than 1.5 N/ mm2 and mixing ratio 2 : 1 (Resin : Hardener). The finished surface shall be cured for 4 to 6 hours as per manufacturer recommendations.

Pot holes in cement plastered surfaces shall be cured with rich cement mortar 1:3 (1 cement : 3 coarse sand) and providing a proper curing of minimum 3 days.

3.4.5.2 Painting of Plastered Surfaces Not in Direct Contact With Water (New/ Rehab)

Apply one coat of single component Acrylic based anti-carbonation primer on the surface which fills the capillaries in the concrete and creates a saturated surface for the Anti- carbonation paint. The curing time of primer will be minimum 4 hours. Consumption can vary from 200 – 300 gms / sq.m depending upon the product manufacturer.

Apply Anti-carbonation paint on the surface of desired colour based on Single Component Acrylic co-polymer technology. The paint should be Anti-fungal, should have crack bridging capacity of minimum 1 mm with elongation above 300%, Solid Contents 55% and DFT of 200 micron after two or more coats.

3.4.5.3 Painting of Exposed RCC Surfaces Not in Direct Contact with Water (New/ Rehab)

Exposed RCC surfaces of all the units and buildings shall be applied with two or more coats of water proofing cement paint. The cement paint shall conform to IS 5410. The primer shall be a thinned coat of cement paint. The cement paint shall be the best quality from an approved manufacturer. Contractor shall obtain prior approval of the Employer for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

3.4.5.4 Protection of exposed RCC surfaces in contact with water or covering (New/ Rehab)

Protective coating should be food grade. It shall be applied to the inner surfaces of the tanks and feeding ducts. It shall be suitable for higher concentrations of the chlorine and also protect the concrete from other corrosive effects. It should be abrasive resistant and chemical resistant. In general it should be non-toxic and solvent free. The multiple coats shall achieve DFT to provide an effective life of 10 years. The coating shall be easily repairable/ reapplied. In general epoxy based coatings shall be used. In this use of appropriate (say glass) tiles may be considered which can give a very long life with good protection due to the inert nature of the material and thickness of the tiles. The adhesive and filler material used between the gaps shall have the properties detailed above.

3.4.5.5 Painting of Internal Surfaces of the Buildings

All internal surfaces of the buildings shall be treated with white cement based wall care putty. Application shall be as per manufacturer's instructions and as directed by Employer.

Internal surfaces of all buildings shall be painted with two or more coats of Oil bound distemper of approved shade and as directed by Employer. Oil bound washable distemper (internal application) shall be of approved make and conform to IS: 428.

1.3.6 Structural Steel Works

3.4.6.1 Material

All materials used shall be new, unused and free from defects. Structural steel and other related materials for construction shall conform to IS 2062 and shall be procured from reputed manufacturers such as SAIL / TATA STEEL LTD / RASHTRIYA ISPAT NIGAM LTD (RINL)/ etc. and as approved by the Employer. Where steel castings are to be used the same shall conform to IS: 1030. Tolerances for fabrication of steel structures shall conform to IS 7215. Tolerances for erection of steel structures shall conform to IS 12843.

Where steel work is directly exposed to weather and is fully accessible for cleaning and repairing the thickness shall not be less than 6mm. Where steel is exposed to weather but not accessible for cleaning and painting, the thickness of steel member shall not be less than 8 mm. A corrosion allowance of 2mm shall be considered over design thickness.

Where steel work is not directly exposed to the weather the thickness of steel member shall not be less than 6 mm. Corrosion allowance of 2mm to be considered if exposure is 'Severe'.

Test certificate from the manufacturer for the material shall be made available along with each lot supplied at site. Scratched or abraded steel shall be given a coat of primer for protection after unloading and handling prior to erection and milling.

For procurement and storage of structure steel provision mentioned elsewhere shall be followed.

In general all requirements of IS:800 (2007 or later) and related codes shall be satisfied for structural steel works including protective coatings, considering the necessary exposure conditions, durability, fire and other requirements. In locations like inside the steel roof of the digester conditions shall be considered extreme/ worst with life requirement of coating being above 20 years as specified and appropriate coating and protection arrangements should be provided (see section 15 of IS:800 on Durability). Equivalent equally durable and effective coatings such as polyurea, polyurethane, hybrids, etc. may be used with the prior approval of the Employer. The emphasis should be on the application in the on-site conditions and requirements thereof and warrantied life performance. Guidelines of codes such as IS:9954, 14428, etc. to be referred for works along with the best international practices in this area (such as using zinc rich primer, epoxy intermediate with polyurethane finish of min. total DFT of 350 µm with appropriate surface preparation of thorough blast cleaning, etc.). Any problem arising with the protective coatings within the stipulated life shall be made good by the contractor by repairs or replacement, partially or wholly – as directed by the Employer, all at his cost and nothing extra shall be claimed or paid.

3.4.6.2 Inspection and Testing

Employer shall have free access to all parts of the job during erection and all erection shall be subject to his approval. In case of faulty erection, all dismantling and reworking required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the Employer.

The Contractor shall give due notice to Employer in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for Employer's inspection. The fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by Employer if it fails to conform to the requirements of these specifications, fails to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer may make because of defective or unsatisfactory materials and/or workmanship.

No materials shall be painted or dispatched to site without inspection and approval by Employer.
The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to Employer.

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the Employer. The Contractor must obtain permission from Employer before any repair is undertaken.

The Employer has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the Employer, only in case of successful testing.
The Contractor shall maintain records of all inspection and testing which shall be made available to Employer.

3.4.6.3 Welding

The sequence of welding shall be as per IS 9595. Welding shall be done by electric arc process as per IS 816 and IS 823. The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used. Symbol for welding on plans and shops drawings shall be according to IS 813. The maximum dia. of electrodes for welding work shall be as per IS 814. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter. All operation connected with welding and cutting equipment shall conform to the safety requirements given in IS 818 for safety requirements and Health provision in Electric and gas welding and cutting operations.

Inspection and testing of welds shall be as per IS 822, IS 1182, etc. as applicable. This shall include 100% visual inspection and other tests as directed by Employer including; Mechanical Tests, Magnetic Particle/ Dye Penetration/ Ultrasonic Examination and Radiographic Examination. No repair of defective welds shall be carried out without proper permission of Employer and his approval for the corrective procedure.

3.4.6.4 Painting on Steel

The painting scheme provide shall be in full compliance with the maintenance schedule, exposure conditions and requirements of the codes such as IS:800. Paints shall be of the best quality available.
Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling and shall be from the same manufacturer for each painting system.

a. Surface Preparation

All un-galvanized steel surface shall be cleaned by grit or shot blasting in accordance with IS 9954 and BS 7079 - General introduction to standards for preparation of steel substrates before application of paints and related products. The cleaned surface shall have maximum amplitude not exceeding 0.1 mm. The grit or shot blasted surfaces shall be primed within four hours of blasting.

b. Primer

Two coats of paint compatible primer shall be applied on the steel structures. First coat of lead-free, oil-based, high-quality, corrosive resistant steel primers such as Red Oxide Zinc Chromate as specified shall be applied before any member of steel structure are placed in position or taken out of workshop. Second coat of primer shall be applied after the erection is completed and before painting commences. The coating thickness shall consist of the following minimum dry film thickness, or as recommended by the manufacturer (Minimum 80 μm).

c. Paint

Two coat of Epoxy paint of approved make shall be applied on all structural steel members. Paint delivered to the fabrication shop/site shall be ready mixed, in original sealed containers, as packed by the manufacturer. Thinner shall not be permitted for usage unless specifically approved by Employer. The application of paint shall be as per manufacturer's instructions. The coating thickness shall consist of the following minimum dry film thickness, or thicker as recommended by the manufacturer and required for protection:

First coating : 100 μm
Second coating : 100 μm

The contractor shall submit test certificates from the manufacturer for every batch of paint supplied. The contractor shall arrange for testing of paint (samples taken from every batch supplied) from approved laboratory if the Employer directs to do so. Test results shall be submitted to the Employer for approval.

3.4.6.5 Galvanizing of Structural Steel

Galvanising of structural member shall conform to IS 4759, 209, 2629, 2633 and 6745. Galvanizing of each member shall be carried out in one complete immersion. Double dipping shall not be permitted, however, in case of members over 7.5 m long, the Contractor shall take prior approval of Employer for double dipping.

Wherever galvanized bolts, nuts locknuts, washers, accessories etc. are specified, they shall be hot-dip galvanized. Spring washers shall be electro-galvanized. Re-chasing of bolt threads after galvanizing shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable rocking of the nuts on the bolts. Readily available GI nuts, bolts and washers conforming to galvanizing requirements may also be used after obtaining approval of Employer.

All galvanized members shall be treated with Sodium dichromate solution or an approved equivalent after Galvanizing, so as to prevent white storage stains.

Contractor shall ensure that galvanizing is not damaged in transit. In the event of occurrence of any damages Contractor shall at his own cost adopt scraping and re-galvanizing the member to satisfy the specific requirements. Cold galvanizing using zinc rich products may be used, as approved by Employer.

1.3.7 Water Supply and Sanitary Works

All works shall be as per the best practices and standards to be complete in all respects and be free from all functional faults.

3.4.7.1 Sanitary Installation

The work covered under this section includes approved quality sanitary ware, accessories and their installation. The work shall be carried out complying in all respects with any specific requirements of the local body in whose jurisdiction the work site is located and as approved by Employer.

Any damage caused to the building, or to installations therein, either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the Contractor.

All sanitary ware shall be glazed earth ware of fireclay as per the approved drawings and shall be the best quality manufactured by approved manufacturer and shall be finally approved by Employer prior to installation. All white glazed porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal etc. shall have hard durable white glazed finish. The material shall be free from any wrap, cracks, blemishes, blisters, uneven glazing and shall be smooth and free from crazing and deformations. Joints between earthenware and pipes shall be made perfectly air and water tight by caulking with neat cement mortar.

3.4.7.2 Water Closet and Cistern

Indian Type Water Closet

This shall be Orissa pattern of size 580 x 440 mm with integrated type footrest made of white vitreous china conforming to IS 2556 part-III. High level flushing cistern of 10 litres capacity of approved make shall be Vitreous china (IS: 774) or Plastic cisterns (IS: 7231).

European Type Water Closet

This shall be "Siphonic Wash down type" of white vitreous china conforming to IS: 2556 (Part VIII) fitted with toilet seat water Jet or hand spray system. Standard toilet paper roll holder of approved type shall be provided, and this shall be surface mounted type fixed with CP counter sunk brass screws. Low level flushing cistern of 10 litres capacity of approved make shall be Vitreous china (IS: 774) or Plastic cisterns (IS: 7231) with all fittings and accessories.

3.4.7.3 Urinals

The urinal shall be half stall urinals of size 580 x 380 x 350 mm of white glazed vitreous china conforming to IS 2556 (Part VI). Granite stone partition slabs shall be provided as per the approved drawings between two urinals. Automatic flushing cistern (5 / 10 litres as required) for urinals conforming to IS.2326 shall be provided.

3.4.7.4 Wash Basins

Wash basin shall be of white vitreous china of size 630 x 450 mm with a pair of 15 mm C.P. brass pillar taps, 32 mm C.P. brass waste of standard pattern and other fittings. All the waste fittings and installation shall be as per approved drawings and as directed by Employer.

3.4.7.5 Sinks

The laboratory sink shall be white vitreous china conforming to IS 771 (Part-III) & IS 2556 (Part-V).

The Stainless steel sink shall conform to IS 13983 and as approved by Employer.

The waste fittings and plug fittings shall be Brass chromium plated. The chromium plating shall be of service grade No.2 conforming to IS 1068.

3.4.7.6 Stop cocks and Bib Cock

Stopcocks and Bib Tap shall be of brass heavy class, chromium plated and of approved manufacture and pattern complying with IS: 781. They shall be of specified size and of the screw down type. The bib cocks shall open in anticlockwise direction. Chromium plating shall be done in accordance with IS: 1068.

3.4.7.7 uPVC Pipes for Rain Water Pipes, Soil Waste and Vent Pipes and Fittings

The specification covers requirements for plain and socket end un-plasticized polyvinyl chloride (UPVC) pipes for use for soil and waste discharge system inside buildings ventilating and rain water applications. All UPVC pipes and fittings shall conform to IS: 13592 (Type-A for rain water pipes & Type-B for soil pipes). Pipes shall be fixed to the wall by W.I. or M.S. holder bat clamps, unless projecting ears with fixing holes are provided at socket end of pipe. The clamps shall be fixed to the walls by embedding their hooks in cement concrete blocks (1:2:4) 10 cm x 10 cm making necessary holes in the walls at proper places. All holes and breakages shall be made good. The clamps shall be kept 25 mm clear of the finished face of the walls to facilitate cleaning and painting of pipes.
Pipes of other new/ appropriate materials shall be used as per application and exposure conditions – as approved by Employer.

3.4.7.8 Poly Propylene Pipes

Three layer PP-R (Poly propylene Random copolymer) pipes PN-16, UV stabilized & anti - microbial fusion welded, having thermal stability for hot & cold water supply shall be used. The fittings shall include all PP – R plain & brass threaded polypropylene random fittings.

3.4.7.9 HDPE Pipes

HDPE Pipes of class PE – 80, PN – 4 shall be used. All pipes shall be ISI marked, manufactured as per IS 14333 – 1996 (Amended up to date). The pipes shall be procured only after approval of the manufacturer by the Employer.

All the tests as specified in relevant IS code shall be performed by the contractor at the manufacturer's place in presence of Employer / Employer's representative and/ or by third Party inspector. The contractor / firm shall submit the name of manufacturers of HDPE pipes from whom he is going to procure the pipes for verification of his ISI mark and previous experience in the field of manufacturing of pipes. The bedding below the pipeline shall be provided as per approved pipe bedding drawings. The backfilling shall be done only after inspection of joints by the Employer is completed and approval given.

The HDPE Pipe manufacturer shall submit test certificates for raw material used for each lot of HDPE Pipes duly supported by purchaser invoices at the time of supply/inspection.

Employer reserves the right to inspect the Pipe Manufacturing unit if required to evaluate the capability and quality assurance before approving the make of pipes.

i. The Colour of the HDPE pipe shall be black,
ii. No reworked material to be used.
iii. The pipes shall be supplied in straight lengths of minimum 6m.
iv. The internal diameter, wall thickness, length and other dimensions of pipes shall be as per IS: 14333.

The manufacturer should provide the test certificates for the tests conducted for each lot of pipes dispatched. The acceptance tests can be performed in the in-house laboratory of the pipe manufacturer. The Employer will depute his representative who will check and approve each lot of the pipes manufactured before they leave the factory after ensuring that they are meeting the required specifications.

Jointing of HDPE Pipes

Jointing between HDPE pipes and specials shall be done as per IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with butt fusion welding using semi-automatic, hydraulically operated, superior quality butt fusion machines which will ensure good quality butt fusion welding of HDPE pipes.

Installation and testing

The HDPE Pipes shall be laid in accordance with the latest IS 7634 Part-2. The pipe shall be laid over 150 mm thick sand bedding. After installation, the pipe shall be provided all around with 150 mm sand cover and then backfilled with the excavated material up to the formation level.

3.4.8.1 Valve Chambers

Valve chambers of adequate size to accommodate valves shall be constructed as per the site condition. The construction shall be similar to that for Inspection Chambers except for benching for the drain pipes. Suitable hand railing on wall of the wall chamber shall be provided.

3.4.8.2 Pipelines, Pipe Work & Fittings

3.4.8.2.1 Ductile Iron Pipes and Fittings

General: -

The specification pertains to ductile iron socket and spigot pipes and fittings (suitable for jointing with rubber gaskets) with ISI make and in standard length and of classes mentioned in the bill of quantities confirming to IS -8329/ IS 9523 with all up to date amendments and revision. The prices should be quoted shall be inclusive of all taxes, transportation loading, unloading from the railway wagons, carting to site of work, stacking at site of work (F.O.R.) site of work including all the taxes and duties. Ductile Iron pipe manufacturer must have ISI licence for the entire range of DI pipes and fittings required for this tender as on date of submission of tender. The ductile iron pipes and fittings including specials shall be sources/supplied by the same manufacturer.

Material :-

The Ductile Iron Pipes and Fittings material shall confirm to the requirements of IS 1387 of 1993 (second revision/latest revision) for General requirements for supply of metallurgical materials and further shall also confirm to all the other mechanical requirement conforming to IS 8329.

Manufacture: -

The Ductile iron pipes and fittings shall be manufactured confirming the procedure laid down in various clauses of IS 8329-2000and IS 9523 :2000 with all amendments.

Mechanical test: -

Shall confirm clause10 J IS: 8329-2000

Hydraulic test :-

Shall confirm clause 10 J IS: 8329-2000

Cement motor lining :-

Shall confirm Annex B of IS: 8329-2000

Rubber gasket: -

Rubber gasket used for jointing shall be of EPDM rubber gasket and physical properties of gasket material shall confirmed to IS: 5382-1985.

Test Reports: -

The contractor shall have to produce the original copy of manufacturer's test certificate & third party inspection certificate from organisation such as DGS & D, SGS, EIL, RITES, Bureau Veritas or any other agency authorized by DJB for quality and strength of D.I pipes.

Transportation :-

The DI pipes and fittings shall be transported to the site of work. Necessary case shall be taken during loading, unloading, transporting, stacking of pipe to avoid damages, cracks etc. Transporting, loading, unloading, stacking shall be done by the contractor at his own cost. No payments will be done for the damage or crack pipes.

LOWERING, LAYING, JOINTING D.I. PIPES: -

The DI pipes and Fittings will be transported to the site of work where actually they are to be laid and jointed. All necessary steps shall be taken to prevent damage to pipes during transport, loading, unloading, operations etc. only approved method for conveyance loading and unloading, stacking operations etc to be followed. Only approved method for transportation, loading, unloading, stacking operations using mechanical means such as Cranes, Hydra, etc. may be adopted. The DI pipe and fittings should be laid as per guidelines provided in IS 12288.

1.22.1.1. Laying of Pipes Under Ground :-

The pipes should be lowered into the trench with tackle suitable for weight of pipe. Either a well-designed set of shear legs or mobile crane shall be used for lowering of pipe into the trench. When lifting gear is used the positioning of the sling to ensure proper balance should be checked when the pipe is just clear of the ground. The pipe should be clearly cleaned of any debris inside the pipe either before or just after joint is made. When the laying is not in progress the temporary end closure should be securely fitted to the open end of pipe line.

On gradient of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of socket of the laid pipe during jointing operation. As soon as the joint assembly is completed. The pipe should be held in position while the trench is back filled over the barrel of pipe. The designed anchorage shall be provided to resist the thrust developed by internal pressure at bends, tees and other specials etc. At places where fittings such as bents tees and other fittings are installed, the restrained joint pipes and fittings shall be used to resist the thrust forces. The length of restrained joint pipes shall be calculated taking into account the maximum pressure, the pipeline is to carry in service or on test and the safe bearing pressure of the surrounding soil.

1.22.1.2. Cutting and Chamfering to D.I. Pipes :-

This item shall be executed for use of cut pipes in required length only when directed by Employer and after obtaining the permission from him. The burn left after cutting should be trimmed off by light grinding or by filing method. The chamfering of pipes shall conform to IS 12288 — 1987 or as per the manufacturer recommendation.

The chamfering shall be suitable for push on joints / mechanical joint without damaging the rubber gasket. The pipe after chamfering should be so smooth that enables to push in gasket for push-on-jointing. This item includes cost of all labour and tools required for executing the complete item.

1.22.1.3. Jointing of Pipes: -

The DI pipes should be jointed either with flexible joints / EPDM rubber gasket joints or by rigid flanged joints. The pipes shall be jointed by the rubber gaskets (EPDM) except where there are specials / valves to be jointed to the pipeline. The EPDM rubber gasket of suitable size required for laying of DI pipes shall have to be procured by the contractor at his own cost. The EPDM gasket should confirm to IS 5382-1985.

Before assembling the joint the spigot of one pipe and the interior of the socket of the adjacent pipe should be thoroughly cleaned. The insertion of the gasket can be facilitated by the prior application of a thin film of food grade lubricant to the bulb seating the inside the socket. The rubber gasket should be wiped clean, flexed and then placed in the socket with the bulb towards the back of the socket. The groove in the gasket must be located in the retaining heel in the socket and the retaining heel of the gasket firmly embedded in its seating. It is necessary to ensure that the EPDM gasket fits evenly around the whole circumferences removing any bulges which prevent the proper entry of the spigot end. In the larger diameter this operation may be assisted by forming a second loop in the gasket opposite the first then pressing the loop flat one after the other.

A thin film of food grade lubricant should be applied to the inside surface of the gasket which will be in contact with the entering spigot. In addition a thin film of lubricant may be applied to the outside surface of the entering spigot for a distance of 25 cms from the spigot end. The pipe to be jointed should be supported centrally by the tackle used for laying and balance just clear of the trench bottom. The spigot of the pipe must be aligned and entered carefully into the adjacent socket until it makes contact with the gasket. Finally assembly of the joint is completed from this position. Joint assembly is completed by forcing the spigot end of the entering pipe through the gasket, which is thus compressed until the spigot end reached the total depth of the socket, if the assembly is not completed with the application of reasonable force, the spigot should be removed and the position of the gasket examined. For joints 200 mm and above rack and level tackle may be used for completing assembly wherever found necessary at the cost of contractor.

The rack is placed on the socket with the hooked end of the rack extending over the spigot of the entering pipe. The tumble on the end of the 3.2 mtrs. Long socket rope is placed over the hook bolt on the rack, which should be in its lowest position, with nut of the top of the thread. The plain end of the rope is passed round the body of the pipe looped through the rope adjuster on the side of the rack housing, wedge inserted and the rope draw tight, this pulls the wedge home thus securing the rope.

The tackle is then tamped firmly to the pipe by tightening the nut on the work bolt once the length of the rope is correctly set, it is not necessary to loosen the wedge adjuster for subsequent joints unless the diameter of pipes being jointed in change. The thimble secured to one end of 6.1 m. wire rope is not loosed over the hook at the end of rack and the free end carried to the socket end of the pipe to be jointed. A special hook and rope adjuster is then fitted on to this rope and securely located in convenient position by means of the wedge. Once the position of the hook and rope adjuster has been thus set subsequent assembly of pipe of similar length should be subsequently jointed.

Hydraulic Test of DI Pipeline: -

The completed pipeline may be tested either in one length or 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.

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

Initial procedure

It is prudent to begin testing any particular pipeline in comparatively short lengths and to increase the length of test section progressively as experience is gained, until lengths of about 1.5 km or more are tested in one section, subject to consideration of the length of trench which it is permissible to leave open in particular circumstances.

Each test section should be properly sealed off preferably with special stop ends, designed for the safe introduction and disposal of the test water and release of air, which should be secured by adequate temporary anchors.

The thrust on the stop ends should be calculated on the full spigot external diameter and on the anchors designed to resist it.

Note: It may often be economical to provide a concrete anchor block, which has subsequently to be demolished, rather than risk movement of the stop ends during testing. Hydraulic jack may be inserted between temporary anchors and stop ends to take up any horizontal movement of the temporary anchors.

All permanent anchors should be in position and if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with clean, disinfected water, taking care that all air is displaced through vents at high points or by using a pig or a sphere. After filling, the pipeline should be left at working pressure for a period in order to achieve conditions as stable as possible for testing. The length of this period will depend upon many factory, such as movement of the pipeline under pressure, the quantity of air trapped and whether the pipeline has a cement mortar lining which absorbs water. If pressure measurements are not made at the lowest point of the section, an allowance should be made for the static head between the lowest point and the point at measurement to ensure that the maximum pressure is not exceeded at the lowest point.

All testing apparatus, gauges, connections, etc. and water required for testing shall be arranged by the contractor at his cost. The DJB does not undertake any responsibility to supply water for testing which the contractor has to arrange by paying the required charges directly. The DJB shall have the right to recover such charges from his bills if complaints are received that contractor has not paid the charges thereof. If there is delay in testing, the contractor shall refill the trenches for the time being and reopen them at time of testing at his own cost failure of which shall entitle the DJB to do the refilling and

reopening of trenches at the risk and cost to the contractor. If the trenches are filled due to any reason whatsoever before testing, the contractor shall have to open them for testing at no extra cost.

Field Testing of pipeline at site which has been installed or Actual field testing of DI pipe is guided by of IS: 12288 (Code of practice for laying ductile Iron pipes.) As per provision of this standard Clause 8.3 of IS:12288, a Ductile iron pipeline is to be hydro tested at site at the following pressure:-

2 TEST PRESSURE

A Ductile iron pipeline is to be tested at the following pressure

- Site Test Pressure (STP) = Actual working Pressure (exclusive of Surge) x 1.5 times

or

- Actual working Pressure (inclusive of Surge) + 5 bar , whichever is higher

NOTE: Actual working Pressure (inclusive of Surge) = 1.2 x Actual working Pressure (exclusive of Surge)

TEST PROCEDURE

- After the line is filled up with water, it should be left in that condition for 24 hours, to allow the cement mortar lining to absorb water and the dissolved air to come out
- The pressure in the pipeline should be raised steadily until the site test pressure is reached in the lowest part of the section
- The pressure should be maintained, by pumping if necessary, for a period of 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 original pressure should be restored by pumping and the loss measured by drawing off water from the pipeline until the pressure reached at the end of the test is reached again
- The acceptable loss should be clearly specified and the test should be repeated until this is achieved. The generally accepted loss for DI Pipe is 0.02 l./mm. of nominal bore per kilometer of pipeline per 24 hours per bar of pressure applied head (calculated as the average head applied to the section under test). The rate of loss should be plotted graphically to show when absorption is substantially complete

3 DETECTION OF LEAKS

If the test is not satisfactory, the fault should be found and rectified. Consideration should be given to leak detection methods such as:

- Visual inspection of pipelines, especially each joint, if not covered by the backfill
- Aural inspection, using a stethoscope or listening stick in contact with the pipeline
- Use of electronic listing devices including leak noise correlators which detect and amplify the sound of any escaping fluid; actual contact between the probe and the pipe may or may not be essential
- Use of a bar probe to detect signs of water in the vicinity of joints, if backfilled
- Where there is difficulty in locating a fault, the section under test should be subdivided and each part tested separately.

NOTE: A pneumatic test with an air pressure not exceeding 2 bars may be used to detect leaks in pipelines laid in waterlogged ground.

After all section has been jointed together on completion of section testing, a test should be carried out on the complete pipeline. During the test, all work, which has not been subject to sectional tests, should be inspected.

3.4.8.3.2 Reinforced Cement Concrete Pipes

RCC pipes shall be in accordance with the relevant clauses of IS: 458:2003. The pipes shall be with Socket and Spigot ends with rubber ring type-2 as per IS:5382. The pipes shall be lined with 2 to 3mm thick HDPE lining.

3.4.8.3.3 Built-in Pipe-work and other Plant

The pipes and other Plant in water retaining structures shall, wherever possible, be built in as the work on the structure proceeds. The Contractor shall ensure that delivery of the requisite pipe work and other Plant is in accordance with the requirements of the construction program.

Where a pipe subject to thrust passes through a concrete structure or where an external seal is required, a puddle flange shall be used. The puddle flange dimensions shall conform to BS: 4504/ IS 6392, 13159, etc. or as required/ directed. The puddle flange shall be fixed to the collar pipe through welding only and shall not be drilled. The puddle flange and collar arrangement shall be fixed at right angle to the RCC wall during casting of the wall. The exterior of the pipe shall be cement washed symmetrically about the puddle flange by the manufacturer for a length at least equivalent to the thickness of the wall through which it passes.

The Contractor shall be responsible through every stage of the Works for checking the correctness of the setting of built-in Plant and shall satisfy himself they are positioned in accordance with his approved drawings.

3.4.8.3.4 Thrust Blocks

Thrust blocks shall be designed and installed wherever there is a change in the direction/size of the pipe line or the pressure line diagram, or when the pipe line ends at a dead end. If required, thrust blocks shall be constructed at valve location also.

The contractor shall prepare design and drawings of the thrust block and get it approved by Employer. The minimum grade of concrete for construction of thrust block shall be M-25. Minimum required reinforcement to be provided, but not less than 10dia bars at 200mm c/c, all faces, both directions.
For slopes up to 30 degree good well drained soil carefully tamped in layers of 100 mm under and over the pipe, right up to the top of trench will not require anchoring.

For steeper slopes, one out of every three pipes shall be held by straps fastened to vertical supports anchored in concrete.

3.1.1 Plant Roads, Cross Drainage, Roadside Drains and Ground Pathways

3.4.9.1 Plant Roads

The roads shall consist of the following crust or layers. These are the minimum specified; however, the thickness and number of layers may change as per the design requirements:

1. Soil subgrade shall be well compacted and tested at OMC to 97% Proctor density. The soaked CBR value of remoulded subgrade soil samples at the specified dry density and moisture content shall not be less than 7% (average of at least 3 specimens), unless specified otherwise.
2. The Water Bound Macadam – shall consist of minimum following layers:

a. Grading-1 - one layer of 100 mm compacted thickness of aggregate size ranging from 90 mm to 45 mm graded.
b. Grading-2 - One layer of 75 mm compacted thickness of aggregate size ranging from 63 – 45 mm graded.
c. Grading-3 - One layer of 75 mm compacted thickness of aggregate size ranging from 53 – 22.4 mm graded.

3. Screening to fill the voids in the coarse aggregate shall be clean, dry stone dust / moorum other non-plastic material having liquid limit and plasticity index below 20 and 6 respectively provided fraction passing 75 micron sieve does not exceed 10%.
   Binding material to prevent revelling of WBM shall consist of fine grained material possessing P.I. Value up to 6. Application of binding material shall not be necessary where murrum or gravel is used as screenings.
4. Construction of earthen shoulders of approved design shall progress side by side with WBM construction. These shall be raised as the constructed height of road progresses. The top surface of the shoulder shall consist of 80 mm thick Paver blocks manufactured in minimum M 40 grade concrete laid over cement-sand (1:10) of 25 to 50 mm compacted thickness. The top surface of interlocking Paver Blocks shall be flushed with Bituminous road surface on one side and top of drain on the other side.
5. Tack coat consisting of a single coat of low viscosity liquid bituminous material to the WBM granular surface. The correct quantity of bituminous material shall be decided by Employer and shall be such that the maximum amount that can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of 10 mm. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Employer.
6. Top layer shall be 50 mm thick dense graded bituminous macadam of prepared in hot mix plant. The Marshall method shall be used for determining the optimum binder content.
7. The bituminous macadam shall be covered with 2 (Two) cm premix carpet surfacing comprising of stone chippings and bitumen emulsion including consolidation with road roller of 6 to 9 tonne capacity.

The initial or breakdown rolling shall be done with 8–10 tonne dead weight smooth-wheeled rollers. The intermediate rolling shall be done with 8–10 tonne dead weight or vibratory roller or with a pneumatic tired roller of 12 to 15 tonne weight having nine wheels, with a tyre pressure of at least 5.6 kg/sq.cm. The finish rolling shall be done with 6 to 8 tonne smooth wheeled tandem rollers. The schedule of rolling shall be as directed by Employer.

In case of difference in specifications of new roads and repaired sections (including shoulders), the directions/ decision of the Employer shall be final.

3.4.9.2 Path Ways

Necessary pathways of 1500 mm width shall be provided connecting various roads to the units. The pathways shall have factory made precast paver blocks 60 mm thick of M30 grade laid over cement-sand (1:10) of 25 to 50 mm compacted thickness. The sides of the pathways shall be protected by kerb stones manufactured in the factory. The area where pathways are to built shall be pre-rolled with a heavy roller after watering the soil.

3.4.9.3 Road Side Drains

Road side drains shall be designed for an intensity of 40mm/hr for 100% run off. The scope of work covered under this specification in general shall comprise of construction of rectangular surface drains. Surface drains shall be provided along the sides of the roads or pavements to collect surface water. Minimum size of drain shall be 300 mm w`ide & 300 mm deep. The surface drain should have sufficient capacity and longitudinal slope to carry away all surface water collected. The side drains

shall be provided at the edges of right of way. The outfall shall be towards the drain. The longitudinal bed slope not milder than 1 in 1000 shall be provided for the side drains.

All buildings and paved areas in the plant area shall be provided with catch drains for collecting the roof top and surface water. All the drains and catch pits shall be covered with factory made precast perforated RCC slabs. Wherever the drains have to cross the road way, cross drainage such as slab or pipe culverts should be provided. All drains having depth less than 0.75 m may be in brick work and greater than 0.75m shall be constructed in RCC. The contractor shall carryout structural designing of the drains and shall submit design and drawings to the Employer for approval.

In addition to above, provision shall be made for collection of roof top rain water from all the buildings in the Rain Water harvesting Chambers and transferred into the ground through Rain Water harvesting system.

In case of RCC drains, the bottom slab and side walls shall be of 120 mm thick (minimum) or as per designs and drawings approved by the Employer in RCC of grade M-25.

In case of drains constructed in brick work (minimum 230 mm thick, including bottom on minimum 100 mm PCC) the internal surfaces shall be plastered (1:4, 20 mm) and finished with a floating coat of neat cement.

The combined design of entire drainage system to be undertaken by the contractor. The old drains (as may be applicable) may be utilized, after proper cleaning and rehabilitation – if their section is sufficient as per the hydraulic design of the drainage system. In this consideration to be given for connecting catch drains.

Other alternatives such as providing piped drainage system with catch chambers arrangement and manholes may be considered, as approved by the Employer.

4.1 Rehabilitation Work

All rehabilitation works shall use the best practices, materials workmanship of the trade. The rehabilitation works shall have assured performance with minimal maintenance and shall exhibit no deterioration of the rehabilitated works. The contractor shall be solely responsible and liable for any deterioration or damage to the structure or part thereof during the stipulated design life. Specifications as given for new structures shall also apply to rehabilitated structures, as applicable. All parts of the structure have to be examined and in accordance with its condition it shall be rehabilitated - including buried parts of the structure. Special care to be taken for areas that are likely to be highly stressed and exposed. All repair and rehabilitation works shall be properly structurally designed.

The proposed scope of the rehabilitation works, keeping in mind the process/hydraulic requirements for the upgraded waste water treatment and the recommendations of the NDT report are mentioned at the relevant place. The same may be amended by the Employer in accordance with requirements of the works and conditional assessments. The techno-financial feasibility of the rehabilitation works is important, say compared to part or whole re-construction.

All materials to be used in repair methods are to be sourced from manufacturers (rather than resellers, etc.), the company should have the necessary ISO, etc. certifications and the products should also have the necessary Standards certifications. The certified and approved product/ data sheet should clearly indicate the proposed uses and compatibility with other materials used in the proposals. Necessary and recommended (including as required by Employer) tests are to be conducted for all materials prior to incorporation in the works. In the event a product adheres to foreign standards and the same cannot be tested and certified here in India – then equivalent tests shall be formulated, conducted and certified by reputed approved agencies. Each batch of the product has to sampled and tested in sufficiently representative numbers. Test certifications from laboratories abroad may be

accepted as long as they are from government agencies and/or attested by government agencies so authorized to do so. In general the product shall also have successful usage history and certifications of quality and performance from long standing reputed testing/ research agencies like CBRI/ CSIR, etc. Note this area is driven by need cum supply of products available as solutions - and there are no unique solutions or products, each varying somewhat - therefore all due care and diligence to be undertaken to ensure compatibility and durability.

NDT report(s) available are annexed with the bid document for general information and guidance. The contractor will assess the actual reinforcement provided by exposing the same after removing/ chipping the cover. The contractor to submit alternative schemes/strategies for rehabilitation along with calculations to show structural sufficiency of strength and durability for various parts of different structures. Only the approved scheme/strategy shall be incorporated in the works.

A suggestive/ preliminary list giving items that are likely to be incorporated in the rehabilitation works is given in the bid document. The bidders should supplement this list with items that are likely to be incorporated in the works at the pre-bid stage, in the pre-bid meetings. Accordingly, a comprehensive list shall be prepared and the rates shall quoted for each item in this comprehensive list. The list should include suggested products and brands/ sources to ensure that products inferior to those proposed while quoting rates are not used later. Works shall be undertaken as per the item rates of the approved rehabilitation strategy/methodology.
The rehabilitation proposals/ strategies shall be submitted along with appropriate structural calculations showing the strength of the rehabilitated structure (which should be safe and durable as per latest codes or older version of the code, as may be considered applicable by the Employer). Necessary post repair/ rehabilitation tests shall be done to check the quality of the rehabilitated works, as ordered by the Employer or his representative. The cost of all such tests, etc. shall be deemed to be included in the bid price quoted.

All works shall be assured and warrantied by the contractor with full responsibility for performance, guarantee and assurance for replacement, etc. at his cost if the works are found deficient and the Employer so conveys/ orders the contractor to do so i.e. repair and/or replace.

It is possible that the quality of the old structures has so deteriorated that rehabilitation becomes unviable, in that event the structure has to be reconstructed anew (in part or whole). During reconstruction the sizes, capacities may be modified marginally (maximum 10%). The reconstruction shall be undertaken as per latest codes and requirements of the specifications for new structures. The works shall be done as per the quoted rates for the relevant items. In the absence of any rate those derived from CPWD DSR shall be apply. In this and all related issues the decision of the Employer shall be binding and final.

Technical submissions of the contractor to be pre-vetted by certified, qualified and trained professionals in the field. They shall not be based on sales documents, etc. Similarly, the execution of works shall be undertaken and supervised by professionally qualified and trained personnel.

Acceptance criteria: The design life of the rehabilitated structures to be at least 30 years. The strength and durability of the rehabilitated structure shall be assessed as per the latest relevant codes and in some rare cases they may deemed to be satisfactory if they meet the criteria of the older codes, if and as considered applicable/ acceptable by Employer.

The criteria for acceptable strength and durability of old deteriorated and chemically aged concrete cannot be the same as for new concrete, as may be given in building codes, especially as the cores may include aged and carbonated/hardened layer. For acceptance, the old concrete shall (after rehabilitation treatments) generally not be less than M20 (20 N/mm2), with similar stress strain behaviour as new concrete. Statistical methods for assessment based on sampling and testing shall be as given for new concrete or as applicable. Calculations have to show that the rehabilitated structure is

safe in strength and durability. Cost of all sampling & testing to be borne by the contractor as required/ directed by the Employer.

Similarly for new rehabilitation materials, to be incorporated in the rehabilitation of works, the strength shall not be less than M35 (35 N/mm2 compressive strength) and the same shall be used in calculations for satisfactory acceptance. Similar assessment to be done for all stresses such as shear, bonding, anchorage, tension, bending, delamination, etc. Cover requirements as per the exposure condition shall not be diluted as stipulated in the codes. In general the overall requirements of the rehabilitated structure shall be the same as for new structures.

Documentary submission requirements for rehabilitation of structures shall at least be as mentioned elsewhere for the works. Structural strength and durability assessment check may consider the sandwich nature of rehabilitated cross section of different materials. In cases, such as in the roofs of existing buildings, the load of repair/ rehabilitation and water proofing, etc. should not be more than the original load on the roof unless extra strengthening is taken into account.

The working platforms, staging, scaffolding, etc. shall be installed and dismantled in safe and prescribed manners without causing any damage to the existing structures.

There is overgrowth at site which is at places impinging upon the structures. The damage due to this shall be properly investigated and all such overgrowth which is causing or likely to cause deleterious effect on the structures shall be removed to provide clear space around structures. Necessary permissions shall be obtained by the Contractor from the Employer and the concerned agencies. Required anti-termite and anti-weed treatments shall be provided for underground structures and the roofs (where soil is likely to deposit over time). Bare soil shall not cover the roofs of the structures and top tiling or other impermeable/ waterproof provisions to be provided in addition to waterproofing of the RCC slab.

All below mentioned brands, tets, repair strategies and materials are suggestive and indicative to indicate some minimum standards of works expected. All works shall in general undertaken with the best materials, workmanship, quality assurance, etc. as per the best practices of the trade. In this evolved methodologies of foreign codes may be adhered to, as similar literature is yet unavailable for India. In this particular mention is made of the European (EN), American (ACI, etc.) and British guidelines and standards – such as EN1504, ACI 546R, BS: 6089-81, BS: 1881, etc.

3.1.2 Other Civil work rehabilitation

1) Cleaning of external/ internal surfaces of the entire existing tanks complete. If concrete and plaster are damaged then the same shall be repaired as per instructions given below and apply anti-carbonation paint on buildings and cement paint on liquid retaining structures along with approved/ specified protective coatings.
2) Worn-out steel bars shall be replaced/ replenished with new one as required diameter using rebar fixing epoxy material.
3) Two coats (DFT of each coat > 40 microns) of Zinc rich epoxy primer shall be provided on reinforcement bars exposed during structural repairs. Along with other specified measures such as using rust converter, etc. as applicable.
4) A milky-white, Styrene-Butadiene (SBR) copolymer based latex liquid designed for use with Portland cement as a reliable water resistant bonding agent, etc. shall be used where repair are to be done.
5) For bonding old concrete to new freshly placed concrete / cementitious mortars. Solvent free, epoxy based bonding agent shall be used.
6) Concrete fibre reinforced repair mortar or micro concrete shall be used for structural repairs

of RCC elements / members including curing etc. complete.

7) Low-viscosity injection resin (high strength epoxy resin) shall be used for filling and sealing voids / cracks in RCC elements including curing etc., complete.

8) Long assured life and in accordance to exposure condition a flexible coating such as Acrylic modified cementitious flexible water proofing coating shall be provided at the junction of wall and base slab of liquid retaining structures extending up to 750 mm vertically and horizontally from the junction. This shall be as approved by the Employer.

9) All the damaged plaster in Existing building shall be removed completely and finished with new plaster after applying cement slurry (with appropriate admixture) as a bond coat.

10) For building internal surface- Oil bound distemper of approved shade and as directed by Employer.

11) Exterior of all the buildings shall be painted with two or more coats of anti-carbonation painting as per specifications.

12) Protective coating should be food grade. It shall be applied to the inner surfaces of the tanks and feeding ducts. It shall be suitable for higher concentrations of the chlorine and also protect the concrete from other corrosive effects. It should be abrasive resistant and chemical resistant. In general it should be non-toxic and solvent free. The multiple coats shall achieve DFT to provide an effective life of 10 years. The coating shall be easily repairable/ reapplied. In general epoxy based coatings shall be used. In this use of appropriate (say glass) tiles may be considered which can give a very long life with good protection due to the inert nature of the material and thickness of the tiles. The adhesive and filler material used between the gaps shall have the properties detailed above. All rehabilitated areas, shall be given a long life assured protective coat as per exposure condition. All protective coatings in different zones (splash, submerged, air & soil exposed) shall be compatible at the interface of two or more zones. For soil exposed faces bituminous based coatings shall be applied, as approved by Employer.

13) The floor slab of the water retaining structures shall be finished with 50 mm thick M-25 grade screed concrete with neat finish at top surface, as required. Styrene-butadiene (SBR) copolymer latex multi-purpose admixture may be mixed with cement, or other admixtures used for designing the mix, in preparing screed concrete. For fixing the proportions manufacturer's recommendation shall be binding. The SBR admixture should be compatible with all types of OPC and other cements. The screed concrete should be abrasion resistant.

14) If the condition of existing parapet is wobbly over roof. The same shall be demolished and constructed anew.

15) Removing of existing and re-fixing of new rain water pipes (UPVC) inclusive of clamping to structure bends fittings etc.

16) Completely dismantle flooring of existing Pump Houses and laying/providing new CC Flooring with metallic hardener topping and Dado in ceramic tiles- 2.1 M in UG portion and 0.9 M in above GL portion. In existing control Room, MCC Room, Belt filter press building, etc. with CC Flooring with metallic hardener topping – all as per specifications.

17) Repair/New Plinth protection shall be done all around the building. The apron shall be 1000 mm wide and in PCC M-20 grade laid to slope of 100 mm to 75 mm. the apron shall be rest on well compacted, watered levelled and thoroughly consolidated ground. Necessary bonding agents and admixtures to be used for repair mixes.

18) If the existing pathways or parts thereof are required to be demolished and constructed anew the same be done as per the specifications.

19) The unserviceable roof top of the existing building should be made approachable by providing stainless steel cat ladder, as per requirements.

20) All the existing water retaining structures shall be made approachable by providing SS

staircase, as per requirements.

21) All the existing railing in the plant shall be replaced with new SS railing as per approved drawing and specifications.

22) Replace all the existing Doors, Windows and Ventilators with new uPVC or Aluminium Doors, Windows and ventilators, or as directed/approved by the Employer.

23) Existing sliding grills and old rolling shutters shall be replaced with new galvanized material products as per conditional and functional requirements. However in rare cases, if they are in very good condition then the same need to be retained then they should be repaired, made fully functional and painted, all as directed by the Employer.

24) Replace all the existing fencing completely and provide and erect PVC coated galvanized steel (wire to be 4mm and finished outer diameter to be more than 5mm) chain link fencing of minimum height 1.8 m.

Demolition

Demolition procedure/ methodology, including list of equipment/ machinery shall be submitted for approval along with details of personnel that will be working to undertake demolition of various structures. Details of safety gear being mobilized should also be submitted.

Demolition and other works shall be carried out under proper supervision by qualified/ certified personnel only. All personnel should be adept at using the safety gear provided to them by the contractor. Necessary precautions will be taken to keep noise and dust nuisance to the minimum.
All glass, fragile and combustible material shall be removed from the structure before demolition begins.

Special measures have to be taken for enclosed areas such as digesters which have to be vented properly including neutralizing active chemical/biological contents. Wherever there are hazardous, inflammable or poisonous gases or other materials present, the same have to be removed/ dismantled with all the necessary safety and precautions.

In addition necessary masks, monitoring meters and neutralizing/ firefighting equipment has to be kept ready of any emergencies along with first aid equipment.

Before commencing demolition, the nature and condition of the concrete, the condition and position of reinforcement, and the possibility of lack of continuity of reinforcement shall be ascertained.
Attention shall be paid to the principles of the structural design to determine which parts of the structure depend on each other to maintain overall stability.

Safe and proper disposal of demolished and or emptied materials shall be the responsibility of the contractor and it shall be done in an environment friendly manner. In this the norm/ practice of the plant may be followed, as directed/approved by the Employer.

3.1.3 Replacement or Providing Additional Steel Reinforcement / Rebar's

If the diameter of corroded part of rebar / reinforcement steel after grit blasting is found reduced by more than 15% of the original diameter then the same be cut, removed and replaced with new rebar. The removal of bar has to be restricted to the minimum possible extent and the cut should be beyond the corrosion zone. The diameter of the new rebar to be provided shall be equal to or greater than the existing rebar diameter being replaced. The rebar's may be suitably lapped and tied or welded as di directed by Employer. Instead of replacing, the same be replenished with new bars along with the specified treatment of old bars.

3.1.4 Anchoring of New Steel Reinforcement / Rebar's

Replacing of worn out reinforcement/steel bars which has lost its section beyond the permissible limits or required any modification in the existing structure (e.g. columns, beams, wall and slabs) as per design by drilling/fixing (vertical or horizontal position) it with the rebar material.

The epoxy should be mixed in accordance with the manufacturer's recommendation and installed in the hole with a caulking gun or similar device that the place the epoxy in the end of the hole without air voids. The dowel should then be inserted and rotated to hold the dowel in place until the epoxy sets. It is important that the dowel not be pumped in and out of the hole during installation as air voids might be formed in the vacuum created when the dowel is pulled outward.

S.No.	Property		Requirements
1.	Number of mixers included	:	2
2.	Anchor type	:	Chemical anchor
3.	Compressive strength(ASTM C579)	:	≥ 80 MPa @ 7 days
4.	Flexural Strength (BS 6319, part 3)	:	≥20 MPa at 7 days
5.	Tensile Strength @ 25 ^{O}C(BS 6319, Part 7)	:	≥10 MPa at 7 days
6.	Pot life @ 40 ^{O}C	:	≥ 25 minutes
7.	Temperature range in application	:	0 – 40 ^{O}C
8.	Bond Strength	:	>2 MPa
9.	Temperature range in service	:	-5 – 60 ^{O}C

Consumption Table

Rebar Dia.(In mm)	Hole Dia.(In mm)	Consumption in ml(cm^3)										
10	14	10	12	13	15	17	19	21	24	29	34	39
12	16		13	16	18	20	22	25	28	34	39	45
16	22				36	41	46	50	57	68	80	91
20	28						77	84	96	115	134	154
25	32								100	120	140	160
Embedment(mm)		100	120	140	160	180	200	220	250	300	350	400

3.1.5 Priming of Steel Reinforcement

If reinforcement is corroded ensure that the back of the steel has been exposed and cleaned around its whole circumference. The reinforcing steel surfaces should be or grit blasted or wire brushed to remove all traces of corrosion. Ensure no oil, grease or dust is present. The blasted or prepared reinforcement steel should not be left uncoated. Cut back the concrete to at least 20 mm behind the reinforcing bars and coat with appropriate rust converter primer and the required zinc rich anti-corrosive epoxy coating. DFT of each coat shall be > 40 microns along with other treatment, etc.

3.1.6 Bonding Agent for Cementitious Mortars

Description

It is a solvent free epoxy resin based system bonding agent for bonding old concrete to new freshly placed concrete / cementitious mortars. It is supplied as a two component system, which is ready for onsite mixing and use.

Typical properties

Bond Strength : Greater than 10 N/mm^2 As per ASTM C - 882 - 05, which exceeds tensile strength of concrete.
Full Cure : 14 days

Standards

ASTM C 881-10-Type II & V, Grade 2 - Class B & C, or equivalent.

Direction for Use

Remove all grease, oil, contamination, dust laitance and loose concrete by scrabbling, wire brushing or other suitable methods. Any free - standing water should be removed and the surface shall be dabbed with some absorbent material.

Mixing: The total quantity of base and hardener components should be thoroughly mixed in the base container and transferred to other container before application, to ensure proper mixing.

Application: After mixing apply to the previously prepared substrate using a short haired stiff nylon brush, roller or trowel, ensuring thorough wetting of surface. In order to achieve a good bond, it is essential that the new concrete is laid whilst the bond coat is still tacky i.e. generally between 2 to 4 hours depending on temperature and humidity conditions present during this operation.

Coverage: Normally 2.5 to 3.5 m^2/kg depending on surface profile.

3.1.7 Bonding Agent (SBR) - specifications

Bonding Agent for Cementations Repair Mortars / Micro-Concrete

Description

A milky-white, Styrene-Butadiene (SBR) copolymer based latex liquid designed for use with Portland cement as a reliable water resistant bonding agent.

Typical Properties of SBR Copolymer Latex Liquid

1	Aspect	:	A milky, white styrene butadiene copolymer latex, specifically made for use with Portland cement.
2	pH	:	8 ± 1
3	Relative density	:	1020 ± 0.01 at 25^{O}C
4	Solid content	:	40 ± 1%

Substrate Preparation

Remove all laitance, oil, grease, mould oil or curing compound from concrete surfaces using wire brush, scabbler or other equipment as appropriate. Ensure that the concrete surface (where repairs are to be done) has been cut back to sound material.

Preparation of Bonding Slurry

Bonding slurry is prepared by mixing 1½ - 2 parts of cement to 1 part of SBR latex liquid by volume to a lump-free creamy consistency.

2 Liquid Integral Water Proofing Admixture - Specifications

It shall be ready-to-use Liquid admixture dispensed into the cement mortar together with the mixing water.

Properties

Appearance / Colour	:	Dark Brown Liquid
Chemical Base	:	Modified Ligno Sulphonate
Specific Gravity	:	1.08 ± 0.02
pH	:	≥6
Air entrainment, %	:	2 ± 1
Chloride ion content	:	<0.2%
Surface Absorption of water, BS 1881	:	Reduction of 60 – 80%
Test certification / approvals	:	IS 2645 IS 9103 ASTM C-494: Types A & D
Consumption	:	Min 0.3% by weight of cement or as per the manufacturer.

3. Polypropylene (PP) Fibres - Specifications

These shall be high performance polypropylene fibres for concrete and mortar as a crack controlling additive.

Properties

Constituents	:	Polymerised / Fibrillated polypropylene
Specific Gravity	:	0.91 g/cm3
Alkali content	:	Nil
Sulphate content	:	Nil
Air entrainment	:	Air content of concrete will not be significantly increased
Chloride content	:	Nil
Fibre diameter	:	15 - 30 micron
Fibre length	:	10 – 20 mm
Surface area	:	230 m2/kg min.
Young's modulus	:	3500-3900 MPa
Tensile strength	:	320-400 MPa
Melting Point	:	160 OC
Consumption	:	0.6 to 0.9 kg/m3 of Cement Mortar or as per Manufacturer

Other fibres may be uses as per design requirements as approved by the Employer.

3.1.8 Acrylic Polymer Dispersed Cement Based Waterproofing Slurry

Easy to apply by brush (slurry consistency); shall have good adhesion to prepared concrete and mortar substrates; good abrasion resistant; protects against water penetration, salt & carbonation and non-corrosive to steel & iron. The waterproofing slurry shall conform to IS 2645: Integral waterproofing compounds for cement mortar and concrete.

Technical data:

1.	Chemical base	:	Acrylic dispersion
2.	Polymer content	:	16% by weight
3.	Specific Gravity	:	1.03 kg/l
4.	pH	:	> 6.5
5.	Chloride	:	No added chloride
6.	Viscosity in seconds (B4 Ford Cup. 30 ^{0}C)	:	15
7.	Pull out Bond Strength by OPC at 28 day (cement : polymer= 2:1 by wt.)	:	1.10 N/mm^2
8.	Flexural strength(OPC) +10°C min. / +40°C max.	:	28 days = 8.50 N/mm^2
9.	Water absorption	:	6.0%
10.	Substrate Temperature	:	+10°C min. / +40°C max.
11.	Ambient Temperature	:	+10°C min. / +40°C max.

Application:

Concrete, mortar and masonry surface must be clean, free from grease, oil and loosely adhering particles. Steel and iron surfaces must be free from scale, rust, grease and oil. All surfaces must be as true and flat as possible. Saturate absorbent surface thoroughly.

A pre-batched mixture of good quality cement with clean fine sand (250 microns) should be prepared with cement and sand in equal proportions by weight. This should be mixed with readymade acrylic polymer dispersion in proportion of one part of polymer to four parts of mixture to form slurry. The mixing of slurry should be done in a clean container by slowly adding the cement sand mixture to polymer dispersion and stirring with a slow speed mixer (500 - 600 rpm). Mixing should be done until the consistency is free from lumps.

Dampen all surfaces immediately ahead of the slurry application. Whilst the surface is still damp from saturation, apply the first coat and leave to harden (2-6 hrs.). For slurry consistency apply with a hard plastic bristled brush or broom. After the second coat has been applied, finish by rubbing down with a soft dry sponge. Slurry should be applied at the rate of 3-4 kg/m^2 for two coats. Use damp hessian or polythene to aid curing, for 3 days. Then allow to dry out.

3.1.9 Patch Repairs in RC Elements

Structural repairs where the thickness of repairs is up to 50 mm, shall be carried out by dual shrinkage compensated, trowel able fibre reinforced thixotropic repair mortar. When mixed with amount of water, as recommended by manufacturer, shall produce a dual shrinkage compensated thixotropic, high strength repair mortar. The repair mortar shall possess excellent bond characteristics to steel reinforcement and concrete. The repair mortar shall be suitable for sprayed or trowelled applications, in both vertically and overhead.

3.5.13.1 Technical and Physical Properties Dual Shrinkage Fibre Reinforced Thixotropic Mortar

S.No.	Property		Requirements.
1.	Appearance	:	Powder containing micro fine fibres
2.	Compressive strength	-	**ASTM C 109 on 7 cm cubes**
	(a) 1 day	:	> 15 N/mm^2
	(b) 7 days	:	> 35 N/m m^2
	(c) 28 days	:	> 45 N/m m^2

3.5.13.2 Application Procedure

Substrate preparation and reinforcement treatment as given above in related sections. Thoroughly saturate the surface of the concrete to provide a saturated surface dry condition. Any surface water should be removed using an oil free compressed air jet or air drying may be resorted to.

3.5.13.3 Mixing and Preparation of Mortar

Only mechanical mixing is allowed. Mixing shall continue for minimum 3 minutes and ensure that the mortar is homogeneous and lump free. The water should be added within the limits as advised by the manufacturer and until the required consistency is achieved.

3.5.13.4 Application

After mixing, the mortar can be sprayed (spraying units as per the manufacturer) or trowel applied. For small patches, hand application shall be resorted to. While applying by hand, the mortar must be forced tightly into the substrate to ensure intimate contact with the pre-wetted substrate. Levelling and initial finishing should be carried using a wooden or plastic float. Final finishing should be carried out using a steel float.

When the material has stiffened to the point where finger pressure lightly marks the surface, a final firm trowelling should be given using the steel float.

3.5.13.5 Curing

Curing by covering the work with plastic sheet fixed over wet hessian or wet foam rubber.

3.1.10 Micro Concreting

Micro concrete pourable mortar shall be a dual shrinkage compensated, high flow, and high strength one component formulation and suitable for placing in thickness of 25 to 200 mm. Micro concreting shall be used for vertical or horizontal structural repairs. Bonding agent shall be used if manufacturer recommendation. Grain sizes shall be as per datasheet of manufacturer.

3.5.14.1 Technical and Physical Properties of Micro Concrete Pourable Mortar

S.No.	Property		Requirements
1.	Appearance	:	Powder form
2.	Compressive strength	-	**ASTM C 109 7 cm cube**
	(a) 1 day	:	> 20 N/mm^2
	(b) 3 days	:	> 35 N/m m^2
	(c) 7 days	:	> 45 N/m m^2
	(d) 28 days	:	> 55 N/m m^2

3.5.14.2 Application Procedure

Substrate preparation and reinforcement treatment as given above in related sections.

3.5.14.3 Application

The prepared substrate should be pre-soaked, preferably for 24 hours, but at least 2 hours before applying ensure all water is removed from formwork and formwork is resealed. Micro concrete should be pumped or poured into the prepared formwork until the void is filled. Pumping is recommended for larger pours. Do not vibrate as it could lead to segregation. The formwork should be

removed after 1-3 days and cured as per manufacturer instructions. If subsequent coats are to be applied the use of clear polythene is recommended for the first three days after removal of formwork. For repairs beyond 80m m to 100mm in thickness, extend micro concrete mortar with up to 12.5kg of 5-12mm sized washed, saturated surface-dry (SSD), graded low absorption, high density aggregates.

3.5.14.4 Curing

After formwork removal the repaired area shall be cured as per manufacturer instructions.

3.1.11 Surface Crack Repair

Often, due to Building/structural ageing or poor masonry, joints and surface crack develop on exterior/interior walls shall be filling by a flexible, solvent free, adhesive and epoxy polysulphide or equivalent (such as PU, etc.) sealant, which has excellent flexibility, excellent weathering characteristic with rain, snow and ultraviolet light and very good adhesion to concrete, it has a particular advantages of bonding firmly to damp surfaces. The sealant shall be suitable for an application thickness up to 12mm in width.

3.5.15.1 Technical and Physical Properties of Sealant

S.No.	Property		Requirements
1.	Composition	:	2 part solvent free epoxy resin
2.	Pot Life	:	70mins@27 ºC
3.	Temperature range (application range)	:	10 ºC to 40 ºC
4.	Temperature range (in service)	:	0 ºC to ≥70 ºC

3.5.15.2 Application Procedure

Open the cracks and widen them to form a ‘V’ shaped groove. Clean the area thoroughly free from oil and dust completely. Apply the first coat by using a spatula or putty knife press the paste firmly in to the crack by consecutive perpendicular layers to avoid leaving air pockets and level with the surface and allow to dry.

3.1.12 Grouting in RC Elements

A two component epoxy resin system based on low-viscosity resins for grouting walls / base slabs / launders etc. and other RCC members. It shall be highly penetrative and cures to form a permanent seal against ingress of corrosive fluids and gases and is capable of restoring integrity to structural elements. It should resist hydrostatic pressure and block penetration of deleterious substances.

Technical and Physical Properties of Solvent Free Non Shrinkage Epoxy Mortar

S.No.	Property		Requirements
1.	Composition	:	2 part solvent free epoxy resin
2.	Specific gravity of mixed material	:	1.05
3.	Final cure	:	10 days
4.	Compressive strength at 7 days	:	60 N/mm^2
5.	Bond strength (mean shear slant) at 14 days	:	19 N/mm^2 (ASTM C-881)
6.	Tensile strength at 7 days	:	20 N/mm^2 (ASTM D-638)
7.	Flexural strength at 7 days	:	70 N/mm^2
8.	Volatile content	:	1.5%
9.	Absorption 24 hours	:	0.2%
10.	Shrinkage	:	Passes (ASTM C-881)
11.	Permeability (cured resin)	:	Impermeable

Application Procedure

All cracks to be treated should be flushed out with clean, dry, oil free compressed air or inert gas (nitrogen). This should be done after drilling of injection holes or fixing nipples. Where loose mortar or aggregate exists these should be neatly routed out into a small U groove and the dust blown out. Manufacturer's instruction in this regard is to be followed.

Horizontal Application

For simple applications such as horizontal slabs, wider cracks can be filled simply by pouring in epoxy resin system. It may be necessary to make a small surface reservoir with mastic or a similar product by applying around the crack perimeter. This will avoid spillage and wastage of epoxy resin system.

Injection of Cracks on Walls

Using a percussion drill with a 10mm bit, drill access holes on either sides of the crack at approximately 45° angles to the centre of the plane of the crack. The drill is to pass through the centre of the crack plane at a depth of ¾th of the wall thickness. Holes are drilled at regular intervals on both sides of the crack. Corresponding holes on opposite sides of crack shall be midway relative to each other.

Using an angle grinder cut a groove 10 - 15 mm deep over the crack. Clean the groove and fill with a cementitious dual shrinkage compensated ready-to-use fibre reinforced structural repair mortar and allowed to cure for a period as per manufacturer recommendation.

Distance between crack and access holes to be approximately 50 mm on either side of crack in a staggered fashion with a vertical spacing between two holes to be maintained at 300 mm.

The back side of the member is sealed where possible using a cementitious dual shrinkage compensated ready-to-use fibre reinforced repair mortar**.** The aluminium injection packers are inserted then the non return valve is screwed onto the first packer to be injected.

The supply line is connected to the first packer then pumping of the resin can commence. For injection to vertical cracks always, start at the lowest point. The injection resin will spread out from the point where the injection hole intersects the crack making total contact at the interfaces. The resin will also fill any voids and subsidiary cracks. Pumping of the resin continues until resin exudes from the crack on either side of the access hole. The injection packer is removed and the access holes temporarily plugged. The process is then repeated in an adjacent access hole.

After initial cure of the epoxy resin the temporary corks are removed and the access holes are permanently plugged to their full depth using a cementitious dual shrinkage compensated ready-to-use structural repair mortar**.**

3.1.13 Grouting Low Viscosity Monomer

Make up of lost strength of core concrete shall be with grouting of low viscosity (2-5cps- as per ASTM-D-2196) monomer. This is a low viscous high molecular weight thermosetting polymer. Due to its low viscosity it effectively fills up all micro-cracks and voids up to full depth of concrete. Grouting with this system shall provide gain in core strength by 15 to 20 %. Beside enhancing existing binding matrix this shall also enhance in ductility property of elements. This may be used in exceptional situations as required by the Employer.

3.1.14 Strengthening of beam with GFRP/ CFRP/ Metal Laminates

Strengthening of beams, slabs, columns, etc. may be undertaken by use of glass/carbon fibre laminates placed as per requirements. The details of the same may be developed and provided as specifically required at particular locations.

3.1.15 Guniting

In general, Guniting (Minimum density 2T/Cum.) on concrete/masonry surface with wire mesh size 50x50mm of wire thickness 4 to 5 mm (as specified/required) and cement mortar 1:3, applied with compressor after cleaning surface and applying with epoxy complete as per technical specification as per clause 2807 of MoRT&H Specification.

3.1.16 Expansion Joint Treatment

The expansion joint system shall be a complete system designed by the manufacturer to withstand structural movement and harsh environmental conditions. The system consists of a preformed profile / filler material, installed using the same dimensions or slightly higher as the joint gap at mid-range temperature, bonded with a two-component epoxy adhesive, and pressurized during the adhesive cure time. Pressurization is done through a valve with cap system or as recommended by the manufacturer. The profile is pressurized during installation and curing time of adhesive to assure complete bonding throughout gap/profile surfaces. Air pressure will bleed itself with time or air valve can be released at any time after 24 hours of installation.

The joint treatment shall be done by applicators recommended by the product manufacturer. In addition, it shall be designed for application on the specified type of surface indicated on the project drawings.

Components and Materials

i. Profile of Filler Material

Polychloroprene (neoprene) elastomer, pre formed by extrusion and vulcanized into its definitive shape, which is supplied in several configurations and dimensions, ranging from ¼ inches to 5 inches. The profile shall have the following properties:

PROPERTY	ASTM METHOD	REQUIREMENT
Tensile Strength, min	D-412	2000 psi (13.8 MPa)
Elongation at Break, min	D-412	250%
Hardness, Shore A	D-2240	65 +/- 5
Oven Aging, 70hrs at 212ºF - Tensile Strength, max loss - Elongation at Break, max loss - Change in Hardness	D-573	 20% 20% 0 - 10 points
Oil Swell, 70hrs at 212ºF - Weight Change, max	D-471	 45%
Ozone Resistance, 70hrs at 104ºF	D-1149	No Cracks
Low Temperature Stiffing, 7 days at 14F - Change in Hardness	D-2240	 0 – 15 points

OR

Closed-Cell Backer rod - a closed-cell polyethylene foam joint-filler and backing for elastomeric sealants. The material should be non-impregnated, non-staining, non-bleeding, inert, round and non-adhering to sealants. Compliance shall be as per ASTM C 1330, Type C.

The size of profile / filler material shall be approximately 25% larger than the width of the joint, however, manufacturer's recommendation in this regard shall be final.

Three samples, each at least 6" (152 mm) long along with manufacturers test certificate shall be submitted for approval of the Employer.

ii. Expansion Joints shall be treated as follows:

1. Existing expansion joint material to be completely removed and cleaned and dried,
2. Insert the profile / filler material in the prepared expansion joint.
3. Lay single component cement grade PU sealant (vertical/horizontal application) followed by high performance elastomeric expansive rust proof, chemical proof sealing tape 150 mm/200 mm wide 2 mm thick.

The tape shall have tensile strength exceeding 6Mpa and resistance to cracking exceeding 600 N/cm when tested as per DIN 53363.The tape shall be fixed by means of epoxy adhesives applied on either side of the joint.

Adhesive shall be two-component, thixotropic, epoxy-based adhesive, which is mixed at the job site. The adhesive shall have the following properties:

PROPERTY	ASTM METHOD	REQUIREMENT
Tensile Strength	D-638	4,000 psi (27 MPa)
Axial Compression	D 638	8,000 psi (55 MPa)
Pot Life at 68ºF (20ºC)	N/A	40 minutes
Flash Point	N/A	> 200ºF (93ºC)
Initial Cure at 68ºF (20ºC)	N/A	24 hours
Full Cure at 68ºF (20ºC)	N/A	7 days

iii. High performance elastomeric expansive rust proof, chemical proof sealing tape 150 mm/200 mm wide 2 mm thick shall be fixed by means of epoxy adhesives applied on either side of the joint.

The tape shall have tensile strength exceeding 6Mpa and resistance to cracking exceeding 600 N/cm when tested as per DIN 53363.

Section 6.2.2.2 – Particular Specifications (Water Supply Works)

1. PIPELINES, PIPE WORK & FITTINGS

1.1. Ductile Iron Pipes and Fittings

1.1.1 General:

The specification pertains to ductile iron socket and spigot pipes and fittings (suitable for jointing with rubber gaskets) with ISI make and in standard length and of classes mentioned in the bill of quantities confirming to IS -8329/ IS 9523 with all up to date amendments and revision. The prices should be quoted shall be inclusive of all taxes, transportation loading, unloading from the railway wagons, carting to site of work, stacking at site of work (F.O.R.) site of work including all the taxes and duties. Ductile Iron pipe manufacturer must have ISI licence for the entire range of DI pipes and fittings required for this tender as on date of submission of tender. The ductile iron pipes and fittings including specials shall be sources/supplied by the same manufacturer.

1.1.2 Material :

The Ductile Iron Pipes and Fittings material shall confirm to the requirements of IS 1387 of 1993 (second revision/latest revision) for General requirements for supply of metallurgical materials and further shall also confirm to all the other mechanical requirement conforming to IS 8329.

1.1.3 Manufacture:

The Ductile iron pipes and fittings shall be manufactured confirming the procedure laid down in various clauses of IS 8329-2000and IS 9523 :2000 with all amendments.

1.1.4 Mechanical test:

Shall confirm clause10 J IS: 8329-2000

1.1.5 Hydraulic test :

Shall confirm clause 10 J IS: 8329-2000

1.1.6 Cement motor lining :

Shall confirm Annex B of IS: 8329-2000

1.1.7 Rubber gasket:

Rubber gasket used for jointing shall be of EPDM rubber gasket and physical properties of gasket material shall confirmed to IS: 5382-1985.

1.1.8 Test Reports:

The contractor shall have to produce the original copy of manufacturer's test certificate & third party inspection certificate from organisation such as DGS & D, SGS, EIL, RITES, Bureau Veritas or any other agency authorized by DJB for quality and strength of D.I pipes.

1.1.9 Transportation :

The DI pipes and fittings shall be transported to the site of work. Necessary case shall be taken during loading, unloading, transporting, stacking of pipe to avoid damages, cracks etc. Transporting, loading, unloading, stacking shall be done by the contractor at his own cost. No payments will be done for the damage or crack pipes.

1.1.10 Lowering, Laying, Jointing D.I. Pipes:

The DI pipes and Fittings will be transported to the site of work where actually they are to be laid and jointed. All necessary steps shall be taken to prevent damage to pipes during transport, loading, unloading, operations etc. only approved method for conveyance loading and unloading, stacking operations etc to be followed. Only approved method for transportation, loading, unloading, stacking operations using mechanical means such as Cranes, Hydra, etc. may be adopted. The DI pipe and fittings should be laid as per guidelines provided in IS 12288.

1.2. Laying of Pipes Under Ground :

The pipes should be lowered into the trench with tackle suitable for weight of pipe. Either a well-designed set of shear legs or mobile crane shall be used for lowering of pipe into the trench. When lifting gear is used the positioning of the sling to ensure proper balance should be checked when the pipe is just clear of the ground. The pipe should be clearly cleaned of any debris inside the pipe either before or just after joint is made. When the laying is not in progress the temporary end closure should be securely fitted to the open end of pipe line.
On gradient of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of socket of the laid pipe during jointing operation. As soon as the joint assembly is completed. The pipe should be held in position while the trench is back filled over the barrel of pipe. The designed anchorage shall be provided to resist the thrust developed by internal pressure at bends, tees and other specials etc. At places where fittings such as bents tees and other fittings are installed, the restrained joint pipes and fittings shall be used to resist the thrust forces. The length of restrained joint pipes shall be calculated taking into account the maximum pressure, the pipeline is to carry in service or on test and the safe bearing pressure of the surrounding soil.

1.3. Cutting and Chamfering to D.I. Pipes :

This item shall be executed for use of cut pipes in required length only when directed by Employer and after obtaining the permission from him. The burn left after cutting should be trimmed off by light grinding or by filing method. The chamfering of pipes shall conform to IS 12288 — 1987 or as per the manufacturer recommendation.

The chamfering shall be suitable for push on joints / mechanical joint without damaging the rubber gasket. The pipe after chamfering should be so smooth that enables to push in gasket for push-on-jointing. This item includes cost of all labour and tools required for executing the complete item.

1.4. Jointing of Pipes:

The DI pipes should be jointed either with flexible joints / EPDM rubber gasket joints or by rigid flanged joints. The pipes shall be jointed by the rubber gaskets (EPDM) except where there are specials / valves to be jointed to the pipeline. The EPDM rubber gasket of suitable size required for laying of DI pipes shall have to be procured by the contractor at his own cost. The EPDM gasket should confirm to IS 5382-1985.

Before assembling the joint the spigot of one pipe and the interior of the socket of the adjacent pipe should be thoroughly cleaned. The insertion of the gasket can be facilitated by the prior application of a thin film of food grade lubricant to the bulb seating the inside the socket. The rubber gasket should be wiped clean, flexed and then placed in the socket with the bulb towards the back of the socket. The groove in the gasket must be located in the retaining heel in the socket and the retaining heel of the gasket firmly embedded in its seating. It is necessary to ensure that the EPDM gasket fits evenly around the whole circumferences removing any bulges which prevent the proper entry of the spigot end. In the larger diameter this operation may be assisted by forming a second loop in the gasket opposite the first then pressing the loop flat one after the other.

A thin film of food grade lubricant should be applied to the inside surface of the gasket which will be in contact with the entering spigot. In addition, a thin film of lubricant may be applied to the outside surface of the entering spigot for a distance of 25 cms from the spigot end. The pipe to be jointed should be supported centrally by the tackle used for laying and balance just clear of the trench bottom. The spigot of the pipe must be aligned and entered carefully into the adjacent socket until it makes contact with the gasket. Finally, assembly of the joint is completed from this position. Joint assembly is completed by forcing the spigot end of the entering pipe through the gasket, which is thus compressed until the spigot end reached the total depth of the socket, if the assembly is not completed with the application of reasonable force, the spigot should be removed and the position of the gasket examined. For joints 200 mm and above rack and level tackle may be used for completing assembly wherever found necessary at the cost of contractor.

The rack is placed on the socket with the hooked end of the rack extending over the spigot of the entering pipe. The tumble on the end of the 3.2 mtrs. Long socket rope is placed over the hook bolt on the rack, which should be in its lowest position, with nut of the top of the thread. The plain end of the rope is passed round the body of the pipe looped through the rope adjuster on the side of the rack housing, wedge inserted and the rope draw tight, this pulls the wedge home thus securing the rope. The tackle is then tamped firmly to the pipe by tightening the nut on the work bolt once the length of the rope is correctly set, it is not necessary to loosen the wedge adjuster for subsequent joints unless the diameter of pipes being jointed in change. The thimble secured to one end of 6.1 m. wire rope is not loosed over the hook at the end of rack and the free end carried to the socket end of the pipe to be jointed. A special hook and rope adjuster is then fitted on to this rope and securely located in convenient position by means of the wedge. Once the position of the hook and rope adjuster has been thus set subsequent assembly of pipe of similar length should be subsequently jointed.

1.5. Hydraulic Test of DI Pipeline:

The completed pipeline may be tested either in one length or 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.

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

1.6. Initial Procedure

It is prudent to begin testing any particular pipeline in comparatively short lengths and to increase the length of test section progressively as experience is gained, until lengths of about 1.5 km or more are tested in one section, subject to consideration of the length of trench which it is permissible to leave open in particular circumstances.

Each test section should be properly sealed off preferably with special stop ends, designed for the safe introduction and disposal of the test water and release of air, which should be secured by adequate temporary anchors.

The thrust on the stop ends should be calculated on the full spigot external diameter and on the anchors designed to resist it.

Note: It may often be economical to provide a concrete anchor block, which has subsequently to be demolished, rather than risk movement of the stop ends during testing. Hydraulic jack may be inserted between temporary anchors and stop ends to take up any horizontal movement of the temporary anchors.

All permanent anchors should be in position and if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with clean, disinfected water, taking care that all air is displaced through vents at high points or by using a pig or a sphere. After filling, the pipeline should be left at working pressure for a period in order to achieve conditions as stable as possible for testing. The length of this period will depend upon many factory, such as movement of the pipeline under pressure, the quantity of air trapped and whether the pipeline has a cement mortar lining which absorbs water. If pressure measurements are not made at the lowest point of the section, an allowance should be made for the static head between the lowest point and the point at measurement to ensure that the maximum pressure is not exceeded at the lowest point.

All testing apparatus, gauges, connections, etc. and water required for testing shall be arranged by the contractor at his cost. The DJB does not undertake any responsibility to supply water for testing which the contractor has to arrange by paying the required charges directly. The DJB shall have the right to recover such charges from his bills if complaints are received that contractor has not paid the charges thereof. If there is delay in testing, the contractor shall refill the trenches for the time being and reopen them at time of testing at his own cost failure of which shall entitle the DJB to do the refilling and reopening of trenches at

the risk and cost to the contractor. If the trenches are filled due to any reason whatsoever before testing, the contractor shall have to open them for testing at no extra cost.

Field Testing of pipeline at site which has been installed or Actual field testing of DI pipe is guided by of IS: 12288 (Code of practice for laying ductile Iron pipes.) As per provision of this standard Clause 8.3 of IS:12288, a Ductile iron pipeline is to be hydro tested at site at the following pressure:-

1.7. Test Pressure

A Ductile iron pipeline is to be tested at the following pressure

- Site Test Pressure (STP) = Actual working Pressure (exclusive of Surge) x 1.5 times
  or
- Actual working Pressure (inclusive of Surge) + 5 bar , whichever is higher NOTE: Actual working Pressure (inclusive of Surge) = 1.2 x Actual working Pressure (exclusive of Surge)

1.8. Test Procedure

- After the line is filled up with water, it should be left in that condition for 24 hours, to allow the cement mortar lining to absorb water and the dissolved air to come out
- The pressure in the pipeline should be raised steadily until the site test pressure is reached in the lowest part of the section
- The pressure should be maintained, by pumping if necessary, for a period of 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 original pressure should be restored by pumping and the loss measured by drawing off water from the pipeline until the pressure reached at the end of the test is reached again
- The acceptable loss should be clearly specified and the test should be repeated until this is achieved. The generally accepted loss for DI Pipe is 0.02 l./mm. of nominal bore per kilometer of pipeline per 24 hours per bar of pressure applied head (calculated as the average head applied to the section under test). The rate of loss should be plotted graphically to show when absorption is substantially complete

2. DETECTION OF LEAKS

If the test is not satisfactory, the fault should be found and rectified. Consideration should be given to leak detection methods such as:

- Visual inspection of pipelines, especially each joint, if not covered by the backfill
- Aural inspection, using a stethoscope or listening stick in contact with the pipeline
- Use of electronic listing devices including leak noise correlators which detect and amplify the sound of any escaping fluid; actual contact between the probe and the pipe may or may not be essential
- Use of a bar probe to detect signs of water in the vicinity of joints, if backfilled
- Where there is difficulty in locating a fault, the section under test should be subdivided and each part tested separately.

NOTE: A pneumatic test with an air pressure not exceeding 2 bars may be used to detect leaks in pipelines laid in waterlogged ground.

After all section has been jointed together on completion of section testing, a test should be carried out on the complete pipeline. During the test, all work, which has not been subject to sectional tests, should be inspected.

3. DUCTILE IRON VALVES

3.1. DI Soft Seated Gate Valve/Sluice Valve

Manufacturing, supply and delivery of DI D/F non-rising spindle soft seated glandless Gate Valves with body and bonnet of Ductile cast iron of grade GGG-50, wedge with fully encapsulated EPDM rubber W-270 (approved for drinking water) and seals of NBR. The valves should be with replaceable stem nut and replaceable sliding shoes. Valve stems shall be of single piece thread rolled. Valve shall have 3 "O" rings of NBR for stem sealing. Gate valve shall be compatible for buried applications without valve chamber. Face-to-face dimensions as per BS 5163-89/IS 14846-PD/EN 558F4 and flange connections as per IS 1538, Maximum Valve operating torque should be at least 40% less than the torque as stated in the standard EN 1074. Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 250 microns. The EPDM rubber & Epoxy Powder should be approved by W 270. (EP- it is a -coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C).

Material of Construction

a.	Body	:	Ductile Iron IS 1865 Gr 500/7 DIN 1693-GGG 50/ EN 1563 GJS 500-7
b.	Wedge	:	Ductile Iron IS 1865 Gr 500/7 DIN 1693-GGG 50/ EN 1563 GJS 500-7
c.	Spindle	:	AISI 410/ AISI 420/ SS 304
d.	Seat Rings	:	St. Steel to CF – 8 / AISI 304
e.	Spindle Nut	:	High Tensile Brass to IS-320 HT2/Gun metal IS 318 Gr LTB 2

4. ELECTRIC ACTUATORS

Electric actuators shall operate valves at opening and closing rates that will not impose unacceptable surge pressures on the pipework.

Actuators shall be rated at not less than 20 percent in excess of the power required to operate the valve or penstock under maximum working conditions.

Actuator enclosures shall have a minimum protection IPW 67 to BS EN 60529.

Actuator electric motors shall comply with BS 4999. For non-modulating type actuators, the motor short-time rating (STR) shall allow the successive full travel operation of the travel from open to closed and vice versa but shall be not less than 15 minutes. For modulating

type actuators the motor shall have a duty-type rating (DTR) to meet the varying cyclic load requirements of the valve.
Electric motors shall be provided with built-in thermal protection complying with BS 4999: Part 111.

Actuators shall be complete with:

(a) An alternative system for manual handwheel and reduction gear operation which shall be lockable.
(b) An interlock, to prevent engagement of the handwheel whilst the actuator is being power driven and to disengage the manual drive positively when the power drive is started.
(c) Reversing type motor starter complete with isolating switch.
(d) Local and remote control selector switch when specified, which shall be lockable.
(e) Open, stop and close push-buttons.
(f) Potentiometer for remote valve position indication when remote control is specified.
(g) Torque switches for mechanical disengagement of the drive at the extremes of valve operation to limit excess torque.
(h) Supply failure and remote control available monitoring relays. The supply failure relay shall operate under single phasing and phase reversal conditions.
(i) Auxiliary and interposing relays as necessary.
(j) Voltage-free changeover type contacts for the remote indication of:
-Motor tripped on overload
-Fully open
-Fully closed
-Operating
-Supply failed
-Remote control available

The rating of volt-free contacts shall be not less than 15 A at 240V a.c. and 2 A at 50V d.c. unless otherwise specified. The contacts shall be suitable for inductive load switching.

(k) Anti-condensation heater Separate or segregated terminal boxes shall be provided for the connection motor, heater and control cables.

5. PRESSURE REDUCING VALVES

The Pressure Reducing Valve shall reduce higher pressure to lower pre-set downstream pressure regardless of fluctuating demand or varying upstream pressure head.

5.1. Main Valve:

The main valve shall be a center guided, diaphragm actuated globe valve of either oblique (Y) or angle pattern, design. The body shall have a replaceable, raised, stainless steel seat ring. The valve shall have an unobstructed flow path with no stem guides, bearings, or supporting ribs. The body and cover shall be ductile iron. All external bolts, nuts, and studs shall be Duplex coated. All valve components shall be accessible and serviceable without removing the valve from the pipeline
.

5.2. Actuator:

The actuator assembly shall be double chambered with an inherent separating partition between the lower surface of the diaphragm and the main valve. The entire actuator assembly (seal disk to top cover) shall be removable from the valve as an integral unit. The stainless steel valve shaft shall be center guided by a bearing in the separating partition. The replaceable radial seal disk shall include a resilient seal and shall be capable of accepting aV-Port Throttling Plug by bolting.

.

5.3. Control System:

The control system shall consist of a 2-Way adjustable, direct acting, pressure reducing pilot valve, a needle valve, isolating cock valves, and a filter. All fittings shall be forged brass or stainless steel. The assembled valve shall be hydraulically tested and factory adjusted to customer requirements. The required numbers of switch/contacts meet requirements for PLC system.

5.4. Quality Assurance:

The valve manufacturer shall be certified according to the ISO 9001 Quality Assurance Standard. The main valve shall be certified as a complete drinking water valve.

5.5. Schedule for Pressure Reducing Valves

Particulars	**As per Technical Specifications**
Standard	ISO 9001:2008 Certified
Rating	12 Kgf/ cm²
Type	Drum
Ends	Flanged, flat faced flanges as per IS-1538 Table IV & VI having off center bolt holes/ ASA-150#

5.6. Material of Construction:

Body	DIN 1693 ASTM A 536 65-45-12 GGG50
Cylinder Bolt	1.4301/1.4401
O-Ring	KNB 35L
Cylinder	1.4301/1.4401
Spring	IS4454
U-Ring	KNB 35L
Piston	1.4301/1.4401
Sealing	KNB35L
Seat	1.4301/1.4401
Shaft	1.4301/1.4401
Controller	1.4301/1.4401
Working Pressure	20 Kgf/ cm²
Test Pressure	32 Kgf/ cm²

6. DISMANTILING JOINTS

CI Double flanged Dismantling joints shall be installed in such a manner that valves can be dismantled without stress to the joints. Dismantling joints shall be suitable for installation with all valves of different diameters.

The dismantling joint shall be designed for a hydrostatic pressure of 10 kg/sq.cm. The sliding flange shall be machined smooth and shall slide at least 30 mm to disengage fully mating flange. All the fasteners for the dismantling joint shall be of SS 304. These shall be completely leak proof with proper gasket arrangement. Flange dimensions shall conform to latest relevant IS code. Flanged specials shall be supplied with required nuts, bolts and rubber gaskets. The dismantling joint shall be internally and externally coated with hot applied (dip) bituminous paint.

7. WATER METERS (CONSUMER)

7.1 Non AMR Water Meters

Water meter straight reading means – 15mm size domestic water meters, inferential type, multi jet, magnetically coupled, having dry dial, Class 'B' conforming to IS-779: 1994 with up to date amendments or ISO 4064:1993 standard with ISI/EEC/OIML/MID certification mark shall be with protection class of IP-68. The meters shall be supplied complete with GI fittings, brass nuts and brass nipples. Strainer & sealing shall be provided as per relevant IS provision.

7.1.1 Material of construction:

a) 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 IS 779:1994 (latest amendments) or ISO 4064:1993.

b) The body of the meter shall be of either Brass or Bronze. 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.

c) 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.

d) 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 colour shall be decided in consultation with the department after order of award

e) Variation in weight of the meter will be permissible to ± 5% of the weight indicated by the bidder in his technical bid.

f) 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. The no. of individual boxes of meters shall not exceed 30 nos in each cartoon.

g) Supply shall be made strictly as per the sample meters including the weight as approved by the Board after testing at National Physical Laboratory or at Fluid Control Research Institute, Kerala.

7.1.2 Markings on the body of the Meter:

(a) Marking on dial/ cap.

i. Class "B"
ii. Multijet/ Model
iii. Magnetic Type
vi. As per IS: 779-1994 OR ISO: 4064-1993
v. ISI OR EEC or OIML Code No.
vi. Make/Brand
vii. Sl.No. / Year of Manufacture.
viii. DJB

(b) Embossing/ engraved on meter body.

i. 15 mm
ii. Direction of flow of water on both sides of the body of meter.

7.1.3 The Totalizer and Totalizer Shield :-

The totalizer shall be designed in such a way that if the totalizer protective glass is broken for a reason or another the totalizer cannot 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.

7.1.4 Totalizer :-

It shall be of straight reading type
The totalizer shall register in cubic meter units
The totalizer reading should be less than 1KL
The totalizer shall consist of a row of minimum five on-line consecutive
digits to read at least 99,999 m3.
Another three digits or pointers shall register flows in litres and be of a different colour.
The totalizer should be of closed type.
The totalizer must be suitable for test on an electronic test bench.
Totaliser shall be made of copper CAN 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.

7.2 AMR Water Meter

Meter shall be manufactured as per ISO 4064 standards & have European Economic Council (EEC) or International Organization of Legal Metrology (OIML)/MID pattern approvals & shall bear EEC marking on dial of water meter for each size.
The water meters of domestic sizes shall be equipped with RF based AMR technology, directly fitted on the water meter & wireless, , multi-jet, inferential type, dry dial, MID approved water meters

Water meters of each size should have been duly tested and passed as per the relevant standards and specifications from Fluid Control Research Institute (FCRI) Kerala for performance test supported with test certificate.

7.2.1 Applicable Standards:

Water meter straight reading means – 15mm size domestic water meters, inferential type, multi jet, magnetically coupled, having dry dial, Class 'B' conforming to IS-779: 1994 with up to date amendments or ISO 4064:1993 standard with ISI/EEC/OIML/MID certification mark shall be with protection class of IP-68.
The meters shall be supplied complete with G I fittings, brass nuts and brass nipples. Strainer & sealing shall be provided as per relevant IS provision.

7.2.2 Material of construction:

a) 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 IS 779:1994 (latest amendments) or ISO 4064: 1993.

b) The body of the meter shall be of either Brass or Bronze. 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.

h) 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.

i) 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 colour shall be decided in consultation with the department after order of award.

j) Variation in weight of the meter will be permissible to ± 5% of the weight indicated by the bidder in his technical bid.

k) 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. The no. of individual boxes of meters shall not exceed 30 nos in each cartoon.

l) Supply shall be made strictly as per the sample meters including the weight as approved by the Board after testing at National Physical Laboratory or at Fluid Control Research Institute, Kerala.

7.2.3 Markings on the Body of the Meter:

(a) Marking on dial/ cap

i. Class "B"
ii. Multijet/ Model
iii. Magnetic Type
vi. 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. DJB

(b) Embossing/ engraved on meter body

i. 15 mm
ii. Direction of flow of water on both sides of the body of meter.

7.2.4 The Totalizer and Totalizer Shield :-

The totalizer shall be designed in such a way that if the totalizer protective glass is broken for a reason or another the totalizer cannot 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.

7.2.5 Totalizer :-

It shall be of straight reading type
The totalizer shall register in cubic meter units
The totalizer reading should be less than 1KL
The totalizer shall consist of a row of minimum five on-line consecutive digits to read at least 99,999 m3.
Another three digits or pointers shall register flows in litres and be of a different colour.
The totalizer should be of closed type.
The totalizer must be suitable for test on an electronic test bench.
Totaliser shall be made of copper CAN 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.

7.2.6 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 – 2005.

2. The remote readings of AMR water meter should be obtainable by 'Walk by' methods.
3. The AMR trans-receivers shall be wireless and 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. AMR shall be obtainable even under submerged conditions.
5. 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.
6. All A. M. R. readings shall show the date and time of the reading recorded.
7. 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 the Hand Held Device (HHU) i.e. AMR reading device and on computer screen.
8. 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 HHU and in software.
9. 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 on HHU.
10. The AMR device of the water meter shall be tamper proof.
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 / Deptt. of Telecom (DOT), for using the said operating frequency band. The cost of the same will be presumed as included in the quoted rates.
12. 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 / Deptt. of Telecom (DOT), stating that the said operating frequency lies in the free band.
13. The AMR water meter shall not get affected for its AMR functioning due to High Tension or High Voltage line concentration.
14. All the time electronic index of the water meter shall match with mechanical index.
15. All water meters shall be fitted with RF based wireless remote transreceivers for A.M.R. reading. It shall be either inbuilt or directly fitted on the water meter without wires.
16. 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.
17. The manufacturer shall specify the frequency of the AMR operating system & shall possess the necessary license of said operating frequency, issued by Government of India (GOI) / Department of Telecom (DOT). In case, if he claims frequency of the operation in the free band, necessary documents / clearance from GOI / DOT shall be submitted, along with the offer.

However, the DJB reserves the right for acceptance of offered frequency & Power subjected to the guidelines issued by DOT / WPC.

18. AMR system should be compatible for up gradation to fixed net work if required in future.

7.2.7 Software

1. The software shall give output, at least in the CSV (Comma Separated Value) format .
2. The Route Management software must be capable of running on a standard PC compatible with minimum Pentium processor; in addition the software must run under Windows95, Windows XP Professional, Windows Vista, Windows 7 and / or latest version of windows operating system.
3. The software shall allow the PC operator to review and edit any account in Route Manager database. Also, the PC operator shall be able to generate route and activity reports.
4. The software shall alert the meter reader for unread accounts in that route.
6. The software shall enable the user to specify the data to be exported from the database for transferring to billing system.
7. The software shall take routes from an existing database for loading into a reading device.
8. The software shall select the routes to be read, and assignment of routes to a reading device and dynamic updating of routes and sub-routes to be enabled.
9. The software shall upload routes from the reading device.
10. The software shall post the reading from the reading device onto appropriate accounts within the database.
11. Software shall be able to set meter status on the fly like, meter not okay, reading not reliable, meter maintenance required etc
12. Software should have a radio configuration tool which can enable/disable meter, set / read meter status

7.2.8 Hand Held Device

1. The hand held device or reading device shall have the sufficient memory(minimum 4000 reading data) for storage of maximum data / reading along with sufficient power back up.
2. The HHU shall have the onsite search facility, to locate the exact physical location of water meter in particular area and to obtain the corresponding details of it.
3. The HHU should be adjustable back light, sun light readable, colour display and touch screen.
4. The HHU shall have minimum 64 MB flash memory and 128 MB RAM.
5. The battery of HHU device shall give power back up for at least 5 hours continuously.
6. The unit must be able to withstand three foot drop on concrete.
7. The handheld must be ergonomically designed to be comfortable for handheld meter reading.
8. There must be audible beep when indicating key has been pressed, there must also be an auto repeat function on keys and a rapid response between keying and seeing results on the screen.

9. The handheld must come with an integrated intelligent fast charge capability that allows full charge within 5 hours.
10. The hand-held must have integration with Global Positioning System (GPS) for route monitoring and configuration.
11. The read-out device should be connected to the Hand held device and needs to be USB powered.
12. The quantity of HHU in BOQ has been considered @ 1 HHU on every 25000 AMR water meters which may vary at the time installation based on capacity of HHU and location/cluster size of meters .Bidders has to quote item rate for HHU.

Lab Testing: The lab testing shall include following tests as per ISO: 4064:2005 standards . The same will be conducted at FCRI, Palghat.

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 flows, magnet and physical damage, etc.
vii. Response time of AMR reading on HHU.
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 hand held unit to PC and vice versa.
xi. Life cycle and endurance test.

8. CONNECTION TO CONSUMERS:

i. All service pipes and fittings from the connection on the water main to any premises shall be laid by the Contractor as per specifications and the approved drawings. The connection pipe shall be laid in the ground and shall not be less than 45 cm below the surface unless laid inside a building. All pipes shall be laid or fixed in such a manner as not to be exposed to the heat and not to cause any damage to any consumer's pipes and fitting and there should not be any risk of mixing waste water or cause contamination of water. The material of the pipes and fittings shall be got approved from the Engineer-in-charge before use. The position of the stopcock on the connection pipe shall be decided by the Contractor. All cocks and taps fitted to the service pipes in any premises shall be of a screw down pattern and of quality approved.
ii. No pipe used for the conveyance of water shall be laid or fixed which shall run through any drain or any place where water through such pipes is liable to become polluted or contaminated or where the pipe is likely to get damaged. However, in unavoidable cases such consumer's pipe may pass through an exterior air tight and water tight pipe or jacket of cost iron or other material approved by the Executive Engineer of sufficient length and strength and of such construction as would provide adequate protection to the inner pipes.

iii. Every premises supplied with water shall have its own specific connection pipe and no connection pipe shall be used to supply water to more than one premises.
iv. The position of stop cock on the connection pipe shall be decided by the Contractor who shall have exclusive control over this stop cock and its operation.
v. The leakages upto the stop cock or up to the meter without stopcock shall be removed by contractor at his cost.

8.1 Composite Strap Saddle

8.1.1 Scope:

The specification covers the requirements for manufacturing, supplying testing at works of Composite Strap Saddle used for tapping water supply connection from D.I. pipe distribution line.

8.1.2 Standards

Pipe compatibility: D.I. K – 7 pipe as per ISO: 2531, EN: 545, EN: 598, IS: 1239-1, IS: 3589. Comply with ISO: 4427 Part – 3 & EN: 12201 – Part -3

8.1.3 Specification

GENERAL SPECIFICATIONS:

- Clamp saddles for service connection from water distribution mains shall be of wrap around design, wide skirt and wide straps support, which shall reinforce the pipe while providing excellent stability to the saddle. Clamp Saddles for service connections shall be of fastened strap type with threaded outlet for service connection.
- The service connection threading sizes shall be conforming to IS: 554
- Clamp saddles shall be suitable for DI/GI/uPVC/HDPE pipes of nominal sizes
- The straps shall be elastomer coated (insulated) type for firm grip on pipe as well as to protect the coating on the pipe and to insulate the un-identical metals. The saddles shall be single strap type up to pipe sizes of NB 600 and service outlet of ½", ¾" and 1".
- The saddles shall be double strap type for pipe sizes above NB 600 or when the service outlet is 1 ¼", 1 ½" or 2".
- Fasteners shall be of threaded nut-bolt-washer type. Nut-bolts of size ½" (M12) shall be used for saddles of size up to 4" (NB 100) and Nut-bolts of size 5/8" (M16) shall be used for saddles of size 6" (NB 150) and above.
- The sealing between the saddle and mains shall be obtained by using a profiled elastomer seal matching to the curvature of the pipe. The seal shall be of elastomer type, suitable for all potable water applications.
- The Material of construction of the body shall be of a non-corrosive material such as engineering plastic (PE/PP) or stainless steel or a combination of both.
- The design of the saddle body should be such that, the service connection outlet metal insert shall project out towards pipe side and align with the hole drilled on the pipe to ensure positive locking against rocking or creeping on the pipe, as might be caused by vibration, pressure or excessive external loading.
- The clamp saddles shall be suitable for maximum working pressures up to 10 bars.

8.2 Material and Design Specifications

8.2.1 Saddle body

Non-corrosive Engineering Plastic (PP / PE) body moulded with Stainless steel threaded metal insert for tapping outlet. Also, the stirrup metal plate shall be duly embedded in the plastic body, except at the place of nut-bolt lugs. Threading size and dimensions shall conform to IS: 554. The body shall have retaining cavity housing for internal and external retention of the elasomeric seal. Sealing shall be achieved by pressure exerted by the body while fastening the saddle straps & body on the pipe.

8.2.2 Saddle Strap:

Saddle straps shall be made of stainless steel 304 grade to prevent corrosion over the long service life.

8.2.3 Strap Insulation

Elasomeric (rubber) insulation / lining shall be such that none of the Stainless Steel Strap is in direct contact with the pipe. It shall ensure a firm non slip grip mounting on the pipe to prevent the saddle from rocking or creeping on the pipe, as might be caused by vibration, pressure or excessive external loading.

8.2.4 Saddle Seal

It shall be virgin rubber SBR Grade 30 / NBR (NSF 61 approved). It shall be of type pressure activated hydro-mechanical design. It shall be contoured gasket to provide a positive initial seal, which increases with increase in the line pressure. Gasket shall be gridded mat, with tapered ends, with the outlet section having o-ring contacting the saddle body multiple o-rings contacting the pipe, preferably with a Stainless steel reinforcing ring insert moulded to prevent expansion under pressure.

8.2.5 Nuts-Bolts- Washer

Stainless Steel Type 304, NC rolled thread, Tightening torque for ½" (M12) nut-bolt: 14 - 15 kg.m and for 5/8" (M 16) nut-bolt: 21-23 kg.m

8.3 Making House Service Connections

One Service connection means one tapping from a distribution main / sub- main including one tapping saddles, elbows, and service pipe from tapping point to the chamber near property boundary or inside the property as per the direction with U-ball valve.

Providing required size of HSC brass ferrule with union confirming to relevant IS make hole by drilling on top of distribution mains, fixing the ferrule making the connection water tight etc., as shown in the drawing and as directed by the Engineer including cost of required specials. Drilling charger, hydraulic testing, maintaining the same for the period under O&M.

8.3.1 Material

Medium Density Polyethylene pipe (MDPE) below and above Ground level shall be used for house service property connection

Section 6.2.2.3 – Particular Specifications (Mechanical Works)

Contents

1. Horizontal Centrifugal Pumps

Sr. No.	Description	Model Town	CD Park, Jahangirpuri	Fruit Market, Azadpur	Mukherjee Nagar
i)	Design Capacity (m^3/hr)	720	900	210	425
ii)	Total Head (m)	39	35	28	31
iii)	Quantity	6 Nos (4W+2S)	6 Nos (4W+2S)	5Nos (3W+2S)	6 Nos (4W+2S)
iv)	Synchronous Speed at 50 Hz rpm (maximum)	1450	1450	1450	1450
v)	Direction of Rotation	Clockwise, from the driven end			
vi)	Minimum pump efficiency at duty point	85%			

Note : The duty parameters indicated above are indicative only, bidders to verify the same and supply the equipment's as per their approved service improvement plan (SIP) & hydraulic model study during execution.

2. Sluice Valves

Sr.No.	Description	Model Town				CD Park, Jahangirpuri			Fruit Market, Azadpur			Mukherjee Nagar			
i)	Size	500	400	800	600	500	400	800	300	200	350	400	300	600	700
ii)	Quantity (nos)	6	6	1	2	6	6	1	5	5	1	6	6	1	2
iii)	Pressure Rating PN	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
iv)	Type of Operation Mot – Motorised/ Man - Manual	Mot	Mot	Mot	Man	Mot	Mot	Mot	Mot	Mot	Mot	Mot	Mot	Mot	Man

Note : The Sizes indicated above are indicative only, bidders to verify the same and supply the equipment's as per their approved service improvement plan (SIP) & hydraulic model study during execution.

3. Non Return Valves

Sr.No.	Description	Model Town		CD Park, Jahangirpuri		Fruit Market, Azadpur		Mukherjee Nagar	
i)	Size (mm)	400	800	400	800	200	350	300	600
ii)	Quantity (nos)	6	1	6	1	5	1	6	1
iii)	Rating (PN)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note : The Sizes indicated above are indicative only, bidders to verify the same and supply the equipment's as per their approved service improvement plan (SIP) & hydraulic model study during execution.

4. SS Expansion Bellows

Sr.No.	Description	Model Town				CD Park, Jahangirpuri				Fruit Market, Azadpur				Mukherjee Nagar			
i)	Size	500	400	800	700	500	400	800	600	300	200	350	600	400	300	600	700
ii)	Quantity (nos)	6	6	2	1	6	6	2	1	5	5	2	1	6	6	3	2
iii)	Pressure Rating PN	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note : The Sizes indicated above are indicative only, bidders to verify the same and supply the equipment's as per their approved service improvement plan (SIP) & hydraulic model study during execution.

5. Pipes and Fittings

Sr. No.	Description	Model Town, CD Park Jahangirpuri, Fruit Market Azadpur, Mukherjee Nagar
i)	DI pipe(K7 & K9),fittings & Specials	As per specifications bill of materials, drawings for complete installation of suction & delivery line including suction bell mouth & suction puddle pipe etc.as required.

6. Air Valves

Sr. No.	Description	Model Town	CD Park, Jahangirpuri	Fruit Market, Azadpur	Mukherjee Nagar
i)	Size (mm)	100	100	100	100
ii)	Quantity (nos)	1	1	1	1
iii)	Rating (bar)	10	10	10	10

7. Electrically Operated Overhead Travelling Crane

Sr. No.	Description	Model Town	Mukherjee Nagar	C D Park	Fruit Market
i)	Capacity (tonnes)	3.0 (New)	3.0 (New)	Existing 5.0-HOT to be modified to EOT Crane.	Existing EOT Crane to be retained.
ii)	Quantity	1	1	1	1
iii)	Class	II	II	II	II
iv)	Lift (m)	7	7	7	7
(v)	Span (m)	9	8.5	9.7	9.1
vi)	Length of the runway (m)	30.0	25.0	34	20

Note : The existing HOT Crane at CD Park (Jahangirpuri) BPS shall be modified to EOT Crane. The travel length of EOT of Fruit Market BPS to be increase to cover the additional pump.

8. Exhaust Fans

Sr. No.	Description	Model Town	CD Park, Jahangirpuri	Fruit Market, Azadpur	Mukherjee Nagar
i)	Size (mm)	300	300	300	300
ii)	Type	Axial	Axial	Axial	Axial
iii)	Quantity (nos)	7	7	5	7

9. Drain pumps/Dewatering pumps

Sr. No	Description	Model Town		CD Park, Jahangirpuri		Fruit Market,		Mukherjee Nagar	
i)	Capacity (m^3/hr)	5	50	5	50	5	50	5	50
ii)	Head	15	15	15	15	15	15	15	15
iii)	Quantity	2	2	2	2	2	2	2	2
iv)	Location	Pump House	Reservoir	Pump House	Reservoir	Pump House	Reservoir	Pump House	Reservoir

10. Vacuum pumps

Sr. No	Description	Model Town	CD Park, Jahangirpuri	Fruit Market, Azadpur	Mukherjee Nagar
i)	Capacity (m^3/hr)	As required	As required	As required	As required
ii)	Head	As required	As required	As required	As required
iii)	Quantity	2nos.(1W + 1S)	2nos.(1W + 1S)	2nos.(1W + 1S)	2nos.(1W + 1S)

11 Sluice Gate

Sr. No	Description	Mukherjee Nagar
i)	Size	1000mm x 1000mm
ii)	Quantity	2 nos.

12. Fire Extinguisher

Sr. No.	Description	Model Town	CD Park, Jahangirpuri	Fruit Market,	Mukherjee Nagar
i)	Type	ABC stored Pressure(4kg)	ABC stored Pressure(4kg)	ABC stored Pressure(4kg)	ABC stored Pressure(4kg)
ii)	Quantity	6	5	6	5

13. SCHEDULES FOR PUMPS

The following details shall be furnished by the bidder for each pumps under this contract :

Horizontal Centrifugal Pump

Sr. No.	Description	Unit	Particulars
1	**General**		
(a)	Make		
(b)	Model		
(c)	Type		
2	**Performance**		
(a)	Capacity	cum/hr	
(b)	Total Head	mwc	
(c)	Efficiency	%	
(d)	WHP	kW	
(e)	Pump Input	kW	
(f)	Shut Off Head	mwc	
(g)	Speed	rpm	
(h)	NPSH required	m	
3	**Materials of Construction**		Shall be as per Technical Specification
4	**Testing and Inspection**		Shall be conducted as per Technical Specification

Section 6.2.2.4 Particular Specifications (Electrical Works)

Contents

1. HT SWITCHGEAR

The following specific requirements along with the general requirement shall be considered.

Sr. No.	Description	Unit	Specification
1.	Nominal system voltage, phase & frequency	V	11000V, 3 phase, 50 Hz
2.	System neutral earthing considered		Non effectively earthed
3.	Maximum system voltage	V	12000
4.	One minute power frequency withstand voltage	kV rms	28kV for 11kV
5.	1.2/50 uS impulse withstand voltage	kV peak	75kV for 11 kV
6.	Short circuit withstand capability Short time for 1 sec Dynamic rating	 kA rms kA peak	 25 62.5
7.	Reference ambient temperature	°C	50
8.	Maximum temperature of Bus Bars, dropper, connectors & contacts at continuous current rating under site reference ambient temperature	°C	90 °C for non silver plated joints 105 °C for silver plated joints
9.	Material of bus bars considered		Copper
10.	Cable entry		Bottom only
11.	Thickness of sheet steel enclosures/ doors.		
	Cold Rolled	mm	2.0
	Hot rolled	mm	2.5
12.	Degree of protection		IP 4X
13.	Shade of paints: Indoor -Outside/Inside Outdoor -Outside/Inside		 RAL 7032/ Glossy white (epoxy) -shade no.6315 as per IS-5. Dark admirability Grey -shade no.6325 as per IS-5 / Glossy white (epoxy) -shade no.6315 as per IS-5.
14.	Earthing bus bar size & material considered		To be calculated
15.	Clearance in air of live parts a) phase to phase b) phase to earth	 mm mm	 As per IS-3716

Sr. No.	Description	Unit	Specification
16.	Circuit breaker Type Rated operating duty Rated current at site reference ambient temp. Rated breaking current Rated making current Short time current withstand capacity for 3 sec duration Asymmetrical breaking current AC component DC component operating time	 A KA rms KA peak KA rms KA rms kA	 Vacuum O-0.3 sec-CO-3 min- CO As per SLD 50^0 C As per IS standard As per IS standard As per IS Standard as per IEC – 62271 3
17.	Trip free operating mechanism type		Motor charged spring (manual trip & close facility to be provided)
18.	Auxiliary control voltage for trip, close, annunciation and spring charging.		110 V DC
19.	Auxiliary control voltage for space heater, DC failure annunciation, motor winding / space heaters, lighting etc		240V AC, 1-Ph, 2 wire, 50 Hz

2. TRANSFORMERS:

The requirement for the three pump houses is listed below.

Sr. No.	Description	Unit	Technical Requirement		
			Model Town UGR	**C D Park, Jahangirpuri UGR**	**Mukharjee Nagar**
1.0	**GENERAL**				
1.1	Application/Designation		Distribution transformer		
1.2	Quantity required	Nos.	2	2	2
1.3	Installation (Indoor/Outdoor)		Indoor		
1.4	Degree of protection of Enclosure		IP 55		
2.0	**RATINGS**				
2.1	Rating	KVA	1000 *	1000 *	500*
2.2	Number of phases & Frequency		3 Phase , 50Hz		
2.3	Type of cooling		ONAN		
2.4	No load voltage				

Sr. No.	Description	Unit	Technical Requirement
	HV	V	11000
	LV	V	433
2.5	Vector Group		Dyn11
2.6	Percentage Impedance	%	As per IS standards
3.0	**WINDING**		
3.1	Material of conductor		Copper
3.2	Class of insulation (LV/HV)		
3.3	Method of connection- HV		Delta
3.4	Method of connection- LV		Star
4.0	**SYSTEM VOLTAGE**		
4.1	Nominal system voltage		
	HV	V	11000
	LV	V	415
4.2	Highest system voltage		
	HV	V	12000
	LV	V	433
4.3	Fault Level on HV side	KA	25
4.4	Fault Level on LV side	KA	50
5.0	**NEUTRAL EARTHING**		
5.1	Transformer Neutral (A – Effectively earthed; B – Resonant; C – Non effectively earthed; D – Isolated)		
	a) HV		-
	b) LV		A – Effectively earthed;
6.0	**INSULATION WITHSTAND**		
6.1	Impulse (1.2/50 micro sec/wave)	HV	75kV peak
6.2	Power Frequency		
	HV	kV	28 kV RMS
	LV (Dry & Wet)	kV	
6.3	Noise at distance of 1.0 meter	db	To be specified by BIDDER
7.0	**TEMPERATURE RISE**		
7.1	Reference Ambient	°C	50
7.2	Winding temp rise	°C	
8.0	**TAP CHANGING LINKS**		
8.1	Taps required	Yes/ No	Yes
8.2	Tappings on windings	HV/ LV	HV
8.3	Total tapping range		+5% to -5%
8.4	Steps	%	2.5

(*) The ratings provided are indicative wherever applicable, the same needs to be verified by the bidder with design calculations subject to approval.

3. LV BUSDUCTS :

The requirement for the three pump houses is listed below. For Fruit Market, Azadpur UGR, the need for a new bus duct depends on the reusability of the existing bus duct subject to the residual life assessment test, to be carried out by the vendor at his own cost.

Sr. No.	Description	Technical Requirement		
		Model Town UGR	**C D Park, Jahangirpuri UGR**	**Mukharjee Nagar**
1.0	Type of Bus Duct	Non-segregated, Self cooled, Rectangular, Totally enclosed		
2.0	Type of Cooling	Natural Air cooled		
3.0	Installation Indoor/Outdoor	Indoor		
4.0	Nominal Service Voltage	415V		
5.0	Rated Voltage Class - kV	1.1kV		
6.0	One minute Power Frequency Withstand Voltage - kV (Peak)	3		
7.0	Continuous current rating	1600 A *	1600 A *	NA *
8.0	Momentary Current Rating - kA (Peak)	105		
9.0	Short Time Current Rating - kA (RMS)	Same as 415V switchgear		
10.0	Design maximum Temperature (Hot Spot) of Busbars at Rated Current - °C	50°C		
11.0	Design maximum Temperature (Hot Spot) of Enclosure at Rated Current - °C	20°C		
12.0	Busbar Material	Aluminium alloy grade 63401 as per IS: 5082 or equivalent IEC/IEEE standard.		
13.0	Busbar Section	Rectangular		
14.0	Bus Enclosure Material	Mild steel for current rating less than or equal to Continuous current rating, Aluminium alloy for current ratings greater than Continuous current rating.		
15.0	Shape of Enclosure	Rectangular		
16.0	Phase Clearance (Minimum) Phase to Phase mm Phase to Earth mm	 25 20		
17.0	Type of Joints between Adjacent Sections of Bus Conductor Welded/Bolted	Bolted		

Sr. No.	Description	Technical Requirement
18.0	**INSULATORS AND SEAL OFF BUSHINGS**	
18.1	Rated Voltage kV(rms)	1.1
18.2	One minute Power Frequency Withstand Voltage	
	Dry kV (rms) Wet kV (rms)	3 -
18.3	Minimum Creepage Distance	31 mm/kV
18.4	Material of Insulators	Epoxy Resin Cast
18.5	Current rating of Seal of Bushings - Amps	To suit bus rating
18.6	Material of Seal Off Bushings	FRP or Epoxy Resin Cast

4. LV SWITCHBOARD:

The requirement for the three pump houses is listed below. For feeder details refer SLD for the pump houses attached.

Description	Unit	Particulars
General		
Constructional features		Indoor, metal enclosed, floor mounted, height (max)- 2450mm
Rated voltage, no. of phases and rated frequency	V / - / Hz	415V, 3, 50Hz
System neutral earthing		Effectively Earthed
Rated short duration power frequency withstand voltage		
Power circuit	kV (rms)	2.5
Control circuit	kV (rms)	1.5
Rated normal current of busbars under design ambient temperature of 50 C and material of busbar	A / -	Refer SLD , Aluminium (Electrical Grade)
Rated short-time withstand current and time	kA (rms) /sec	50 kA for 1 sec
Constructional Requirements		
Thickness of sheet steel in mm Cold rolled (Frame/Enclosure/Covers)	mm	Frame – 2.5 Doors/Covers – 2.0
Degree of protection of enclosure		IP-54
Colour finish shade / Painting		Powder coating – 7 tank process
Interior		Glossy White
Exterior		Light Grey
Cable connection/ Busduct		Bottom entry/exit for cables Top entry for Busduct

Description	Unit	Particulars
Current and Voltage Transformers		
Details of ratio, taps, burden, accuracy		As per Single Line Diagram (*)
Protective Relays		
Type		Numerical (Microprocessor based)
Circuit Breaker		
Circuit Breaker Type		Air Break Circuit Breaker
Rated Breaking Duty		B-0.3 sec-MB-3 min-MB
Rated Current At Site Reference Ambient Temperature		Refer SLD
Type Of Operating Mechanism		Motor Wound Spring Charged
Control Voltage (A) For Spring Charging Motor (B) For Closing/Tripping	 V AC/DC	 230V AC 110V DC
Moulded Case Circuit Breakers		
Type		Moulded Case (Microprocessor based)
Rated current when installed within cubicle under design ambient temperature of 50 0C	A	As required
Rated short-time withstand current	kA (rms)	50 kA
Miniature Circuit Breakers		
Type		Miniature
Rated current when installed within cubicle under design ambient temperature of 50 0C	A	As required
Rated short-time withstand current	kA (rms)	25 kA

(*) The ratings provided are indicative wherever applicable, the same needs to be verified by the bidder with design calculations subject to approval.

Note: Depth of the switchboard shall be restricted to 1000 mm.

5. LV INDUCTION MOTORS

The specific requirements of the three pump houses are indicated below:

Description	Unit	Particulars			
		Model Town UGR	**C D Park, Jahangirpuri UGR**	**Fruit Market, Azadpur UGR**	**Mukherjee Nagar UGR**
Type		Squirrel cage Induction motor			
Rating	kW	110	125	30	55
Rated voltage	kV	415V			
Synchronous speed	rpm	1500			
Quantity	Nos.	6 (4W+2S)	6 (4W+2S)	5 (3W+2S)	6 (4W+2S)
Type of mounting		Horizontal			
Duty type		Continuous (S1)			

Description	Unit	Particulars			
Method of starting		Variable Frequency Drive			
Type of system earthing		Effectively Earthed			
Class of insulation		F °			
Design ambient temperature	C	50			
Location		Indoor			
Degree of Protection		IP55			
Cooling designation		IC411			
Terminal box		Non Phase Segregated Terminal Box (NPSTB) on both sides			
External cable details		1.1 kV, Aluminium, XLPE, armoured			
		1x3C x 300(*) sq.	1x3C x 300 (*) sq. mm.	1x3C x 35 (*) sq. mm.	1x3C x 70 (*) sq. mm.
Space heater for motor		Required			

(*) – Indicate rating, to be verified by the bidder with design calculations subject to approval.

6. Variable Frequency Drive (VFD) :

The requirements for Variable Frequency Drive for the pump houses are as below:

Sl. no.	Particulars	Units	Specification requirements
1.0	**GENERAL**		
1.1	Scope of supply for VFD.		The VFD shall consist of a continuous line-up of free standing, floor mounting panels of uniform height. The system shall be complete with input transformer, rectifier, DC bus, IGBT inverter, protection devices, etc. Design shall consist of modular cells.
1.2	Rating of driven equipment		As per motor rating above in motor datasheet
1.3	Application		Pump for Clear water system
1.4	Quantity	Nos.	As per the number of pumps
1.5	Ambient temperature	0 C	50
1.6	Motor type		Squirrel Cage Induction Motor (SCIM)
1.7	Panel Mounting location and Protection		Indoor, IP-42 degree of protection
2.0	**POWER SUPPLY**		
2.1	Supply voltage and frequency		415 kV +/- 10 %, 50 Hz +/- 5 %
2.2	Combined Voltage & Frequency Variation		10%
2.3	System fault current		50 kA for 1 second
3.0	**VFD**		
3.1	Input Supply		3-Phase, 415V +/-10%, 50Hz +/-5%, Combined variation 10%

3.2	Output		3-phase, variable voltage & variable frequency (Sinusoidal waveform with near zero harmonics)
3.3	Design ambient temperature	0 C	50
3.4	Over load capability		
	100%		Continuous
	120%	Sec	60 (Once in every 10 minutes)
	150%	Sec	3
	200%		Momentary
3.5	Control mode of converters		V/f Control; Digital Vector Control
3.6	Overall Efficiency		
i.	At 100% load & speed	%	>96.5 including auxiliaries
ii.	At 50% load & 80% speed	%	>95% including auxiliaries
iii.	Power factor over entire speed & load range of 25% to 100% without use of power factor correction capacitors.	lag	> 0.95
iv.	THD (Current & Voltage) on Supply side	%.	< 3 at all conditions
v.	THD (Current & Voltage) on load side	%.	< 3 at all conditions
vi.	Speed regulation		Within 0.5% of full speed without encoder or tachometer feedback
vii.	Out frequency resolution	Hz	0.01
viii.	Noise level		Less than 75 db(A) at one meter distance at any speed or load condition
ix.	Torsional analysis		VFD output shall not produce electrically induced pulsating torques
x.	System availability		99.99%
3..7	Special features		
i.	Direct communication with DCS through Modbus TCP/IP port for parameterization, control, monitoring, fault diagnosis, trending and log downloading.		Required
ii.	Analog input/output (isolated)		4/4**
iii.	Digital input/outputs		16/5**
3.8	Protections		

i.	Static instantaneous over current and over voltage protection		Required
ii.	Under voltage protection		Required
iii.	Over temperature protection		Required
iv.	Failure of forced cooling detection		Required
v.	Over speed protection		Required
vi.	Over frequency protection		Required
vii.	Electronic inverse time overload motor protection		Required
viii.	dv/dt protection		Required
ix.	Motor stall protection		Required
x.	DC under and over voltage protection		Required
xi.	Protection for short circuit (1 phase or 3 phase) at output terminals of VFD		Required
xii.	Protection against failure to commutate		Required
xiii.	Semiconductor fuse failure detection		Required
xiv.	Protection for loss of one phase of incoming power		Required
xv.	Protection against regeneration from motor		Required
xvi.	Protection against earth fault in VFD or in motor or in cable from VFD to motor		Required
xvii.	Protection against open circuit at VFD output		Required
xviii	An anti-back spin device to prevent the pump from starting while it is rotating in reverse direction		Required
xix.	Power interrupt ride through		Required to withstand power loss for 5 cycles or more
xx.	Power sag ride through		VFD shall be capable of continuous operation with 30% voltage sag on incoming line
xxi.	VFD shall be capable of quick transfer to mains in the event of VFD failure		Bidder to indicate the recommended time settings and also indicate the setting range available. (The time shall be from the instant the VFD trip is initiated till the time the mains supply is established to the drive. Also, dead time (no supply voltage condition across the motor) shall be indicated)

xxii.	Catch a spinning load capability		Required
xxiii	Auto restart - VFD shall be capable of automatically restarting in the event of momentary loss of power or clearing a drive trip. This facility shall be user selectable		Required
xxiv	In case of a ground fault the VFD shall annunciate the fault & shall be capable (by user selection) of safe operation or trip. There shall be no risk of fire or electric shock as a result of ground fault		Bidder to furnish the details to achieve this feature.
xxv.	Input side surge suppressor		Required
xxvi	All low voltage wiring/circuits shall be suitably isolated from Medium voltage part.		Required
4.0	**Other features**		
4.1	Cooling method		Air forced redundant cooling system with provision to switchover without interruption of the drive.
4.2	Cable entry		Bottom
4.3	Castell lock and keys shall be provided for mechanical interlocking among different doors of VFD as well as with upstream circuit breaker feeding power to VFD		Required
4.4	Sheet steel thickness (CRCA)	mm	2mm for load bearing members 1.6mm for non load bearing members 3mm for gland plate (Aluminium gland plate to be provided for single core power cables)
4.5	Paint Shade		RAL 7032 epoxy based paint
4.6	Is GA drawing enclosed		Required

** To be verified by Bidder

7. Cables

Description	Unit	Particulars
MV XLPE Power Cables		
Rated voltage U / Uo (Um)	kV	18 / 30 (36) and 3.6 / 6 / (7.2)
Material of conductor		Aluminum (stranded)
Cross-sectional area		(*)
Type of insulation		XLPE
Inner sheath		Extruded
Outer sheath		Extruded
Conductor and insulation screening		Required
Material of Armour		Galvanized Steel (Aluminum for single core cable)
LV Power, Control and Lighting Cables		
Rated voltage U / Uo (Um)	kV	0.6 / 1 (1.2)
Material of conductor		Aluminum for Power and Tinned Copper for Control cable (stranded)
Cross-sectional area		(*)
Type of insulation		XLPE for power and PVC for control cables
Inner sheath		Extruded
Outer sheath		Extruded
Material of armour		Galvanized Steel (Aluminum for single core cable)
Cable Protection		Compound of outer sheath of all HV/MV/LV cables shall contain suitable chemicals for preventing attack by rodents.

(*) Value to be verified by Bidder with supportive design calculations and subject to approval.

6.2.2.5
Particular Specification
(Instrumentation Control & Automation, SCADA)

Contents

1.0 General

This section outlines the particular requirements for the instrumentation, control & automation works. This section shall be referred in conjunction to the general requirements for instrumentation, control and automation works specified in this document. Unless specified in this section to the contrary, the system provided by the Contractor and workmanship shall comply with the General Chapters of these Requirements.

The scope of instrumentation, control and automation (ICA) works under this contract shall comprise of the design, manufacture, supply, programming and configuration, off site testing, delivery to site, installation and erection, testing, commissioning, setting to work and provision of documentation for a complete instrumentation, control and automation system including the interfaces required to provide monitoring and control for a safe and efficient operation of the plant.

The minimum scope of work for ICA at the UGR Local control centre shall include but not limited to:

Design, supply, install, test and commission a redundant PLC based SCADA system for the LCC UGR. The system shall include on a minimum, but not limited to process controller including its central process units (CPUs in redundant configuration), redundant communication modules, RIO's, Simplex input-output (I/O) modules (Hot swappable), control networks, Blade servers, Historian server and software, operator workstations, Engineer workstation and printers;

All servers under this contract shall be based on Blade server technology. All servers for SCADA, Historian, CCTV system, etc shall be redundant (Refer control system architecture). All necessary enclosures chassis, precision cooling systems for the blade servers shall be provided by the contractor.

Design, supply, install, test and commission field & analytical instrumentation for the UGR (level instrumentation comprising of level transmitters and switches and level gauge, electromagnetic flow meters at the inlet and individual outlet of the UGR ;)

Design, supply, install, test and commission field instrumentation for the pumping station comprising of –pressure Gauges & pressure transmitters at the individual outlet of each pump discharge and common discharge of pumps, electromagnetic flowmeter at the common discharge of pumps,

Design, supply, install, test and commission LCC SCADA system which shall control and monitor the data from the UGR, pumping system, DMA data, control & monitoring of inlet actuated valve of each DMA and pressure measurement;

Design, supply, install, test and commission CSC SCADA system which shall integrate the control system from each of the three UGR LCC and monitor the data;

Control room furniture include but not limited to system consoles for placing servers, workstations and printer compartments, Engineer workstation and printer compartment and ergonomic designed seating systems.

The Contractor shall be responsible for the design of each instrumentation and plant monitoring system, including the selection and design of appropriate transducers, transmitters, signal conditioning devices, indicators, alarm system programmable devices, communications, cable system etc. The Contractor shall take account in his design of all installation and environmental conditions prevailing at the site.

1.1 System Completeness

This section of specifications defines the particular requirements of instrumentation, control & automation works to be installed. For selection of field instruments and control system or anything related to instrumentation, the Contractor shall follow the specifications contained herein. Irrespective of the detailed specifications of the respective items detailed in the various chapters of the tender specification, the Contractor shall be required to provide all the equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic, interlocks ,cabinets, panels etc. to achieve the functional requirements described in the Bid Document. The System completeness shall be the Contractor's responsibility.

1.2 Field Instrumentation and Control

Each field instrument shall be operable in local mode and have display functions in SCADA. The Contractor shall be responsible for providing the appropriate signals at the locations required to provide the specified control and monitoring functions.

The Contractor shall ensure that field measuring systems shall respond quickly to any changes of the measured process variables.

All field instruments shall, as far as practicable, be mounted in a location that shall be free of vibration and shall be powered from the instrument control system.

24V dc power wiring for field instruments shall be individually fused and provided with a means of disconnecting the power without disturbing terminated wiring (e.g. knife-switch-type terminal blocks). Visual indication of a blown fuse condition shall be provided.

All field instrument components shall be of a proven and reliable design and shall have a high degree of uniformity and shall, wherever possible, be interchangeable. The design shall facilitate easy maintenance and repair, taking into account the availability of access routes through plant and structures generally.

Field Instruments shall perform sensing, indicating, transmitting and controlling. The devices shall generally interface with the SCADA, either directly or indirectly. The materials of those parts of the field instruments, including piping material, which are exposed to the measured media shall be compatible with the conditions of the respective media and of the ambient fluid and atmospheric conditions.

All field instruments shall be mounted within enclosures that are corrosion proof, dustproof and waterproof to provide a minimum protection specified in elsewhere in this Specification. The enclosure design shall be submitted along with the instrument datasheet for review and approval before any design of the same.

All field instruments, including the components, shall be tropicalized and designed for the ambient conditions detailed elsewhere in this Specification. Lighting protection barriers shall be used for protecting transmitters and receiving instruments from the surge voltage due to lighting strike. Lighting protection barriers shall be supplied at both receiving and sending ends for all signals from outside building and those installed between the buildings.

1.3 Instrumentation Design Criteria

The design criteria to be applied to instrumentation systems shall be as follows:

1. all instruments shall be suitable for continuous operation;
2. all transmitting instruments shall have a 4 - 20 mA linear output;
3. all digital outputs shall be volt free;
4. all instruments shall be designed for the ambient conditions of temperature and humidity;
5. all wetted parts of instruments sensors shall be non-corrosive.
6. all instrumentation systems for use out of doors shall be protected to IP 65;
7. all analogue displays shall be of the digital type with no moving parts utilizing back lit liquid crystal diode LED technology;
8. instrumentation shall utilize solid state electronic technology and avoid the use where practical of any moving parts;
9. minimum maintenance requirement;
10. Instrumentation shall resume operation automatically on the application of power following a power failure.
11. All analytical instruments shall be single channel and have individual analyzer units.
12. All flow meters shall have local totalizer flow indications in addition to the same being indicated on the plant SCADA system

Digital systems shall be provided as detailed in the Employer's Requirements and as necessary for the efficient and safe operation. Instrumentation sensors shall be suitable for the environment in which they are expected to work. Sensor located in hazardous (flammable) or potentially hazardous atmospheres shall be certified for use in these areas. All Sensors should be of self-cleaning type.

1.4 Flow Measurement and Control

The Contractor shall use electromagnetic flow meters, for all closed pipe liquid flow measurement as the standard flow meters under this contract. Each flow meter shall be installed in the pipeline within a suitable access chamber. The access chamber shall be designed to provide adequate space for personnel access to the chamber and around the flow meter for maintenance. The flow meter system shall provide flow rate and totalized flow indication.

The pressure rating of the flow meter and flanges shall be equal to or greater than that of the pipeline within which it is installed. Where this is not possible, then the converter shall be installed in a suitable above ground enclosure providing the converter with suitable mechanical and environmental protection.

The flow signal converters/transmitters shall provide 4-20mA output linearly proportional to the rate of flow and shall provide a pulse output for flow totalizing. The flow meter electronic supervisory unit shall display the following on a minimum:

- Flow rate;
- Flow total-totalizer;
- High flow rate alarm;
- Low flow rate alarm.

Signals for the items above shall form inputs to the PLC and SCADA and be utilized within Operator displays. The integrator used for the second item above shall have at least six digits. Each flow meter shall be provided with downstream and upstream isolation valve including the washout facility.

1.5 Electromagnetic Flow Meter

Full bore bi-directional electromagnetic flow meters shall be designed, manufactured and calibrated as per ISO/IEC 17025 standard. Meters shall also have actual Flow rate & Totalized value. The accuracy shall be +/- 0.5% of reading.

The sensors shall be as per DVGW / ISO standard lengths (ISO 13359), so that inter-changeability can be carried out for the applicable flow meter sizes. The sensor shall also have built in grounding and empty pipe detection electrodes of SS316 for detecting partial flow condition & efficient operation purposes. The liner material shall be Polyurethane (PU)

The sensors shall be rated IP68. The transmitter shall be rated IP67 in line with local operating conditions. Installations shall be made with cables and /or conduits that guarantee the integrity of the system under all operational conditions. The transmitter/converter shall be wall-mounted type with a 2 line display for the indication of Actual Flow rate & Totalized value. A glass window within the protection enclosure with optical switches shall be provided for local reading purposes.

The non-corrosive, Die cast Housing material of the enclosure shall be sufficient to guarantee fifteen years operational life. Magnetic flow meters should be supplied with built in software feature to analyze and continuously monitor the health of the sensor, display errors in text format. Transmitter should be capable of performing the verification program on demand or on request without taking meter off the line.

The transmitter shall be capable of being fully programmable. It shall have a set-up menu so that all relevant parameters may be user-set from the self-prompting driven menu.

The transmitter shall have totalizer units and shall have one (1) scalable pulse output & one (1) current i.e.4-20mA HART output. The current output shall be galvanically isolated. It shall be fitted with switched mode power supply capability 0-250V or 24 DC and 45-65Hz to cope with power transients without damage. The Totalizer value shall be protected by EEPROM during power outage, and utilizes an overflow counter.

The transmitter shall be having facility of indicating flow measurement. It shall be possible to separate the sensor and transmitters up to 200 meters without the need for signal boosters or amplifiers

Detailed technical specification of Full bore electromagnetic flow meter is as below

General		
1	Application (Suitable for)	Water
2	Op Temperature	0 to 50 Deg C Max
3	Op Pressure	Max 6 Bar g
4	Measurement	Instantaneous water flow Rate, Totalized Flow
Flow Sensor		
5	Type	In-Line Full Bore Electromagnetic flow meter.
6	Power supply type	Mains operated
7	Sizes (mm)	As per Line size
8	Sensor Type	Pulsed DC
9	Process Connection	Flanged type
10	Weather Protection Class	IP68 as per IS 13947
11	Full Scale Velocity	0.4 to 10 m/s, vendor to provide the detailed sizing calculations based on the process details.
12	Electrodes	SS 316 L, Total 4 Electrodes system. Measuring electrodes – 2 Nos. Grounding electrode- 1 No. and Empty pipe detection electrode -1 No.
13	Coil Housing	Powder-coated die-cast aluminium Anti corrosive grade with IP 68 protection class with minimum 20 meter cable for remote mount transmitter connection
14	Flanges	Carbon Steel PN 10 as per EN 1092-1
15	Flow sensor Grounding	In- built Grounding Electrode SS316L is must. Grounding rings shall also be acceptable
16	Flow Tube material	SS304
17	Flow Tube Liner	Polyurethane
Flow Transmitter Unit		
1	Type	Microprocessor based with facility to configure the range
2	Type of Display	2 -Line LCD display with operation keys (touch control)
3	Transmitter Type	Remote Wall Mounted with 5 cable glands, integrated fixing points for wall mounting, with sensor interface
4	Units For Display	Flow Rate m3/Hr , Totalized Flow ML
5	Input	From Flow Tube
6	Accuracy	+/- 0.5 % of Measured Value
7	Operation	Via local display, Via HART handheld terminal
8	Output proportional to Flow rate	Current output (4–20 mA HART); pulse/frequency/switch output (2); status input
9	Power supply	0-250 VAC , 45-65Hz – Optional - 11 to 40 V DC
10	Self-diagnostic feature	Following minimum diagnostic features shall be provided Empty pipe detection, system diagnostic features
11	Transmitter Enclosure material	Non corrosive, Die Cast Aluminium
12	Communication	Suitable for Wired communication with control system and HART based integrated and service interface

13	Memory	100% secure data storage
14	Weather Protection Class	IP 67 (NEMA 4X) for flow transmitter
14	Calibration Method	Gravimetric Method ISO 4185 / volumetric method (ISO 8316). All test equipment fully traceable to national and international standards with 3 point calibration.
15	Flow calibration rig	Duly Accredited according to ISO/IEC 17025

1.6 Level Measurement and Control

The following section describes the minimum technical specifications for level measurement and control under this contract.

Radar Microwave Level Transmitter :

	Transmitter	
1	Type	Microwave Level measurement
2	Principle	Pulse Time of flight
3	Output	4-20 mA HART current
4	Housing	Die Cast Aluminium
5	Electromagnetic compatibility	Interference Immunity to EN 61326, Annex A (Industrial) and NAMUR Recommendation NE 21 (EMC)
6	Ingress Protection	IP 67
7	Accuracy	+/- 3 mm
8	Area Classification	Non-Hazardous. Hazardous
9	Display	4 line LCD display. Service: Display of Envelope curve
10	Configuration	Using Keypad on display
	Sensor	
11	Range	Liquids 0 to 5m and 0 -10m depending on Tank size
12	Temperature range	-40°C ... +80°C
13	Max Pressure	3 bar abs
14	Materials	Sensor: PVDF Seal: EPDM
15	Antenna seal	FKM Viton
16	Process connection	Threaded or universal flange dependent on model selection
17	Degree of protection	IP65

Ultrasonic Level Transmitter:

	Transmitter	
1	Type	Ultrasonic
2	Principle	Pulse Time of flight
3	Output	4-20 mA HART current
4	Housing	Die Cast Aluminium
5	Electromagnetic compatibility	Interference emission to EN 61326; Equipment class B Interference immunity to EN 61326; Appendix A (Industrial)
6	Ingress Protection	IP67
7	Accuracy	+/- 2 mm or 4 mm depending on selection or 0.2% of set measuring distance Whichever is greater.
8	Area Classification	Non-Hazardous/Hazardous as applicable
9	Temperature range	-40°C ... +80°C
10	Display	4 line LCD display. Menu guided operation Display of Envelope curve.
11	Configuration	Using Keypad on display
	Sensor	
12	Range	Liquids 0 to 5m and 0 -10m depending on Tank size
13	Temperature range	- 40°C ... + 80°C
14	Max Pressure	3 bar abs
15	Materials	Sensor: PVDF Seal: EPDM
16	Process connection	Threaded or universal flange dependent on model selection
17	Degree of protection	IP 68

Level Gauge (float & tape)

1. Type : Float and Tape
2. Float & Tape MOC : AISI 316
3. Pulley material : Aluminum
4. Guide wire : SS 316 Stainless steel
5. Accuracy : +/- 2 mm
6. Indication : On circular or vertical dial
7. Rating : Twice the design pressure

Sight Glass

1. Type : Flap-type
2. End connection : Screwed / Flanged
3. Material :
   a) Body - SS-304
   b) Cover Plate - SS-304
   c) Indicator - SS-316
4. Sight Glass : Toughened Borosilicate
5. Gasket : Neoprene
6. Bolts & Nut : High tensile steel
7. Hydraulic Test Pressure : 1.5 times maximum working pressure
8. Accessories : As required

1.7 Pressure Instrumentation

Pressure Gauges & Indicating Transmitters:

1. Pressure gauges shall comply with BS EN 837- Parts 1, 2 and 3. Pressure Gauges & Indicating Transmitters shall have over range protection up to 1.5 times the maximum anticipated line pressure.
2. Internal parts shall be of stainless steel, bronze or other corrosion resistant material.
3. All Pressure Gauges & Indicating Transmitters shall be supplied complete with isolating valves and calibration points to enable calibration or removal without loss of fluid.
4. Where compensation of more than 2% of the instrument span is needed for the difference in level between the instrument and the tapping point, the reading shall be suitably adjusted and the amount of compensation marked upon the dial.
5. Pressure and differential pressure switches shall have contacts with separate 'cut in' and 'cut out' pressure values.
6. The nominal pressure values at which pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value(s) shall be clearly indicated by means of a scale and pointer.
7. Pressure monitoring shall be by a sensor suitable for the medium and pressure/level range.
8. The sensor shall be selected to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure without damage. The sensor shall be suitable for either free wire suspension in the medium or fitted remotely and provided with threaded sockets to permit connection of pressure pipe work.
9. A transmitter shall be provided either integral with the transducer or separately mounted and converting the signals received from the transducer to a 4 to 20 mA signal proportional to the range specified.
10. The transmitter shall have provision for span and zero adjustment.

Specifications for Pressure Transmitters:

Pressure measuring system shall consist of pressure transmitter and digital pressure indicator and any other items required to complete the pressure measuring system. Pressure transmitter shall be rugged in construction and shall be suitable for continuous operation. Pressure transmitters shall be designed for operation over 130% of full range. It should have EEPROM for storing of history data.

Pressure transmitter shall be suitable for field mounting. They shall provide 4-20 mA Current output proportional to pressure. Transmitter output shall be isolated and shall be suitable for transmitting over long distance. Pressure transmitters shall have high degree of weatherproof protection as specified in technical particular. Pressure transmitters shall have LCD display to indicate pressure.

The Contractor shall mark the exact location of pressure measuring point on the pipe line. The contractor shall provide all the hardware items including manifolds , nuts, bolts, pipes, valves, gaskets etc. required for the work.

Sr. No	Detailed specifications for Pressure Transmitters	
1.	Specifications	Pressure Range 0 to 10 /20/50/ 100 Kg/cm2 g
2.	Process Temperature range	-20 to +125 deg.C.
3.	Output Signal	4 to 20 mA with superimposed digital communication protocol HART 6.0, 2-wire
4.	Signal range –	4 to 20 mA HART 3.8 to 20.5 mA
5.	Signal on alarm	As per NAMUR NE 43 • 4 to 20 mA HART
6.	Resolution	Current output: 1 micro Amp
7.	Response time	<250 ms
8.	Damping	required
9.	Supply voltage	11.5 to 45 V DC
10.	Reference accuracy	± 0.1%
11.	Housing	Die Cast Alu. Housing
12.	Diaphragm Material	Ceramic
13.	Long Term Stability	± 0.25% URL/year
14.	Turn Down	10 1

Differential Pressure Transmitter

1. Working Principle : Smart
2. Type : 2-Wire
1. Output signal : Superimposed field bus over 4-20 mA DC.
2. Signal Processing Unit : Silicon solid-state electronic circuitry
3. Measuring element : Capsule/ Diaphragm
4. Element material : AISI-316 (Stainless Steel) or better
7. Static Pressure/ Overload Pressure : Maximum line (or static) pressure on either side without permanent deformation or loss of accuracy
9. Turn-down ratio : 100 : 1 minimum
10. Span and Zero : Locally adjustable, non-interacting
11. Enclosure class : IP-65

12. Zero suppression / Elevation : At least 100% of Span

13. Output Indicator : LCD type

14. Performance:-

    i) Accuracy : ±0.1 % of span or better

    ii) Repeatability : ± 0.05 % of span or better

    iii) Response time : 100 mSec or better

15. Sealing / Isolation armoured capillary for viscous Fluid applications. : Extended diaphragm with 5 meters SS

16. Accessories 2" pipe mounting. :
    a) Universal mounting bracket suitable for
    b) High tensile carbon steel U-bolts.
    c) Companion flange with nuts, bolts and gaskets.
    d) Hand held configurator kit for calibration of Smart Transmitter.
    e) ½" NPT cable gland
    f) ½" NPT generally 5-valve stainless steel manifold, constructed from SS316 bar stock.

1.8 Temperature Instrumentation

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C and chromel-alumel thermocouples for spans exceeding 200°C.

The accuracy for temperature meters shall be ±0.03% of span. Configuration data shall be stored in the EEPROM memory.

In critical and important application, the temperature sensors shall be of a dual type arrangement for easy replacement. Each temperature sensor, unless otherwise specified, shall have a stainless steel thermo well, or pocket-and-extension assembly, non-corrodible metal sheath and waterproof terminal head. Pockets for steam, oil and pressurized-water lines shall be welded; pockets for other duties shall be screwed. The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

Platinum resistance thermometers shall comply with BS 1041 and BS EN 60751 or equivalent Indian Standards on the approval of the Employer Representative. Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where Alpha = 0.00385. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier. Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be

hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

Thermocouples shall be of the mineral-insulated type and unless otherwise specified shall be of the chromel-alumel (nickel-chromium v nickel-aluminum) type and shall comply with BS 1041 and BS EN 60584-1.

Thermocouple junctions shall be welded. Ceramic-insulation material may be used for base-metal thermocouples but low-silicon insulation material shall be used for noble-metal thermocouples. Thermocouple systems shall have thermoelectric ice point reference chambers or receivers or amplifiers with automatic cold junction compensation.

Thermocouple receivers and amplifiers shall also have zero and span adjustment, common and series mode interference rejection circuits, radio-frequency filters, input-output circuit isolation and thermocouple break feature whereby the output is driven to zero or full-scale, as stipulated by the Employer Representative, when the receiver or amplifier input circuit is broken.

Thermocouple elements shall be electrically isolated from their sheaths but each terminal head shall have facilities for earthing the thermocouple and for terminating the screen of the extension or compensation cable.

Amplifier chassis shall have facilities both for being earthed to the instrument case via a capacitor and for being electrically isolated from the instrument case.

Temperature transmitters shall be of rugged construction microprocessor based instruments. They shall provide simultaneous digital and analogue outputs and the 4mA to 20mA dc output shall be linear with temperature.

1.9 Analytical Instrumentation

Online Analytical Instrumentation shall be used to provide continuous monitoring of water quality on continuous basis and to provide early warning of WTP malfunction. The monitors and their associated sensors or cells shall be selected as appropriate to the particular application.

In all cases, the location and housing of the monitor shall take into account the provision of a representative sample to the monitor sensor, the pre-conditioning if any, required prior to the sample's analysis, operator requirements for access, maintenance, calibration, repair and replacement of the monitor or its sensors.

All online analytical instruments shall be single channel and shall have individual analyzer units only.

Online Chlorine Measurement (at UGRs):

Online chlorine analyser shall be based on Amperometric/membrane based measurement of active chlorine converted to free chlorine by means of pH compensation. The sensor shall have digital communication based on inductive energy transfer which will withstand moisture, corrosion and ensure reliable data transmission at all times.

The offered transmitter shall be IP67, Interference emission & immunity shall be as per EN 61326-1:2006.

	Transmitter	
1	Measuring parameter	Free Chlorine
2	Transmitter type	4- wire
3	No of channel	Two channel (one for chlorine , one for pH)
4	Output	4-20 mA HART current
5	Supply voltage	100 / 115 / 230 V AC +10 / –15%, 48 ... 62 Hz
6	Material	Field Housing : ABS / Polycarbonate
7	Display	LC display, two lines, with status indicators Graphic display : backlit ; transflective display ; user settable measuring menus ; red display for alarms
8	Electromagnetic compatibility	Interference emission and interference immunity acc. to ISO EN 61326: 1997 / A1: 1998
9	Protection class of field housing	IP 67
10	Ambient temperature	–20 ... +60 °C
	Sensor	
11	Principle	Amperometric measurement of free chlorine with pH compensation
12	Measurement range	0,01 - 5ppm free chlorine
13	Material	Sensor shaft : PVC
14		Membrane : PTFE
14		Membrane cap :PBT (GF30); PVDF
15	pH compensation	pH sensor for compensation required
16	temperature sensor	NTC / Pt100
17	Connection	Inductive digital connection with Transmitter
18	Ingres protection	IP68
19	Resolution	0.01mg/l
20	Repeatability	+/- 1 %
21	Measurement Error	1 % of measured value
22	Mounting	Flow assembly

The residual chlorine analyzer shall continually measure the concentration of free chlorine residual present and, by control of the chlorine dosage rate, shall maintain the predetermined concentration. The residual analyzer shall have the capability to initiate high and low alarm locally and to SCADA.

Control & Automation Particular Requirements

General

This part covers the Particular requirements for the design, supply, installation, Inspection and testing of Programmable Logic Controllers (PLC) and Supervisory Control and Data Acquisition (SCADA) and associated plant and materials.

Related Sections to be Referred with this Document

a) Part A- General Instrumentation, Control & Automation Requirements
b) Part-B- Particular Instrumentation Requirements

Applicable Standards

All equipment shall comply with all applicable national and local laws regulations and standards, in addition to those listed below:

a) ISO 9000 and 09004	-	Quality Systems
b) IEEE 587	-	Power Supply Surge Protection
c) IEC 61131-3 Programmable	-	Programming Languages for Controllers.
d) IEC 61158-2	-	Communication Protocols
e) ISO 9075 (BS 6964)	-	Structured Query Language (SQL)
f) BS 5515 Systems	-	Documentation of Computer Based
g) BS 7165	-	Recommendation for Achievement of Quality in Software
h) BS EN 50081	-	Electromagnetic Compatibility
i) ISO 3511	-	Process measurement control functions instrumentation symbolic representation.
j) ISO-OSI	-	7 Layer Communication Model
k) IEEE 472-1974	-	Surge protection.
l) IEC 61850	-	PLC sub-station automation protocol.
m) IEC 8705101	-	Modbus protocol conversion

Statement of Compliance

The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the Bid submission, and FDS submission. Failure to do so will be treated as a non-responsive bid. Contractor should take note on the importance of this obligation.

Quality Assurance

The Manufacturers shall be operating under an accredited ISO 9001 or above Quality System. Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost. These shall include all hardware and software necessary to implement the upgrade.

HMI

The HMI shall be with colour screen and touch screen capabilities. All Remote I/O panels which are connected to the main plant PLC based SCADA system and the main PLC panel

shall be equipped with a 16" panel HMI. The HMI shall be suitable for day to day operation by non-computer literate personnel in the monitoring and operation of the treatment works.

It shall be possible to view and acknowledge the alarms and view set points for the particular process from the HMI.

The HMI shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimization. The system will allow operators, technicians and Employer Representatives to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the particular system. HMI unit along with software packages shall be considered, and also those software packages and Hardware shall be compatible with TCP / IP protocols as well as OPC communication (Open Standard Communication)

(a) Design and Construction Requirements

Local control centre at the UGR shall be equipped with PLC based SCADA system. PLC shall be provided in a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, Simplex input/output (I/O) modules, communication interface modules and Human-Machine Interface (HMI) required performing the desired functions.

PLC shall have the following attributes as a Hot Stand-by Controller.

- carry out sequential logic implementation for operations of plant;
- carry out computation and interfacing for data acquisition, data storage and retrieval;
- it shall accept downloaded program from a programmer;
- it shall have different functional modules to perform the desired functions;
- it shall scan the inputs in time cycles and update the status of its outputs.

The PLC system shall be expandable, OPC Compatible and shall be modular in construction, so as to be capable of future expansion without hardware modifications. PLC s shall be microprocessor based. PLC shall use standard known protocols and structures for communication outside the system.
In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

The contractor shall note that PLC System & RIO systems should be housed in air conditioned environment. The contractor shall submit the sizing calculations for the air conditioning system for review and approval for the PLC based SCADA system control room and the RIO panel room where the RIO panels shall be installed.

The contractor shall refer the approved vendor list for the PLC system and hardware, specified elsewhere in this document.

Remote input/output modules (RIO)/Panels

The PLC system shall consist of field remote input/output modules (RIO) and panels. Each RIO panel shall consist of redundant communication modules, power supply modules, minimum 16" colour panel mounted HMI with touch screen functionality. It shall be possible to view and acknowledge the alarms and view setpoints for the particular process from the HMI etc.

I/O Modules:

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Refer the approved vendor list for the PLC system and hardware, elsewhere in this document. Contractor should take note on the importance of this obligation.

Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable. 20% extra modules of installed capacity for each type of module shall be provided as spare. In addition to the above, provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity in the panel. The panel drawings shall reflect the same.

I/O modules shall be as follows:

a) inputs shall be opto isolated.;
b) filters shall be provided for noise rejection;
c) output status shall be indicated by an LED;
d) all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module;
e) all the modules shall be of addressable type.
f) Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event. PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications

The PLC system shall be expandable, OPC Compatible (OPC should be a built in feature of the software and hardware. No external software patch or hardware module is allowed) and

shall be modular in construction, so as to be capable of future expansion without hardware modifications.

(b) Dual redundant processors (CPU)

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode. Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 7 MB. Both the CPU's should have separate backplane and associated hardware for redundancy. CPU system should have built in WEB server.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided. PLC CPU and I/O modules shall be of the same logic family. Failure to do adhere to the above will be treated as a non-responsive bid and lead to technical disqualification. Contractor should take note on the importance of this obligation.

The system shall be designed and implemented such that when the Main processor fails, the Standby one shall automatically take over. The changeover shall be seamless, smooth and without any time delay and shall not cause any disruption to the overall distributed control system and to the ongoing processes.

The PLC system shall be expandable (OPC Compatible) and shall be modular in construction, so as to capable of future expansion without hardware modifications.

A. The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone.
B. Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 20 % for each IO card
C. Each IO card shall be able to accept at least two more I/O cards without requiring replacement of, or additions to, the original equipment.

PLC s shall be microprocessor based. PLC s shall use standard known protocols and structures for communication outside the system. In case of system failure or power supply failure the outputs shall attain a predetermined fail safe condition (this shall normally be 'off').The PLC used shall have a proven record in the type of application concerned and in the prevailing environmental conditions.

Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 61131-3. The PLC shall be powered by two independent sources provided by the UPS system and all internal operating supplies shall be derived from the UPS.

The power supplies, I/O, CPU and communication modules and battery backup rates shall be monitored by the PLC and shall be available by report.
During the times of the battery discharge, the PLC shall initiate an orderly self-shutdown and automatically restart on the main power restoration without the need for reloading or

initiation of any kind. The PLC shall comply with the specification specified elsewhere in this specification. Each PLC shall have built in web server capability allowing system information to be stored in a format that allows for easy access and viewing with standard Windows™ based browser. Each unit shall be furnished with built in O & M data associated with its specific site including; as a minimum , basic system information, panel layouts, wiring diagrams, material lists w/part numbers, and operational summary. This information shall be accessible locally or remotely

(c) Central Processing Units

The central processing units (CPU) shall be a high performance processor with modular configuration suitable for real time process applications. The following additional features shall be provided:
Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup system will not be not acceptable. CPU should have the memory expansion capability of minimum 7 MB. Both the CPU's should have separate backplane and associated hardware for redundancy. No deviation from the same shall be acceptable.

RIO's shall have dual redundancy on network level connected to both the CPU. Even on the failure of one CPU backplane the other system should be available on dual network at RIO level.

SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity should be provided. Communication between CPU and peripherals shall be by an I/O bus. The individual device, interfaces shall be capable of being plugged into the I/O bus. On resumption of power following a power failure the PLC shall automatically restart its controlling function.

CPU shall have a real time clock capability to accept a time synchronization pulse and adjust its internal clock with the pulse. CPU shall have extensive self-diagnostic facilities and watch dog timers to identify faults at card levels

(d) Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for the upgrading and expansion of memory to meet future demands.

Not less than 50 % spare program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM or EPROM. Operating data shall be stored in a RAM fitted with an internal battery backup. The battery backup provided shall support the memory on loss of power for at least one month. The battery life shall be at least 2 years.

(e) I/O Modules

Standard rack mounted plug in I/O modules shall be provided. I/O Modules should be of the same series as the PLC CPU. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor I/O system with prefabricated cables and plug in card type connectors. I/O Modules should be hot swappable. 20% extra modules of installed capacity for each type of module shall be provided as spare. Provision shall be made for future expansion of additional 20% extra I/O modules of the installed capacity.

I/O modules shall be as follows:

- inputs shall be opto isolated
- filters shall be provided for noise rejection
- output status shall be indicated by an LED
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted externally from the output module
- all the modules shall be of addressable type
- Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 Base T connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane

(f) Analogue Input Modules

They shall consist of an input isolation unit, signal conditioning unit and an analogue to digital converter (ADC). In addition, the following features shall be provided.

- cross talk attenuation
- provision for monitoring of the ADC for overflow detection
- gain amplifier with high common mode rejection ratio
- accuracy for analogue signals shall be 0.5%

(g) Digital Input Modules

The following design features shall be provided.

- contact bounce protection;
- choice of type of contacts.

(h) Digital Output Modules

The digital output module shall provide contact closure output by driving relays. The features to be provided are as follows:

- contact bounce protection shall be provided
- relay output shall be provided to operate pump motors and motorised valve actuators
- fail safe position in case of output module failure and fault indication

PLC's provided under this specification shall be capable of performing the necessary logic to control the system as previously defined. These capabilities shall include, but not be limited to the following:

1. Discrete input/output
2. Analog input
3. Analog output
4. Timers
5. Pump Controller
6. Pump Alternation
7. Mathematical Function Blocks
8. Stage Blocks
9. Trending
10. Latch/unlatch relays
11. Counters
12. Comparators
13. Ladder logic
14. Flow Totalization/Integration
15. Intrusion Detection
16. Time of Day Control w/Lockout
17. Ramp Blocks
18. Data Logging

(i) PLC Programming

PLC programming shall be carried using FBD. The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.

The system shall support a simple programming of the application software comply with IEC 61131-3.

The system shall support a structured, modular programming. At least the following standard operations shall be applicable:

(1) Logic functions (such as AND/OR/AND NOT etc.);
(2) Timer functions (externally adjustable);
(3) Counter functions;
(4) Skip functions;
(5) Comparison functions;
(6) Limit value functions;
(7) Arithmetic functions;
(8) Physical unit functions;
(9) Closed-loop functions such as P/PI/PID/etc.

The Contractor shall submit the logic diagrams for review. The Contractor shall include the as-built logic in the final submission.

(j) Programming Unit

The programming unit shall be of the portable type, industrial model with minimum 19" screen designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a LCD display

At least the following functions shall be included:

i) On-line programming
ii) Off-line programming
iii) Flexible corrections during input
iv) Full screen editing functions
v) Absolute and symbolic programming

vi) Input of comments and title blocks for complete documentation
vii) Complete application software documentation functions. Printouts of application Software logic functions shall preferably be in Ladder logic diagrams.
viii) Load and transfer functions

The portable programming unit shall be provided complete with proprietary PLC programming and SCADA software with license complete with plant mimics and documentation software. Communications cables required to interact with the PLC, (Eg: Modbus Cable) would be supplied by the contractor.

The software shall provide facilities for:
- carrying out program revision management;
- insertion of comprehensive program subroutine and rung comments;
- search and find and search and replace 'contacts' and 'coils';
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs;
- preparation of coil and contact list and their locations and memory maps;
- make system backup copies while the system is online;
- upload and down load programs to the PLC on line;
- Carry out on line maintenance and fault finding on the PLC.

(k) Ethernet Switches

The contractor shall only provide managed industrial grade Ethernet switches under this contract. All switches shall be in redundant configuration.

Note: The complete PLC system (inclusive of Hot standby system, RIO panel, systems, IT hardware, etc. shall be powered by separate dedicated redundant UPS system, to be provided by the contractor. The UPS system shall be designed and supplied with minimum two (2) hours backup on full load. The UPS system parameters and system diagnostics shall be made available to the PLC based SCADA system for monitoring.

Minimum I/O Requirements for Automation System :

The detailed I/O list shall be finalized during FDS finalization. Design shall include complete auto mode of operation of the entire pump house and associated plants/stations with all necessary interlocks.

Typical I/O to be provided on a minimum is as under:

Sl No	TYPE	MINIMUM I/O'S TO BE CONSIDERED
1.	**Pump, Motor**	Start, Stop, Auto –Off-Manual, Run, Emergency Stop, Fault/Trip
2.	**Valve**	Auto-Off-Manual, Open, Close, Travelling Indication, Fault
3.	**Drives**	Start, Stop, Auto /Manual, Run, Emergency Stop, Fault
4.	**Level Indicator**	HH, H, L, LL, Analog value, Alarm
5.	**Level Switch**	HH, H, L, LL, Alarm

6.	**Analytical Instruments**	Analog Value, Alarm
7.	**Pressure Indicator/transmitters**	**(**in addition to individual pumps, at common discharge end of pumps,): Analog Value, Alarm
8.	**Flow Indicator/Transmitters**	in addition to other outlets and inlets, at common discharge end of pumps,): Analog value, totalizer, Alarm

Typical Drive Control Philosophy to be provided on a minimum shall be as follows:

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
1.	**PLC INTERFACE FOR UNIDIRECTIONAL HT DRIVE / LT BREAKER CONTROL DRIVE (Signal Exchange has been envisaged between PLC and switchgear)**		
a.	Start Command	DO	1
b.	Stop Command	DO	1
c.	ON Feedback	DI	1
d.	OFF Feedback	DI	1
e.	Swgr Disturbance (Overload relay operated/ control supply fail)	DI	1
	Emergency LPBS stop	DI	1
f.	Electrical Trip (Motor Protection Relay)	DI	1
g.	Switchgear Available (breaker in service position, switchgear in remote & breaker spring charged)	DI	1
h.	Pump bearing temperature measurement	AI	2
i.	Motor Bearing temperature measurement	AI	2
j.	Motor Winding temperature measurement	AI	6
k.	Current Transducer input	AI	1
2.	**PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE- For Integral starters (Signal Exchange has been envisaged between Actuator and PLC.)**		
a.	Open Command	DO	1
b.	Close Command	DO	1
c.	Integral starters Fault	DI	1
d.	Open limit switch feedback	DI	1
e.	Close limit switch feedback	DI	1
f.	Position Transmitter (For inching type Drive)	AI	1
3.	**PLC INTERFACE FOR BIDIRECTIONAL LT DRIVE-For Non-Integral starters (Signal Exchange has been envisaged between Actuator and PLC.)**		
a.	Open /Start Command	DO	1
b.	Close/Stop Command	DO	1
c.	Swgr/MCC Disturbance (Overload relay operated/ control supply fail)	DI	1
	Emergency LPBS stop	DI	1
d.	Switchgear/MCC Available	DI	1

SL. NO.	DESCRIPTION	Type of I/O	No of I/O
	(switchgear/MCC in remote)		
e.	Open limit switch feedback	DI	1
f.	Close limit switch feedback	DI	1
g.	Position Transmitter (For inching type Drive)	AI	1
5.	**PLC INTERFACE FOR SOLENOID DRIVE (Single coil)**		
a.	Energise or DeEnergise	DO	1
b.	Open limit switch feedback	DI	1
c.	Close limit switch feedback	DI	1
6.	**PLC INTERFACE FOR SOLENOID DRIVE (Double coil)**		
a.	Energise	DO	1
b.	DeEnergise	DO	1
c.	Open limit switch feedback	DI	1
d.	Close limit switch feedback	DI	1
7.	**PLC INTERFACE FOR PNEUMATIC DRIVE**		
a.	Command to I/P converter	AO	1
b.	Position Transmitter	AI	1
c.	Open limit switch feedback	DI	1
d.	Close limit switch feedback	DI	1
e.	Command to Solenoid valve (Wherever applicable)	DO	1

1.10 Supervisory Control and Data Acquisition System (SCADA)

SCADA system at LCC:

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system such that reliable and automatic plant control can be achieved.

The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room.

SCADA system would be dual redundant server system. All SCADA servers shall be based on Blade server technology. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

The SCADA system shall provide a complete monitoring & control (through the wireless telemetry system) of the UGR facilities (level, Flow), pumping system and the DMA system (inclusive of the inlet valves for each DMA, pressure measurement and online monitoring of the same).

The SCADA system shall comprise on a minimum the following:

a) Dual redundant SCADA servers with SCADA software unlimited tags license and web servers..
b) Historian system inclusive of the software to match the tag database of the SCADA software
c) Operator work stations loaded with SCADA software and with latest Windows Operating system, minimum 1TB storage, latest processor, etc.
d) Engineering work stations loaded with SCADA software & PLC programming software and with latest Windows Operating system, minimum 1TB storage, latest processor, etc
e) Two numbers of LED screens of minimum 65" size, which shall be connected over LAN to the SCADA system and to display the process screens, alarms and reports
f) Fire alarm work station to monitor the fire alarm system remotely.
g) Operator & engineering work stations with latest Windows Operating system, MS Office, Antivirus (licensed)minimum 1TB storage, DVdR/W, latest processor, etc
h) Industrial managed redundant Ethernet switches
i) Hardware based firewall system.
j) Web servers.-The contractor shall configure the SCADA system in such a way that DMA data and SCADA screens are made available to the employer's personnel at remote locations via web servers. The data shall be available via standard windows browsers with all applicable data access privileges to allow only view access.
k) Licensed Antivirus software to be loaded on each system
l) Industrial grade control system console to house the entire PLC based SCADA system and other equipment as indicated in the system configuration diagram.
m) All required software and hardware to implement the system as indicated in the specifications and system configuration drawings.

The SCADA system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation.

The system will allow operators, technicians and Employer Representatives to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Employer Representatives Terminal (ET), after successful log-on by security password.

The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system. For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the MMI shall provide the appropriate alarm.

Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.

An alarm horn with silence button shall be provided to alert the operator of an alarm condition. Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.

SCADA system at UGR :

The SCADA shall be a fully integrated microprocessor based control and data acquisition system which will monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant microprocessor based computer system .

The main process monitoring and control shall be by means of VDU based process operator workstations that shall be located in the central control room.

SCADA system would be redundant server system. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.

Failure of a single outstation or communications to that outstation shall not effect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.

An alarm shall be generated whenever a communications system failure occurs.

The Common SCADA system(CSC) shall provide a complete monitoring (through the wireless telemetry system) of all the LCC and the DMA system (inclusive of the inlet valves for each DMA, pressure measurement and online monitoring of the same).In addition to the same, the CSC shall control and monitor the Mukerjee Nagar UGR .

Common SCADA center shall also be equipped with following Software packages and the same shall be integrated with the SCADA system at the CSC-

- Water Distribution & Pressure Management.
- Water Leakage Management.
- Water Supply Operation

The SCADA system shall comprise on a minimum the following:

a) Redundant SCADA servers with SCADA software unlimited tags license and web servers.
b) Historian system inclusive of the software to match the tag database of the SCADA software
c) Operator work stations loaded with SCADA software and with latest Windows Operating system, minimum 1TB storage, latest processor, etc.
d) Engineering work stations loaded with SCADA software & PLC programming software and with latest Windows Operating system, minimum 1TB storage, latest processor, etc
e) Two numbers of LED screens of minimum 65" size, which shall be connected over LAN to the SCADA system and to display the process screens, alarms and reports
f) Fire alarm work station to monitor the fire alarm system remotely.
g) Operator & Engineering work stations with latest Windows Operating system, MS Office, Antivirus (licensed)minimum 1TB storage, DVdR/W, latest processor, etc
h) Industrial managed redundant Ethernet switches
i) Redundant Blade servers for SCADA software, Historian software, Fire alarm system. The blade server system shall be complete with required chassis, enclosures, precision cooling system.
j) Hardware based firewall system.
k) Web Servers- The contractor shall configure the SCADA system in such a way that DMA data and SCADA screens are made available to the employer's personnel at remote locations via web servers. The data shall be available via standard windows browsers with all applicable data access privileges to allow only view access.
l) Licensed Antivirus software to be loaded on each system.
m) Industrial grade control system console to house the entire PLC based SCADA system and other equipment as indicated in the system configuration diagram.
n) All required software and hardware to implement the system as indicated in the specifications and system configuration drawings.

The SCADA system shall follow the International Standards Organization (ISO), Open Systems Interconnect (OSI), reference model guidelines. All central system hardware and software devices shall be interconnected using a bus topology data highway. The communications protocol used shall generally meet the requirements of the ISO.

The system shall provide efficient and safe operation of the process plant by detecting alarm and error conditions, alerting the operator to these conditions both visually and audibly, monitoring all important system parameters and providing facilities for plant optimisation.

The system will allow operators, technicians and Employer Representatives to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Employer Representatives Terminal (ET), after successful log-on by security password.

DMA Flow measuring systems & Associated Instrumentation system

The flow measurement system for DMA flow measurement to be used under this contract shall be electromagnetic type meters with GPRS communication module. Additionally the contractor shall install actuated flow control valve at the inlet of the each DMA, and the same shall be controlled from the Local control centre (LCC) SCADA system to be installed under this contract. All the data (valve status, flow & pressure data) shall be connected to the remote telemetry unit with wireless GPRS Communication modules. Necessary Remote telemetry unit with wireless GPRS communication equipment, required power supply, panel, with secure locking facility to securely house all the equipment, security of the entire system shall be under the scope of work of the contractor.

The contractor shall submit the design of the control cabinet/panel with secure locking facility to be installed for review and approval before any procurement if carried out.

DMA Flow Measuring System:

Each water meter intended for district metering is for a potable water supply. It shall comprise two principal components, as follows:

- A flow sensor of the electromagnetic type, which shall be suitable for installation in a buried water main. The sensor shall be connected to the main by means of PN16 flanged connections. The meter shall be suitable for installation in a flooded chamber and for being directly buried.
- An electronic display unit. This shall be installed in an above ground cabinet enclosure in a convenient location as close as possible to the water meter.

The water meter shall be powered by batteries which shall be integral to the electronic display unit. The batteries shall be capable of being replaced by the Employer's staff at site and capable of providing uninterrupted power supply at the specified voltage for not less than five (5) years duration without battery replacement. The Contractor shall replace at no cost any batteries that fail or require routine replacement throughout the contract period.

On a minimum, water meter shall be provided with the following facilities at the electronic display unit:

- integral real-time clock for date and time recording of flow data
- integral data logger for storing data for a minimum of 31 days.
- Serial or suitable communication port to enable data to be passed from the display unit to display flow and pressure details.
- a second serial or suitable communication port for the temporary connection of a lap-top computer
- Input/output block for connecting GPRS transmitter –for 2-way communication and for the transfer of all display /error codes and status functions from the electronic display unit to the Local control centre SCADA system, to be executed by the contractor

PSION and Laptop, leads and appropriate software and software licences shall be provided to facilitate configuration of the water meters and for down-loading the integral data logger for data analysis.

DMA Electromagnetic Flow meter Requirements

a) Full bore electromagnetic flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter and flow indicator and integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer and in line with the applicable standards. Contractor shall finalize the exact location of flow meter in consultation with Engineer.

b) Flow measurement shall not be affected by physical properties of water viz., temperature, pressure etc., within given limits. Contractor shall provide compensating electronic circuits, if required.

c) A lockable enclosure shall be provided for the flow transmitter cum computing unit.

d) Flow meters shall be suitable for the water turbidity at site during various seasons. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flow tube shall have waterproof construction and shall be suitable for installation on underground /above ground pipe lines.

e) The flow computer and transmitter shall be a single unit suitable for field mounting. It shall accept inputs from flow tube process the signals and shall provide an output proportional to the flow rate. The output shall be 4-20 mA.

a) **General**:			
1.	Accuracy of flow measurement during FAT	± 0.4% of measured value	
2.	Overall accuracy of flow measurement loop.	± 1.0 % of measured value	
b)	Flow tube		
(i)	Application	:	Water applications
(ii)	Type	:	In line full bore electromagnetic
(iii)	Size of flow tube	:	To suit mains flow parameters, with pipe reducers provided as necessary
(iv)	Process connection	:	Flanged
(v)	Weather Protection Class	:	IP 68 as per IS 13947
(vii)	Material of Construction :		
	Electrodes	:	Hastelloy C276
	Coil Housing	:	non corrosive
	Flanges	:	Carbon steel
	Grounding ring	:	Hastelloy C276
(viii)	Flow tube Lining	:	*EPDM*
c)	Flow Transmitter Unit		
(i)	Type	:	Microprocessor based with facility to configure the ranges.
(ii)	Type of display	:	4 digit backlit LCD / LCD , for flow rate in m3/hr. 8 digit backlit LCD / LCD for totalized

a) **General**:			
			flow in ML • Display with 8 digits for main information. Index, menu and status symbols for dedicated information • Key for toggling through the information and reset customer totalizer and call-up function • Selectable default information and accessible menus: - Operator - Meter - Service - Data Logger
(iii)	Units of display	:	• Volume: m3 x 100, l x 100,G x 100, G x 1000, MG,CF x 100, CF x 1000, AF, Al, kl • Flow: m3/min, m3/d, l/s, l/min, GPS, GPH, GPD, MGD, CFS,CFM, CFH
(iii)	Input	:	From flow tube
(iv)	Output	:	4-20 mA DC (isolated) proportional to flow rate
(v)	Power Supply	:	In built lithium batteries. batteries shall work on a minimum for five years without external AC/DC power supply
(vi)	Zero and Span Adjustment	:	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.
(vii)	Weather Protection Class	:	IP 65 as per IS 13947,IP 67
(viii)	Battery backup for totalized flow Type Capacity Backup Time Data Protection:	:	 Online 2.5 Mva 8 hours. Data protection • All data stored shall be stored in an EEPROM. Totalizers shall be backed up every10 min, statistic every hour and power consumption and temperature Measurement every 4 hour. Minimum 31 days of data shall be stored in EEPROM. • Password protection of all parameters and hardware protection of calibration and revenue parameters.
(xi)	Facility for on line diagnosis & 2 way communication with the SCADA server	:	Required : Diagnostic • Continuous self test shall include - Coil current to drive the magnetic field

a) **General**:		
		- Signal input circuit - Data calculation, handling and storing • Features - Alarm statistics and logging for fault analysing - Electrode impedance to check actual media contact - Flow simulation to check pulse and communication signal chain for correct scaling - Number of sensor measurements (excitations) - Transmitter temperature (battery capacity calculation) - Low impedance alarm for change in media - Flow alarm when defined high flow exceeds - Verification mode for fast measure performance check - Statistic flow and consumption data

Flow Sensor

The sensor shall be suitable for being directly buried and shall have a degree of protection to IP 68 (NEMA6). The sensor shall have PN16 flanged end connections.

The sensor shall be suitable for an operating pressure of 16 bar gauge and a system test pressure of 25 bar gauge. The metering tube shall be suitably lined to withstand abrasion of the fluid. The lining shall be EPDM and shall have been type-tested in an accredited laboratory and have been shown to be suitable for use in contact with potable water (UKWFBS listed).

The electrodes for sensing the voltage induced in the liquid shall be made of type Hastalloy C267. The coil housing shall be fabricated from corrosion resistant material capable of submerged or buried operation.

The sensor shall be supplied complete with a factory-fitted umbilical cable for communication with the electronic display unit. The cable length shall be determined by the contractor for each meter location, but shall be not less than 20 metres long so that it can be cut on site to suit the selected location for the electronic display unit. The construction of the signal connectors and cable shall protect the water meter from electromagnetic interference and shall be suitable for buried use and outdoor installation. The cable shall be protected by a suitably robust polyethylene sleeve to prevent accidental damage.

The Contractor shall provide all sundry items such as grounding electrodes and/or grounding rings necessary for satisfactory operation of the sensor.

Electronic Display Unit

The enclosure of the electronic display unit shall have a degree of protection to IP 65 or better.

The display unit shall have a configurable password protection for accessing the flow meter menu. The unit shall have LCD displays to show the following parameters, as selected by the operator:

- Cumulative forward flow
- Cumulative reverse flow
- Cumulative net flow
- Instantaneous flow rate
- Instantaneous velocity
- Minimum night flow
- Peak day flow
- Pressure
- Date and time

The user shall be able to configure the electronic display unit to display:

- Cumulative flow in m^3
- Flow rate in m^3/h or l/s
- Velocity in m/s
- Pressure in m or kg/cm2

There shall also be status indicators for each of the following conditions:

- Battery low
- Fault
- Empty pipe

Calibration:

The Electromagnetic flow meter shall be calibrated for the full flow range specified as per BS EN 29104 latest version (Methods of evaluation of electromagnetic flow meters). The calibration method shall be gravimetric method as per ISO 4185 (Measurement of fluid flow in closed conduits – weighing method) .

The 'test bed' shall be accredited by national /international certifying authority. The Contractor shall produce accreditation certificates for the test facility and calibration certificate for each flow meter, for the review by Engineer. The Contractor shall also demonstrate complete calibration on the test bed in the flow meter laboratory. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

Operation & Performance

The accuracy, linearity and repeatability of each water meter shall be in accordance with the latest version of ISO 4064, Class C or better, and shall be maintained for an ambient and liquid temperature range of 0°C to 50°C.

In addition, the flow meter shall confirm to the below standards

• CEN EN 14154
• PED: 97/23EC
• EMC: EN 61000-6-3,
EN 61000-6-2, EN 61326-1

Pressure Measuring System

Pressure Transmitters (sensors)
Each pressure sensor shall be capable of operating in the range required, and be of the diaphragm type. It shall be provided complete with non-ferrous pipe-work, isolation valves, calibration valves and a surge damper device. Local and remote display units shall be provided. Pressure transmitters shall be designed for operation over 130% of full range. They shall be capable of withstanding surge pressures likely to occur in the monitored system.

(i)	Service	:	Pipeline, adjacent to electro-magnetic meter
(ii)	Quantity & Ranges	:	As per process requirements.
(iii)	Accuracy of measuring loop	:	± 0.25% of reading or better

Pressure Sensor/Transmitter

(i)	Sensor	:	Diaphragm Sensor
(ii)	Material	:	SS 316
(iii)	Range	:	Adjustable over full span
(iv)	Zero and span adjustment	:	Required
(v)	Output signal	:	4-20mA, DC
(vi)	Enclosure Protection	:	IP 68 of IS 13947 (Part I)
(vii)	Accessories	:	Isolation valves, Impulse tubing and all installation hardware
(viii)	Local display		: LCD Display Required
(ix)	Dampening circuit		: Required

Facilities for Configuration of DMA Meters

Each DMA meter shall be such that it can be configured using a laptop computer. The Contractor shall therefore provide within 6 months of the commencement date of the contract:

- 2 Nos lap-top computers
- 2 Nos flexible leads, each complete with any necessary associated components, to connect the lap-top computers to the water meter display units
- All software and software licences needed to configure the water meters.
- 2 Nos PSION with all accessories.

Each laptop computer shall be of the latest configuration and incorporate:

- An Intel Centrino or equivalent 2 GHz dual core processor (or equivalent), or better
- 8 Gigabyte (GB) DDR2 Random Access Memory (RAM), or better
- hard disc with 1 Terra Byte memory, or better
- 15.4" TFT display
- DVD RW drive
- keyboard with English letters
- ports to enable the computer to be connected to a water meter electronic display unit, an external mouse, a printer, another computer and to a CD writer.
- at least three USB ports
- Wi-Fi

The Microsoft Windows latest operating system shall be installed on each lap-top computer, together with any other software (licensed version) needed for the configuration of the water meter electronic display units and for communication with the data loggers. The Contractor shall obtain software licences permitting the software supplied to be used simultaneously on two computers.

The above specification for computer hardware and software is indicative only. The contractor should take the approval of the engineer before commencing any design or purchase of the above mentioned hardware and software. The above specifications shall be an integral part of the FDS submittal.

Submissions by the contractor:

Functional Design Specifications

The Contractor shall submit a complete functional design specification (FDS) for approval by the Engineer within 3 months of the award of the contract. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

The FDS shall comprise an overall description of the DMA instrumentation and SCADA process, its functioning and control, and a detailed description of each section of the control system .The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock.

The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure or loss of an input signal affecting a control loop or process sequence.
The FDS shall describe control actions taken and monitoring functions which remain available during a power failure/battery failure, and any automatic controls or sequencing which take place during system start-up and shut-down.
The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.
The Contractor shall submit and obtain approval of the FDS from the Engineer before beginning the detailed control system design. The contractor should take note of the importance of this obligation.

In general, the submissions of the DMA instrumentation and SCADA system shall comprise the following as a minimum:

(a) A functional design specification (FDS) for DMA instrumentation and SCADA system. This document shall serve as the primary mechanism by which the Engineer may confirm that the Contractor possesses an accurate understanding of the system and its requirements.

The FDS shall include a detailed block diagram of the system with description of the scheme to be provided. The FDS shall include operational details of the UFW system. The FDS shall include a description of the interface of the system with DMA instrumentation and SCADA system to be installed under this contract.

The Contractor shall submit a preliminary FDS and obtain approval before the system architecture design is finalized or detailed design takes place. The Contractor shall formally notify the Engineer for approval of any amendments or additions to the approved FDS. The final FDS shall be submitted for approval before submission of the factory acceptance test definition documents. The Contractor should take note of the importance of this obligation.

(b) Layout drawings for each piece of equipment fabricated or assembled by the Contractor, showing the position of each component with required clearances where applicable, and with overall dimensions.

(c) Wiring diagrams indicating each component of the system and all wiring and cabling thereto, showing manufacturers, types, duties, ranges and nomenclature, with inputs, outputs, cable wiring and terminal identifications clearly marked.

(d) Complete input and output list giving type, circuit number, tag name, short description, outstation, database reference, associated field device, range (if applicable), critical/non-critical alarm status and the like.

(e) Description of quality control methods and approvals.

(f) Detailed works and factory acceptance test procedures.

(g) Programme for manufacture, delivery, installation and commissioning.

(h) Appendices, as necessary, to include manufacturer's literature for each item of equipment supplied.

(i) Operation and maintenance manuals detailing the following:

a. General description and operating principles;
b. Technical description of the equipment (manufacturer's standard brochures only being acceptable if the particular item of equipment described is clearly designated, adequate information is supplied, and irrelevant information is deleted or otherwise delineated)
c. Complete operating instructions defining the sequence of operations, including flow charts;
d. Procedures for dismantling, cleaning, servicing, replacing parts and reassembling, including recommended clearances and tolerances;
e. Details of all instrument and equipment settings as applicable to this contract;
f. Maintenance and lubrication schedules;
g. Fault diagnosis procedures;
h. Dated and priced list of significant spare parts and special tools, including identification numbers and sources of supply;
i. Simplified arrangement drawings showing all components of the equipment.

(j) General operating manual comprising the following:

a. General description and operating principles;
b. Operating instructions for normal procedures in a step-by-step format including control operations, requirements for display or printing of data, performance monitoring, response to alarms or failures, changing of operational parameters, and manual data entry.

Factory Tests & Inspection

Each DMA meter shall be subjected to a hydrostatic test and shall be calibrated in the manufacturer's works prior to dispatch. Calibration and hydrostatic test certificates shall be inspected by the end user and consultant and shall be provided with each meter.

Installation

(a) Flow Sensor and Electronic Display Unit

Every DMA electromagnetic water meter shall be installed in accordance with the manufacturer's instructions and recommendations. In particular, the sensor body shall be installed such that it is always full of water to ensure full bore meter operation at all times, even during periods of intermittent supply, and with the electrodes always submerged. This may be achieved by utilizing natural dips in the pipeline, re-laying existing pipes with deflections at joints to create the necessary installation conditions, or creating a low point for the sensor body in the. Pipe transition slopes shall be such as to ensure any debris suspended in the flow of water is carried through the meter without any deposition. Pipe reducers shall be used to minimize excavation depths and pipework modifications. A slab or plate shall be buried above the sensor to warn other contractors of its location beneath and to provide appropriate protection.

A sluice valve shall be provided at a suitable location downstream of the meter, or a nearby sluice valve in the distribution network may be used, to stop flow through the water meter to enable zero checks to be made. The payment for sluice valve is not included in item 2.9 and 2.10 of bill of quantities and any sluice valve installed will be paid separately under item 2.5 of bill of quantity.

Wherever a DMA meter is to be installed in a water main with cathodic protection, insulating flanges shall be provided on both sides of the sensor and insulated copper straps shall be installed to provide electrical continuity between the pipes on each side of the sensor.

The electronic display unit shall be installed on a removable backboard in a vandal-resistant weatherproof IP65 floor, wall or post mounting cabinet enclosure. The enclosure shall be constructed from galvanised steel which is at least 3 mm thick. The enclosure shall have a hinged access door, which shall have a facility for padlocking in the closed position. Batteries shall be easily accessible for periodic changing. For floor mounting enclosures, the enclosure shall be mounted on a concrete plinth, the surface of which shall be at least 150 mm above the surrounding finished ground level. A cable duct shall pass through the plinth to enable the cable from the flow sensor to enter the enclosure. A label showing details of the Employer's name and the water meter's unique reference number shall be fixed to the

external face of the access door. Contractors or equipment manufacturer's details shall not be fixed to the external face of the access door.

The enclosure shall be well-ventilated, dust-proof and vermin-proof, and be suitable for robust use in a tropical climate. It shall also be suitable for:

- the housing of the integral data logger and the temporary housing of a battery powered data logger which could periodically be used in conjunction with the meter
- the permanent housing of any lightning protection system
- the permanent housing of GPRS transmitter and battery pack, and any other items necessary to facilitate communication with the local control centre(LCC) at the UGR location.
- mains pressure recording - see (b) below

Except where the cable is underneath the concrete plinth, there shall be a minimum of 500 mm cover for the cable. The cable shall be surrounded by a sand bedding at least 75 mm thick and interlocking cable protection tiles shall be installed above the cable. An 'electric cable' warning tape shall be installed above the tiles. Wherever practicable, the cable shall be installed at least 600 mm away from any other cables.

Details of the sensor, including its diameter and the size of main together with a unique reference number, shall be permanently indicated on the outside of the cabinet enclosure housing the electronic display unit. A laminated copy of the DMA record plan shall be installed in each DMA meter cabinet enclosure for that DMA.

As flowmeter installation and commissioning progresses, a selection of 20% of the DMA meters shall be check-calibrated in situ to verify that the meter accuracy is unchanged and installation arrangements are satisfactory. If any check-calibration results are unsatisfactory, all DMA meters shall be check-calibrated. No payment will be made for such check-calibrations or for any undertaken subsequently during the contract period.

(b) Pressure Monitoring

A pressure tapping shall be made in the pipeline adjacent to the electromagnetic district meter for pressure monitoring. A pressure transducer shall be connected to the pressure tapping, with the connector and signal cable sealed to IP68 standard. The pressure signal cable shall either be integral with the meter signal cable or bundled with it and connected to the electronic display unit in the steel cabinet enclosure through a protective PE sleeve. Wherever the protective PE sleeve is above ground it shall be further protected, for example by installing it within a mild steel pipe or, if the enclosure is post mounted, within the post itself.

1.11 SCADA software functions

General:

1. The Contractor shall be responsible for supplying complete software packages to enable the equipment to operate as stated in this specification. Provision must be made for the adding of further software tasks as and when required. All software functions shall be user friendly, with instruction and messages to aid the operator. The Contractor shall make available all standard software functions, even if not specifically detailed in the specification.

2. The computers shall utilize a real time multi-tasking and networked operating system with a proven track record in real time control applications.

3. The Operating System shall be latest windows operating system for Operator and engineering workstations and windows server systems for all servers, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.

4. The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).OPC should be a in-built feature of the software.

5. LCC SCADA/DMA SCADA shall be configured to have 2 way communication with all DMA meters and field instrumentation. The SCADA system shall be configured to request and gather data in real time from the field instrumentation (DMA meters) and as per user defined intervals. It shall also be configured to modify the meter program from the local control centre SCADA System.

The System shall support fully distributed 64 bit Client/Server architecture. The System shall include Visual Basic for Applications (VBA) as a built-in programming language. Facility shall be available for building custom objects using VBA.

Object oriented graphics and tools to easily build reusable control strategies.
ODBC Application Program Interface (API) capable of collecting and writing secure real-time electronic records to one or more relational database.

The software shall support OPC standards as both a client and a server for fast and reliable communications with a wide variety of hardware devices. Provide Active-X controls with selection of third-party Active-X controls for ready-made solutions without VBA programming. The SCADA software shall use SQL server as the integral database.

A standard software package, such as Crystal Report shall be provided to facilitate generation of free format, intuitive and presentation quality reports.

The engineering Workstation shall be provided with simulation tools to support off-line testing of the control logics.

The Server shall provide the master clock for the SCADA time synchronization.
The system software shall be from the SCADA equipment manufacturer. Third party software is not acceptable. It is a requirement that the system be supported by on line configuration and editing of all VDU mimic displays and database and to create new displays and additional database.

Operational mimics and other graphics shall be presented in an industry standard graphical user interface (GUI) format. A minimum of two active windows shall be displayable concurrently. Both text and graphics shall resize automatically to accommodate changes made to the size of a window. The system shall be designed to minimize the operators use of the keyboard. All major functions shall be accessible on-screen through use of the mouse or track ball.

Operator system entry, for each area will be password coded with different levels of entry depending on the level of authority of the operator. Development and systems level entry passwords will be provided for engineering workstations. Each action taken by any operator at any level of entry, or at any operator terminal, shall be log file recorded and time and date stamped. Log in and out time and dates will be printed on the control room event logging printer.

VDU mimics will display dynamic color details of flow rates and pressures, pump status, well levels, alarms, electrical power supplies and other general equipment status conditions. All requests and commands shall be via icons, whether menu linked or linked to equipment control actions. A permanent dynamic alarm banner shall be displayed at the bottom or top of each operator screen. Each control action will be routed through a series of confirmation routines.

The reports shall be available for printing in graph or tabular format. Dynamic trend displays shall also be available for all analogue flow, level and pressure values. Custom, as well as preconfigured reports and trends shall be available to a higher level of entry. A colour, A4/A3 size, screen dump printer shall be provided for graph and trend prints.

An operator help utility shall be provided, offering help linked to the particular action being carried out by the operator at that time. At least one help screen per screen page shall be available. This facility shall be preconfigured with an option for updating by operators, via a password entry.

The Application Server software shall be configurable to provide for the monitoring and control of all points, loops, and systems through graphic display screens and hard copy reports. These shall include:

- Parameter Displays for signal control
- Control Loop Status Displays
- Real Time and Historical Data Trend Displays
- Event Displays and Log Reports
- Alarm Displays and Log Reports
- Equipment Diagnostic Displays and Reports.

The system shall provide on-line diagnostics that display the current status and operation of the local area network and its nodes. The diagnostic display shall include the LAN adapter status for the machine showing the display, as well as the current number of messages, errors and retries.

The system shall conform to and take advantage of industry standards. These shall include, but not be limited to:

- ODBC
- OLE
- ActiveX
- COM/DCOM
- DDE and Advance DDE
- C programming language
- Visual Basic
- Microsoft Windows XP or the most current Operating System
- TCP/IP
- OPC

- XML

(b) Display Facilities:

The displays shall be user configurable, with the user being able to construct any desired symbol for display. Any display shall appear (excluding historical recall) within 1 seconds to 3 seconds of selection and the displayed data shall be updated from the database .Alarms shall typically appear within 3 seconds to 5 seconds of occurrence and within 1 second of being received into the central system database.

The Contractor shall configure all display pages as fully as possible. However, facility must be incorporated to permit easy construction and modification of the display pages, by using a standard library of shapes and symbols. The library shall be added to and modified by the user as required. The configuration shall be object orientated for ease of use.

The initial application software shall provide for the display pages listed below and any pages necessary for the system to function as a complete entity.

g) Mimic displays.
h) Graphic displays.
i) Trend displays.
j) Alarm summary tables with date and time.
k) Event logs of past 72 hours with date and time.
l) Tabular display of data.
m) Inset windows showing an analogue trends may be mixed with mimic displays. In such a display the main mimic and inset trend shall all be live with automatic display updates.

Indexing of information and menus shall be presented in the form of active windows on the screen, while the mimics etc. are still available for view.
No display or function shall effect the logging/monitoring of data. It shall be possible for the master station terminal and auxiliary terminals to perform simultaneously, different tasks within the display.

Monitoring and Alarms

1. The operator shall be able to monitor all of the information at the workstation. It shall be able to view active equipment information on a series of VDU based graphical and tabular displays.

2. In the event of an equipment alarm, the following shall occur at the master station:
    a. Alarm message displayed in the alarm message area of the screen.
    b. The audible alarm shall sound.
    c. The appropriate Section of the display page shall change colour and flash.
    d. A full message shall be written on the alarm page.
    e. The full alarm message shall be printed on the alarm printer.
    f. The full alarm message shall be recorded, stored on disk and automatically archived.

3. The operator should be able to acknowledge the alarm by pressing an accept alarm key or icon. This action shall stop flashing of all associated alarm messages and

displays. However the display shall remain in the alarm state fixed colour to indicate an accepted alarm. When all outstanding alarms have been acknowledged the audible alarm shall be silenced.

4. Once the alarm has cleared, the messages and displays shall return to normal. The alarm message shall stay recorded on the event/alarm log and an alarm cleared message shall also be recorded.

5. If the alarm clears before being acknowledged the sequence of events shall continue as above except the message shall change to indicate a cleared alarm.

6. An audible alarm silence function shall be provided to enable an operator to silence the audible alarm without acknowledging all alarms. On occurrence of any subsequent alarm, the audible alarm shall sound.

7. Each signal within the configured system shall be capable of being assigned an alarm based
on the following:
    a. Four levels per analogue (Lo Lo, Hi Hi, Lo and Hi).
    b. Rate of change.
    c. Deviation from set point or other control parameter.

8. Alarms shall be time tagged to 1 second resolution at the I/O's.

9. A minimum of four alarm priorities shall be provided so that those requiring immediate attention may be separated from alarms of lower priority. An audible alarm shall sound for alarms requiring operator action.

10. Typical alarm assignments are as follows:

a. critical alarm	-	an alarm that requires immediate operator action
b. non critical alarm	-	an alarm that requires operator action but not necessarily immediate action
c. operator guide alarm	-	an alarm that provides information to the operator
d. event	-	a low priority condition which is recorded.

Data Archiving

Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 75% full.

Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored.

The system will provide any combination of the following:

- Instantaneous value.
- Average value.
- Maximum value.
- Minimum value.
- Not stored.

Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.
The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

SCADA Screens

The Contractor shall configure all the mimics to provide total detailed coverage of the monitoring and control of equipment as detailed in this specification. It is expected that display modifications will be required in the future and therefore the ability to change the displays without programming skills is essential.

Instrumentation shall be displayed using ISO standard symbols. For mimic configuration, it shall be possible to call up a library of standard symbols representing items (e.g. pumps, valves) and add new symbols to the library. Building mimics shall be simple and be achieved by using a mouse or tracker ball pointing device.

The mimic displays shall consist of the following pages:

a. A general diagram covering the whole of the system on a single screen with key data
b. A general block diagram for each site or area of Site showing the equipment displayed on a series of single screens with key data
c. Mimic of the equipment and instrumentation connected to each IO module displayed on as many screens as necessary.
d. Login screens, reports screen, security screen, overall UGR screen, pumping station screen, DMA area screen, individual location screen ,real time data polling screen, user defined polling screen, etc. shall be configured.

The SCADA software shall have the ability to limit the number of displays being opened simultaneously at any given point of time. The software shall be able to display at least three process screens/pop up screens simultaneously and shall be active screens

Trend Displays

It shall be possible to plot dynamically updated real time data and archived data on a line graph, to represent analogue or digital information. Each graph shall be capable of displaying 8 plots overlaid on a graph of different colours and line texture. Next to the graph, there shall be a key relating each colour to its function.

The horizontal axis shall be time based and user selectable in minutes, hours, days, weeks, for example, together with a start time.

The vertical axis shall be scaled as a percentage of range and be displayed in the colour of the selected reading. To avoid cluttering, the vertical axis scale shall be changed by selecting the individual display. The vertical axis shall be automatically scaled for each selected point, between limits entered by the user.

Actual values in engineering units shall be displayed by positioning a cursor at the desired point of the trend graph. The display of the data shall also be available in tabular form.

(a) Manual Data Entry:

The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:

a. Constants which will be changed infrequently. This data may have time and date associated with it.
b. Maintenance related comments.

(a) Manually Corrected Data:

The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor. The users shall be able to transfer data from either the archive system or live data to the spreadsheet.

The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator.

Typical reports on a minimum would be:

- Flow rates and total.
- Failures of equipment.
- UGR levels & Flow.
- Discharge pressures.
- Maintenance schedules.
- Process alarm conditions.

Note: The above list of reports are indicative only. The contractor shall co-ordinate with the employer's representative and finalize the type and content of reports to be generated by the SCADA system and the same shall be indicated and represented in the FDS submissions.

Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW.

The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.

Data Manipulation:

It shall be possible to perform simple mathematical functions on any data, including the following functions:

- Addition
- Subtraction
- Multiplication
- Division
- Square root

It shall be possible to log, display or use in a control loop, the resultant data.

Database Query Facilities:

The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use.

Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the SCADA and external applications, including spread sheets and databases.

Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits.

Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

Downloading IO Configuration:

It shall be possible to download configuration to the IO's from the engineering workstation and the Portable Programming Unit (Laptop)

Diagnostics:

The system shall have on-line diagnostic facilities to report system faults as they occur. A set of off-line diagnostic routines shall be supplied for more extensive fault diagnosis.

Security Access Levels:

The functions available on the system shall be fully flexible so as to allow users access levels to be customised by the system operator, to suit individual user requirements.

Access to management and engineering levels shall be restricted by user selectable passwords or key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.

Windows functionality of CNTRL+ALT+DEL shall be disabled. On SCADA startup, the system shall load and directly enter in the SCADA welcome home page .The design shall ensure that SCADA software development page shall not be accessed during the startup and only on appropriate login access, the same shall be accessible.

The security/access levels would be divided between Engineers, supervisors and operators.
The system shall be protected from un-authorized changes to the operating system and application programs.

The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.

A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.

The system shall provide a password-protected, user log-on facility for definition of the user access level. It shall be possible to define a minimum of eight privilege levels.

Passwords entered during the log-on process shall not be printed or displayed.

The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system.

System-generated log messages relating to operator actions, such as alarm acknowledgements or set-point changes, shall include the identification of the current logged-on user.

The Contractor shall provide the following defined user access levels as a minimum and additional levels as instructed by the Employer Representative:

1. **Default level**:

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

2. Operator level:

The operator level shall permit authorised users to access default level activities in addition to the following:
(a) Perform control actions;
(b) Acknowledge alarms;
(c) Enter or modify manually entered data for inclusion into reports.

3. **System manager level**:
The system manager level shall permit authorised users to access default level and operator level activities in addition to the following:

a. Modify alarm and control set points, dead bands and time delays;
b. Enter or modify historical data;
c. Add, delete or modify individual I/O points or point attributes;
d. Add, delete or modify field device configurations;
e. Create, delete or modify control algorithms;
f. Create, delete or modify graphic displays;
g. Create, delete or modify system reports;
h. Configure trend displays;
i. Access the operating system;
j. Assign access levels and user passwords;
k. Perform any other system maintenance function

Programming:

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:

a. All programmes shall be written such that they lend themselves easily to alterations and additions.
b. Good programming practice shall be followed using structured programming techniques. All programmes shall be tidy in format and logical to follow. Programmes should be extensively annotated with comments and be self-documenting.
c. The system shall be supplied with programmes that use a high level language.

Programme – Documentation:

As part of the requirements of this specification full documentation is required as below:

a. Software user manuals
b. Database point allocation table
c. Complete program listing, flow charts for all sequences and control routines
d. Application software source code
e. End user license agreements.

SCADA Hardware

The system shall support hardware and software interconnectivity to other networks generally in accordance with the ISO Open System Interconnect 7 layer reference model.

Computers:

1. The computer hardware shall be of current technology at the time of installation. Standard server stations, Standard PC technology with modern hardware, Windows operating system and data transmission over Industrial Ethernet must be used for the Engineer workstations. It must be possible to install more than one engineer workstation in the system.
The Engineer workstations system must be an open system that, for example, permits the importing of project data from Microsoft Excel, SQL or from

CAD/CAE programs. It must be possible to import/export messages to/from Excel and Access for simple processing.
Removable memory media must also be provided for each workstation.
It must be possible to back up all database and configuration data both on removable media and on non-removable storage media without the system being offline.
Provision of redundant storage media must be possible for the configuration database.
The specs for computer hardware shown are indicative only and minimum requirement to be supplied by the contractor.
The computer shall, as a minimum comprise of a personal computer (PC) type architecture, with IBM compatible Pentium IV based system or better, capable of running a multi-tasking real time operating system suitable for process control applications:

2. All workstations, servers, communications equipment and peripherals shall be from reputed manufacturers, suitable for continuous operation and shall be the most currently available models at the time of construction, subject to approval. Adequate spare capacity shall be included to meet the specified requirements and future expansions.

3. The system shall support hardware and software interconnectivity to external Programmable Logic Controllers (PLC's) over an RS-232/RS-485 serial data link using Profibus / Modbus, Ethernet or similar protocol, subject to the approval of the Employer Representative.

Visual Display Unit (VDU)

1. Visual Display Units (VDU's) shall be colour monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colours, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less that 1024 by 768 pixels and a refresh rate of not less than 70 Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. LCD VDUs shall be flat screen, minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels,
2. VDU's shall be 32 inch minimum.
3. VDU's shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.
4. two numbers of LED screens of minimum 65 inch screen size shall be supplied at the LCC and four numbers of LED screens of minimum 65 insch screen at the centralized SCADA location.

Printers:

DeskJet:

Logging / Alarm / Report Printers – Continuous Feed:

1. Printers used for logging of system wide events and alarms shall comply with the following:-

Speed:

Print speed, black (draft quality mode)	Up to 21 ppm
Print speed, black (normal quality mode)	Up to 7.7 ppm
Print speed, black (best quality mode)	Up to 0.9 ppm
Print speed, color (best quality mode)	Up to 5 ppm
Print speed, color (draft mode)	Up to 15 ppm
Print speed, color (best quality mode)	Up to 0.9 ppm
Monthly volume (duty cycle):	5,000 pages **Print Quality & Technology:**
Print technology	Technology: Thermal Inkjet
Print quality, black	Up to 1200-rendered dpi black text
Print quality, color	Up to 4800 x 1200-optimized dpi color printing and 1200-input dpi
Resolution technology	PhotoREt III (PhotoREt IV-enabled)
Print cartridges	Color: Black, cyan, magenta, yellow
Ink types	Pigment-based, dye-based
	Memory & Print language:
Memory, std.	8 MB
Memory, max.	8 MB
Print languages, std.	PCL Level 3 Enhanced
Typefaces	8 built-in, 4 each in portrait and landscape orientations: CG Times, CG Times Italic; Univers, Univers Italic; Courier, Courier Italic; Letter Gothic, Letter Gothic Italic
	Paper handling:
Paper trays, std.	1
Paper trays, max.	2
Input capacity, std.	Up to 150 sheets

Input capacity, max.	Up to 150, up to 400 with optional 250-sheet paper tray sheets sheets
Standard envelope capacity	20 envelopes envelopes
Output capacity, std.	Up to 50 sheets
Output capacity, max.	Up to 50 sheets
Duplex printing (printing on both sides of paper)	Automatic (optional)
Media sizes, std.	Letter, legal, executive, cards, borderless media
Media sizes, custom	3 x 5 to 8.5 x 14 in
Media types	Paper (plain, inkjet, photo, banner), envelopes, transparencies, labels, cards, premium media, iron-on transfers, borderless media
Media weight, recommended	US letter: 16 to 24 lb, legal: 20 to 24 lb, banner: 16 to 24 lb, envelopes: 20 to 24 lb, cards: up to 110 lb index maximum, photo paper: up to 130 lb index
Media handling	Sheetfed
	Connectivity:
Connectivity, std.	IEEE 1284-Centronics parallel compatible, Universal Serial Bus
Connectivity, opt.	Jet direct external print servers
Macintosh compatible	Yes

Colour Multifunction Printer:

Colour Multifunction printer shall be used for the production of colour screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the colour printer is operational and comply with the following:

Printer Specification:

All-in-one functions	Print, copy, scan, fax, stand alone scan-to email, photo card slots
Multitasking capability	Yes.
Paper Size	A3,A4
Print speed, black (normal quality mode)	Up to 21 ppm
Print speed, color (normal quality mode)	Up to 21 ppm
Print speed footnote	Exact speed varies depending on the system configuration, software program, and document complexity.

First page out (color)	As fast as 17.9 sec
Monthly duty cycle	Up to 40,000 pages
Footnote for duty cycle	Duty cycle is defined as the maximum number of pages per month of imaged output. This value provides a comparison of product robustness in relation to other LaserJet or Color LaserJet devices, and enables appropriate deployment of printers and MFPs to satisfy the demands of connected individuals or groups.
	Paper Heading:
Paper handling standard, input	50 sheet multi-purpose tray 1, 250-sheet input trays 2 and 3, 50-sheet ADF
Paper handling standard, output	150-sheet face-down output bin
Envelope capacity	Up to 30 envelopes
Envelope feeder	No
Duplex printing (printing on both sides of paper)	Automatic (standard)
Document finishing	Sheetfed
Media sizes, standard	Letter, legal, executive, envelopes (No. 10, Monarch)
Media sizes, custom	Tray 1: 3 x 5 to 8.5 x 14 in; Tray 2, Tray 3: 3.94 x 5.83 to 8.5 x 14 in
Media types	Paper (bond, brochure, colored, glossy, letterhead, photo, plain, pre-printed, pre-punched, recycled, rough), transparencies, labels, envelopes
Media weight	Tray 1: 16 to 47 lb (up to 58 lb with Color Laser glossy photo papers); tray 2, tray 3: 16 to 43 lb (up to 47 lb with postcards, up to 58 lb with Color Laser glossy photo papers)
Weight	71.2 lb
Processor speed	450 MHz
Memory, standard	160 MB
Memory, maximum	416 MB
	Scanner Specification:
Scanner type	Flatbed, ADF
Scan resolution, optical	Up to 1200 dpi
Bit depth	42-bit
Scan size, maximum (flatbed)	8.5 x 11.7 in
Scan size, maximum (ADF)	8.5 x 14 in

Scan speed (default)	Up to 15 ppm
Automatic paper sensor	No
	Copier Specification:
Copy speed (black, best quality, A4)	Up to 20 cpm
Copy speed black (best, letter)	Up to 20 cpm
Copy speed color (best, letter)	Up to 20 cpm
Copy resolution, black	Up to 600 x 600 dpi
Copy resolution, color	Up to 600 x 600 dpi
Copy reduce/enlarge settings	25 to 400%
Maximum number of copies	Up to 99 copies
	Fax Specification:
Faxing	Yes
Fax transmission speed (seconds per page)	3 sec per page
Fax memory	Up to 250 pages
Fax note	Based on standard ITU-T test image #1 at standard resolution. More complicated pages or higher resolution will take longer and use more memory.
Fax resolution, black (dots per inch)	Up to 203 x 196 dpi
Speed dials, maximum number	Up to 120 numbers
Auto redial	Yes
Fax delayed sending	Yes
Fax broadcast	119
Junk fax barrier	Yes
Polling	Yes (receive only)
Remote retrieval	No
Fax forwarding	Yes

LED Screen :

A LED Screen shall provide an elementary full colour & animated real time display of the entire system. The mimic shall measure not less than 65” LCD Screen.

The operator interface shall provide facilities to:

- display status of devices associated with the process area concerned (i.e. running, stopped, fault etc.);
- display analogue values associated with that area of the plant;
- annunciate alarms associated with the area of the plant concerned;
- provide facilities for the operator to:
- silence the alarm (the alarm shall automatically silence after one minute (manually adjustable) if not manually silenced);
- acknowledge alarms
- select the duty drive of duty / standby drive pairs;
- adjust process set points;
- prompt process actions.

Control Room Design :

An ergonomic approach to the design of centralized control and monitoring center workstations and the layout of the control room shall contribute to achieving safety and performance objectives set for the centralized control room.
Effective control room design shall consider both form and function to create workspaces that facilitate the complex interaction between operators, technology and the environment. Raised flooring, acoustic concerns, indirect lighting and the wellbeing, health and safety of each operator shall need to be addressed.
Operators in the control room shall work 24 hours a day, 7 days a week.
Control room design shall take into consideration room size, number of operators, viewing requirements and equipment. Operators shall be able to communicate with each other as well as have easy access to essential equipment. The height of the console shall be calculated so the shortest operator can see over the top of any workstation mounted electronics to remote monitor walls, control panels or displays and the clearance underneath the work surface should allow for the tallest operator to sit comfortably.
When designing the control room to address these and other concerns, the following steps shall be taken to ensure operator comfort and minimize fatigue:

- Test console layout with operators for “human tasks” including sequential task simulations.
- Develop workstation layouts designed around acceptable reach zones and visual limitations.
- Take into account maintenance requirements and removal of equipment from both the rear and front of the workstation.
- Provide ergonomic footrests where appropriate.
- Provide chairs with full adjustment capabilities.
- Reduce excess heat and noise by locating electronics in an equipment room.
- In workstation dimensions, consider the full height and size range of the operators, utilizing height adjustable work surfaces where appropriate.

A. Control centre Overview:

The scope of the Contractor shall include complete design, modification and construction, interior design of the existing civil structure to match international control centre standards, supply and installation of control centre equipment which shall not be limited to furniture, telecommunication equipment, ergonomically designed chairs etc.

Control centre shall include the following on a minimum but not be limited to:

a) Main control room
b) 65" LED screens
c) Server room
d) Fire alarm system & UPS room
e) Electrical equipment room
f) Air-conditioning and precision air-conditioning for control centre
g) Bio-metric & Card based access control system
h) Close circuit television(CCTV) system
i) Store room for equipment, spares.
j) Rodent control facilities
k) False flooring
l) False ceiling, etc…

B. Main Control Room:

The main control room area shall be equipped with the following blade servers

1. Dual redundant SCADA servers
2. Historian server

The main control room shall be equipped with 65" LED screen for display of SCADA & DMA data feeds and shall be networked.

C. Server room

The control center shall be provided with a server room. Server room shall house the SCADA server & historian server's applications and other servers under this contract.

D. UPS room

The control center shall be provided a separate room for the online UPS system and the status and health shall be monitored on the SCADA system.

E. Air-conditioning(including precision air-conditioning)

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he control center shall be provided with air-conditioning. Precision air-conditioning shall be provided for server rooms. The sizing calculations shall be submitted for review and approval.

F. Rodent Control

Supply, installation and Commissioning of Pest Repellent System

Note:

1. All walls / partitions in centralized SCADA centre must be 1 hr. fire rated.
2. 1 Hr. fire rated clear glass for limited area of SCADA control room area.
3. Door to SCADA Control room should be provisioned with security system(Access Control) and surveillance cameras

4. All entry to SCADA control room shall have provisions for dust proofing and there shall be provisions for shoe racks outside the server room..
5. Anti-static Laminate covering on the floor duly laid with grounding grid.
6. Floor Insulation of the wall in SCADA Control room with 9mm thick nitrile rubber.
7. Water Proofing for floors wherever required,
8. All furniture and fixtures shall be termite resistant.
9. Illuminated signs with proper naming convention should be installed in the Control room.

Uninterruptible Power Supply (UPS)

The UPS system shall be redundant for the complete instrumentation, control & automation system. The minimum backup period for the UPS system individually shall be minimum 120 minutes on full load.
The UPS shall be floor mounted; self-contained and metal clad and shall be suitable for supplying a non-linear load. It shall be possible to open the enclosure front door when the unit is in use without exposing any live contact to touch.

The UPS shall be an on-line type incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch which shall operate in the event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.
The UPS shall incorporate a dc under voltage trip circuit to electronically trip the UPS output in order to protect the batteries.

The noise level of the unit shall not exceed 60dB(A) at 1 m from the UPS cabinet.
The output of the inverter shall be a sine wave having less than 2% THD for linear loads and less than 4% for 50% non-linear load. It shall be suitable for load power factors 0.7 lag to 0.9 lead.

The unit shall have a dynamic response such that a 100% step load causes an output voltage transient of less than ± 4% with a recovery time of less than 4 ms.
For three phase output units the output voltage shall not vary by more than ± 1% for an unbalance of 10%.

The load crest factor shall not be less than 3:1.
The efficiency at full load and 0.8 power factor shall be greater than 88%.

Indicators to indicate

- UPS status
- UPS alarm conditions

The UPS shall provide a volt free contact output to indicate:

- warning, i.e. low battery capacity
- fault
- static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

Technical Particulars:

Each UPS shall have the following features:

a) The UPS shall be stand alone, parallel redundant, true on line, based on advanced IGBT PWM technology with microprocessor based control, monitoring and fault diagnostics, static by pass switch and front access oriented layout.

b) Main Parameters:

1	Input Voltage	415V +10% -15 % A.C. Three phase 4 wires with Solidly earthed Neutral.
2	Symmetrical Short circuit level. Frequency	25kA 50Hz ± 5%
3	Output Voltage	415V ± 1% A.C, Three Phase 4 wire with Solidly Earthed Neutral.
4	Frequency Wave form	50Hz ± 5% True Sine Wave
5	Isolation	True on line with complete galvanic Isolation
6	Total harmonic Distribution	< 2% for linear load, < 3% for non-linear load
7	Over load Capacity	125% for 10min 150% for 10Sec
8	Transient Response	Remain within ± 1% and recover to 100% within ¼ Cycle
9	Crest factor	3 : 1
10	Duty	Continuous
11	Static by pass	to be provided
12	Efficiency Converter Inverter Overall	 > 94% > 93% > 87%
13	Max Ambient Temp and Relative Humidity	45°C & 100%
14	Cooling	Forced air
15	Acoustic Noise Level	<60db at 1.5m
16	Battery backup	60min for full load.

c) The UPS shall be complete with Isolation transformer, Converter cum Changer, inverter, protections, indications, programming, microprocessor based monitoring and fault diagnostic system, communication facilities, redundant control power supplies, SMF battery, accessories and interconnecting Cables.

d) Constructional Features: The UPS shall be high quality CRCA sheet steel enclosed suitable for floor mounting. The sheet steel shall be of 2mm thick. All sheet parts shall undergo phosphating process to ensure anti rust conditioning and superior finish. Premier quality powder coating shall be applied. The degree of protection shall be IP 54. The UPS panel shall be provided with two earthing terminals. The final finish shall be Light Grey Semi Glossy Shade 631 of IS 5.

Converter cum Charger:

When normal AC supply is available, DC power for the inverter is fully supplied by the converter and the battery is kept under float charge. On main supply failure, the battery shall be automatically connected to the Inverter without interrupting the output voltage for critical load. Similarly on normalization of AC power, the DC load shall be transferred to the converter and battery shall be put on float charge without interruption at output side. The converter cum charger shall be designed to deliver the full load DC required by the inverter and charging of the battery. Battery charging shall be with float & boost mode selection with current limit.

1) Inverter:

The static inverter shall convert the power from the converter/battery into stable AC power which is supplied to load. The inverter shall be with the latest IGBT PWM technology with specially designed output transformer.

2) Battery Bank:

Batteries shall be 12V, SMF (sealed maintenance free) type. The Qty& AH of batteries shall be suitable for backup period of 60 minutes for full load.
The battery shall be rated to provide full load power for required backup time on AC power failure. After delivering this amount of power, the battery shall be suitable for recharging through converter cum charger on AC power restoration. The battery shall be mounted on a separate rack. The battery bank shall be complete with battery stand, interlinks and UPS to battery interconnecting cable.

3) Other features:

The other features of UPS shall be as follows:

i) Micro processor based Control, monitoring and fault diagnostics.
ii) Comprehensive LED mimic and LED display with keypad Control to enable the following:
   a) Date-time stamped event recording and logging in a non-volatile memory
   b) Programming and Monitoring of various system parameters
   c) Status indications and number of LCD digital meters.
iii) 100% Non linear local handling Capability with low distortion of less than 5% and high crest factor of 3:1
iv) RS 232c/ RS 485 interface port.
v) Front access layout.
vi) Inbuilt line chokes for main power supply.
vii) Indications:
   - Mains ‘ON’

- Converter 'ON'
- Inverter 'ON'
- Battery Low
- Over load
- Inverter Trip
- Charger Trip
- Output 'ON'

viii) Protections:

- Incomer MCCB with Overload & Short circuit releases
- Outgoing MCCB with Overload & Short circuit releases
- Battery MCCB with Overload & Short circuit releases
- Input under/over voltage
- Converter over voltage
- Battery Low
- Battery charging current limit
- Output under voltage
- Output over voltage
- Output over load
- Output short circuit
- Inverter over temp
- Single phase prevention

Alarm and trip conditions shall be separately enunciated.

The backup period shall be minimum 2 hr on full load.

Testing Requirements

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.
The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.
The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC& SCADA system while running on UPS power.
- All Routine/acceptance tests as per relevant Indian / International standards shall be carried out in the presence of Employer / his Employer Representative
-

Quality Assurance/Quality Control (QA/QC)

QA/QVC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC & SCADA systems. The quality assurance/control procedures shall include, but not be limited to the following:

- Continuity and Wiring tests;
- Insulation and High Potential Testing;
- Packaging and Shipping;

- Welding;
- Cleaning and Painting.

The quality assurance/quality control documentation shall include, but not be limited to the following:

- Material Certifications;
- Shop Test Reports;
- All other documentation required by applicable codes and standards.

Testing Requirements

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.
The tests shall be carried out on the fully assembled control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

Factory Acceptance Test (FAT)

The Contractor shall conduct a full programme of tests of the PLC & SCADA system along with the water management softwares that are listed in the requirements and required integration at the Contractor's testing facility in the presence of the Engineer to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. Unless otherwise specified or agreed by the Engineer, the entire PLC & SCADA system along with the water management software's shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Engineer at least four weeks before the test.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Engineer for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.

Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Engineer that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Engineer or unless otherwise approved by the Engineer. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Engineer.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.
After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Engineer. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be entered into the system documentation before delivery of the system to Site.

The entire cost of the complete FAT and any other required testing (interoperability, site visits etc..), including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for DJB & employers representative personnel attending the tests, shall be the responsibility of the Contractor/ system supplier and shall be included in the contract price.

Factory Acceptance Test Procedures

General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

Hardware tests

(a) Verify the correct inventory of hardware including cables and printed circuit boards;
(b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;
(c) Demonstrate all hardware and software diagnostics;
(d) Verify all power supply voltages are within tolerance;
(e) Verify proper earth connections and isolation of instrumentation earth for all equipment;
(f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

Software tests

(a) Demonstrate the editing of all system parameters including set-points, timers and the like;
(b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;
(c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Engineer whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor

and Engineer and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Engineer may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

(a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update

(b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified
(c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;
(e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;
(f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;
(g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;
(h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;
(j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;
(k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

Reliability test
After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.

During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Engineer shall be included during this test. Upon any system failure during this period, it shall be the decision of the Engineer whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described

in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final factory acceptance test documentation.

Factory acceptance test documentation

As a minimum, the following information shall be included in the factory Acceptance test manual for each test:
• Test identification number;
• Test name and description;
• List of all equipment to be tested including any special test equipment required;
• Description of the test procedure broken down into logical steps;
• Description of the expected system response verifying the completion of each logical step;
• Space for recording the results of the test and the time and date of the test;
• Space for signatures of the Contractor and the Engineer.
In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

A. Pre-commissioning tests

The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has been verified, tests of automatic controls of each process system shall be conducted wherever practical.

B. Commissioning

Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Engineer for approval prior to commissioning tests. Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Engineer before commissioning is allowed to commence.

As part of commissioning, the PLC & SCADA system shall be tested for availability for a continuous period of ninety (90) days. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Engineer.
The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test,

unless otherwise agreed by the Engineer. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Engineer. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Engineer and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

C. Uninterruptible Power Supplies (UPS)

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.
The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.
The Contractor shall demonstrate the following on a minimum:

- change-over from full load with mains present to full load on battery supply;
- carry out a discharge test on the system at full load and for the specified duty bridging time period;
- carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.
- Demonstrate the full functioning of the PLC& SCADA system while running on UPS power.

Training :

The Contractor/ system supplier shall conduct training courses for personnel selected by the end user. Training shall be conducted by personnel employed by the Contractor/ system supplier familiar with the system supplied and who have experience and training in developing and implementing instructional courses.

The entire cost of the complete training programme, including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all end user personnel attending the training program, shall be the responsibility of the Contractor/ system supplier and shall be included in the contract price.
The Contractor/ system supplier shall submit information on the training programme for approval, prior to shipment of the equipment. This submittal shall include a course outline; time required, course schedule, sample workbook and instructor qualification information for each level.

The Contractor/ system supplier shall make a workbook on each course available to every person taking the courses listed herein. The workbook shall be of sufficient detail so that, at a later date, a trainee could review in detail the major topics of the course.

The training times shall be scheduled by the end user in advance with the Contractor/ system supplier.

Operations and Maintenance Training

Training shall be provided for ten (10) of the end user personnel at the system supplier facility and on plant site on operations and maintenance of all system components. The training program shall be divided into two segments and shall consist of at least ten (10) working days, each of 8 (eight) hours duration.

The maintenance training program shall be developed for personnel that have electronics maintenance and repair experience and a general knowledge of computer systems, but shall not assume any familiarity with the specific hardware furnished.
As a minimum, the following subjects shall be covered:

- System Architecture and Layout
- Hardware Components
- Module Switch Settings (Configuration Switches)
- I/O Modules
- Power Supplies
- Data Highway:
- Programmer connection
- IOP programming and diagnostic techniques
- Battery replacement and recharging
- PC and workstation familiarization and maintenance:
- Troubleshooting
- Disassembly
- Cleaning
- Component Replacement
- Re-assembly
- The operation training programme shall include the following topics:
- Power-up, bootstrapping and shutdown of all hardware devices
- Interpretation of all standard displays
- Appropriate actions for software and hardware error occurrences
- Use of operator interface displays and keyboards
- Use of printer including replenishment of supplies
- Manual data entries
- Creation and editing of graphic operator display screens.
- Loading of any required software into the system
- Data base creation and editing.