Greater Visakhapatnam Smart City Corporation Limited

BIDDING DOCUMENT

for the

Procurement

of Works for Design, Build, Testing , Commissioning, Operation and Maintenance of

Distribution Network Improvements for NRW reduction and 24x7 supply i*n ABD Area of Greater Visakhapatnam Municipal Corporation*

Under International Competitive Bidding

Volume 2 of 3 – Technical specifications

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PART 1 – GENERAL SPECIFICATIONS

1. GENERAL

1.1. Reference mentioned herein shall be applicable to all sections to the extent the context permits and are intended to supplement the provisions in the particular section. In case of any discrepancy/ deviation, the provisions in the particular section shall take precedence.

2. INTERPRETATIONS

2.1. The Employer/Engineer-in-charge shall be the sole deciding authority as to the meaning, interpretation and implications for various provisions of the specifications. His decision in writing shall be final.

2.2. Wherever any reference is made to any Indian Standard, it shall be taken as reference to the latest edition with all amendments issued thereto. In the event of any variation between the Andhra Pradesh Detailed Standard Specifications , CPWD specifications and the Indian Standard, the former shall take precedence over the latter.

2.3. In case the specification of an item is not available in this document or documents specified in Clause no 2.2, Contractor shall be permitted to use following alternative specification subject to the following conditions:

a. He shall demonstrate that the proposed specification conforms to any of the following international Standards, Codes of Practice, Specifications, Guidelines, etc.

b. it shall delivering an equal or better product and shall fulfil the intent of the product.

1. International standard organisation (ISO)
2. British Standards
3. American Society for Testing of Materials (ASTM)
4. German Standards
5. Euro Codes

3. DEFINITIONS

The following terms and expressions in the specifications shall have the meaning or implication hereby assigned to them unless otherwise specified elsewhere.

Contractor: The Contractor shall mean the individual or firm or company whether incorporated or not undertaking the works and shall include the legal personal representatives of such individual or the persons composing such firm or company, or the successors of such individual or firm or company and the permitted assignees of such individual or firm of company.

Engineer-in-Charge: The ‘Engineer-in-Charge’ means the Engineer officer who shall supervise and be in-charge of the work and who shall sign the contract on behalf of the President.

Site: The ‘site’ shall mean the land/ or other places on, in, into or through which the work is to be executed under the contract or any adjacent land, path or street through which the work is to be executed under the contract, or any adjacent land, path or street which may be allotted or used for the purpose of carrying out the contract.

Store: The ‘store’ shall mean the place of issue of materials.

IS: The standards, specification and code of practices issued by the Bureau of Indian Standards.

Best: The word 'best' when used shall mean that in the opinion of the Engineer-in-Charge, there is no superior material/ article and workmanship obtainable in the market and trade respectively. As far as possible the standard required shall be specified in preference to the word 'best'.

Department: 'Department' shall be GVMC /GVSCL

Floor 1 is the lowest floor above the ground level in the building unless otherwise specified in a particular case. The floors above floor 1 shall be numbered in sequence as floor 2, floor 3 and so on. The number shall increase upwards.

Floor level: For floor 1, top level of finished floor shall be the floor level and for all other floors above floor 1, top level of the structural slabs shall be the floor level.

Plinth level: Floor 1 level or 1.2 m above the ground level whichever is lower shall be the plinth level.

3.1. Special Structures

For structures like retaining walls, wing walls, chimneys, over head reservoirs/ tanks and other elevated structures, where elevations/ heights above a defined datum level have not been specified and identification of floors cannot be done as in case of building. Level, at 1.2 m above the ground level shall be the floor 1 level as well as plinth level. Level at a height of 3.5 m above floor 1 level will be reckoned as floor 2 level and level at a height of 3.5 m above the floor 2 level will be floor 3 level and so on, where the total height above floor 1 level is not a whole number multiple of 3.5 metre. Top most floor level shall be the next in sequence to the floor level below even if the difference in height between the two upper most floor levels is less than 3.5 metres

4. FOUNDATION AND PLINTH

The work in foundation and plinth shall include:

· For buildings: All works upto 1.2 metre above ground level or upto floor 1 level whichever is lower:

· For abutments, piers and well steining: all works upto 1.2 m above the bed level:

· For retaining wall, wing walls, compound walls, chimneys, over head reservoirs/ tanks and other elevated structures: All works upto 1.2 metre above the ground level:

· For reservoirs/ tanks (other than overhead reservoirs/ tanks): All works upto 1.2 metre above the ground level:

· For basements: All works upto 1.2 m above ground level or upto floor 1 level whichever is lower.

Note: Specific provision shall be made in the estimate for such situations where the foundation level is more than 3 (three) metre depth from the plinth for all types of structures mentioned above.

5. MEASUREMENTS

5.1. In booking dimensions, the order shall be consistent and in the sequence of length, width and height or depth or thickness.

5.2. Rounding off: Rounding off where required shall be done in accordance with IS: 2-1960. The number of significant places rounded in the rounded off value should be as specified.

6. MATERIALS

6.1. Samples of all materials to be used on the work shall be got approved by the contractor from the Engineer-in-Charge well in time. The approved samples duly authenticated and sealed shall be kept in the custody of the Engineer-in-Charge till the completion of the work. All materials to be provided by the contractor shall be brand new and as per the samples approved by the Engineer-in-Charge.

6.2. Materials obtained by the contractor from the sources approved by the Department shall be subjected to the Mandatory tests. Where such materials do not conform to the relevant specifications, the matter shall be taken up by the Engineer-in-Charge for appropriate action against the defaulters. In all such cases, necessary documents in original and proof of payment relating to the procurement of materials shall be made available by the contractor to the Engineer-in-Charge.

6.3. All the Materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance. These may be tested according to relevant Indian Standards (IS) or International Standards Organization (ISO) standards in qualified labs and certificates produced to the satisfaction of the Employer's Representative.

6.4. The objectives of the specifications given are to specify the details pertaining tothe designs, drawings, and selection of equipment or product. The equipment or product supplied shall be of high standard of quality and best engineering practices and shall comply with all currently applicable standards, regulations and codes.

6.5. All necessary safety measures and precautions (including those laid down in the various relevant Indian Standards) shall be taken as also of the work itself.

6.6. The materials, supplied by the client shall be deemed to be complying with the specifications.

6.7. Contractor shall submit sample of the material and get written approval of the Employer/Engineer – charge before placing the order. Any work executed without approval of sample shall be deemed rejected.

6.8. All work shall be executed as per approved drawing only

6.9. Approval to any of the executed items for the work does not in any way relieve the Contractor of his responsibility for the correctness, soundness and strength of the structure as per the drawings and specifications.

6.10. All works shall be carried out strictly as per detailed technical specification provided in the tender. If not specified, the work shall be executed according to relevant applicable IS codes and standard engineering practice. In such case decision of the Engineer-in-charge shall be final and binding to the Contractor and in no case the Contractor will claim any extra for the same.

6.11. If the specifications for a particular item are not given by the Employer, the Standard Specifications of Andhra Pradesh/CPWD specification/Indian standard shall be followed. In all the conditions, direction of Engineer in charge shall be final binding upon the contractor.

6.12. Materials stored at site, depending upon the individual characteristics, shall be protected from atmospheric effects due to rain, sun, wind and moisture to avoid deterioration.

6.13. Materials like timber, paints etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials and explosives shall be stored in accordance with the relevant rules and regulations or as approved by Engineer-in-Charge in writing so as to ensure desired safety during storage.

6.14. The unit weight of materials unless otherwise specified shall be reckoned as given in IS: 1911-1967.

7. SAMPLES AND TESTS OF MATERIALS

All tests as required, both at the factory i.e. Factory Acceptance Test (FAT) before dispatch, and at site after installation i.e. Site Acceptance Tests (SAT), shall be carried out. Detailed Test reports and certificates shall be submitted.

The Contractor shall submit samples of such materials as may be required by Engineer in charge and shall carry out the specified tests directed by GVSCL/GVMC/ Engineer in charge at the Site, at the supplier's premises or at a laboratory approved by GVSCL/GVMC/ Engineer in charge. All other incidental expenditure to be incurred for testing of samples e.g. packaging, sealing transportation, loading, unloading etc. testing charges shall be borne by the contractor.

Employer may appoint separate third party inspection for the material testing to ensure the quality of the work. The Contractor shall replace the defective material as an outcome of these tests.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by GVSCL/GVMC/ Engineer in charge. The Contractor shall give seven days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by Employer. Representative of Employer shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by Employer to carry out such a test on a mutually agreed date in his presence. rior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employer’s Representatives who would witness the testing. The Contractor shall in any case submit to GVSCL/GVMC/ Engineer in charge within seven days of every test such number of certified copies (minimum six) of the test results as GVSCL/GVMC/ Engineer in charge may require. Approval by GVSCL/GVMC/ Engineer in charge as to the placing of orders for materials or as to samples or tests shall not prejudice any of NDMC's powers under the Contract. The provisions of this clause shall also apply fully to materials supplied under any nominated sub-contract.

8. SAFETY IN CONSTRUCTION

8.1. The contractor shall employ only such methods of construction, tools and plant as are appropriate for the type of work or as approved by Engineer-in-Charge in writing.

8.2. The contractor shall take all precautions and measures to ensure safety of works and workman and shall be fully responsible for the same. Safety pertaining to construction works such as excavation, centering and shuttering, trenching, blasting, demolition, electric connections, scaffolds, ladders, working platforms, gangway, mixing of bituminous materials, electric and gas welding, use of hoisting and construction machinery shall be governed by CPWD safety code, relevant safety codes and the direction of Engineer-in-Charge.

9. ABBREVIATIONS

The following abbreviations wherever they appear in the specifications, shall have the meaning or implication hereby assigned to them:

Mm	Millimetre
Cm	Centimetre
M	Metre
Km	Kilometre
Mm2/sqmm	Square Milimetre
Cm2/sqcm	Square centimetre
Dm2/sqdm	Square decimetre
M2/sqm	Square metre
Cm3/ cubic cm	Cubic centimetre
Dm3/ cubic dm	Cubic decimetre
M3/cum	Cubic metre
Ml	Millilitre
Kl	Kilolitre
Gm	Gram
Kg	Kilogram
Q	Quintal
T	Tonne
Fps system	Foot pound second system
°C	Degree Celsius temperature
Fig	Figure
Re/Rs	Rupee/ Rupees
No	Number
Dia	Diameter
AC	Asbestos cement
CI	Cast Iron
GC	Galvanised corrugated
GP	Galvanised plain
GI	Galvanised iron
PVC	Polyvenyl chloride
RCC	Reinforced cement concrete
SW	Stone ware
SWG	Standard wire Gauge

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PART -2 - GENERAL (MATERIAL) SPECIFICATIONS

1.1 GENERAL

Materials to be used in the work shall conform to the specifications mentioned on the drawings, the requirements laid down in this section and specifications for relevant items of work covered under these specifications.

If any material, not covered in these specifications, is required to be used in the work, it shall conform to relevant Indian Standards, if there are any, or to the requirements specified by the Engineer.

1.2 SOURCES OF MATERIAL

The Contractor shall notify the Engineer of his proposed sources of materials prior to delivery. If it is found after trial that sources of supply previously approved do not produce uniform and satisfactory products, or if the product from any other source proves unacceptable at any time, the Contractor shall furnish acceptable material from other sources at his own expense.

1.3 BRICKS

The bricks shall be modular type class designation – 25, kiln-burnt bricks of regular and uniform size, shape and colour, well burnt throughout. They shall be free from cracks or other flaws viz. lumps of lime, laminations, soluble salts causing efflorescence, air-holes which may in any way impair their strength durability, appearance etc. They shall give a clear metallic ringing sound when struck together.

After absorbing water the bricks shall not exceed 20% of their dry weight as per IS: 1077 - 1992. According to IS: 1077 - 1992 crushing load shall not be less than 25 Kg. /Sq. Cm. Samples of bricks shall also be subjected to the following tests:

(a) Dimensional tolerance.

(b) Water absorption.

(c) Efflorescence.

(d) Compressive strength.

1.4 STONES

Stones shall be of the type specified. It shall be hard, sound, free from cracks, decay and weathering and shall be freshly quarried from an approved quarry. Stone with round surface shall not be used.

The stones, when immersed in water for 24 hours, shall not absorb water by more than 5 per cent of their dry weight when tested in accordance with IS: 1124-1972.

The length of stones shall not exceed 3 times its height nor shall they be less than twice its height plus one joint. No stone shall be less in width than the height and width on the base shall not be greater than three-fourth of the thickness of the wall nor less than 150 mm.

1.5 CAST IRON

Cast iron shall conform to IS: 210-2009. The grade number of the material shall not be less than 14.

1.6 CEMENT

Cement to be used in the works shall be any of the following types with the prior approval of the Engineer:

a) Ordinary Portland cement, 43 Grade, conforming to IS: 8112-1989.

b) Rapid Hardening Portland Cement, conforming to IS: 8041-1990.

c) Sulphate Resistant Portland cement, conforming to IS: 12330-1988.

Cement conforming to IS: 8112-1989 and IS: 12269-1987 may be used provided the minimum cement content mentioned elsewhere from durability considerations is not reduced. From strength considerations, these cements shall be used with a certain caution as high early strengths of cement in the 1 to 28–day range can be achieved by finer grinding and higher constituent ratio of C_3S/C_2S, where C_3S is Tricalcium Silicate and C_2S is Dicalcium Silicate. In such cements, the further growth of strength beyond say 4 weeks may be much lower than that traditionally expected. Therefore, further strength tests shall be carried out for 56 and 90 days to fine tune the mix design from strength considerations.

Cement conforming to IS: 12330-1988 shall be used when sodium sulphate and magnesium sulphate are present in large enough concentration to be aggressive to concrete. The recommended threshold values as per IS : 456-2000 are sulphate concentration in excess of 0.2 per cent in soil sub-strata or 300 ppm (0.03 per cent) in ground water. Tests to confirm actual values of sulphate concentration are essential when the structure is located near the sea coast, chemical factories, agricultural land using chemical fertilizers and sites where there are effluent discharges or where soluble sulphate bearing ground water level is high. Cement conforming to IS: 12330-1988 shall be carefully selected from strength considerations to ensure that the minimum required design strength can be achieved without exceeding the maximum permissible cement content of 540 kg/cu.m. of concrete.

Cement conforming to IS: 8041-1990 shall be used only for precast concrete products after specific approval of the Engineer.

Total chloride content in cement shall in no case exceed 0.05 per cent by mass of cement. Also, total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 per cent and 3.0 per cent when tri-calcium aluminate per cent by mass is upto 5 or greater than 5 respectively.

1.7 COARSE AGGREGATES

For plain and reinforced cement concrete (PCC and RCC) works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel,

natural gravel or a suitable combination thereof or other approved inert material. They shall not contain pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregate having positive alkali-silica reaction shall not be used. All coarse aggregates shall conform to IS : 383-1970 and tests for conformity shall be carried out as per IS : 2386-1963, Parts I to VIII.

The contractor shall submit for the approval of the Engineer, the entire information indicated in Appendix A of IS: 383-1970.

The maximum value for flakiness index for coarse aggregate shall not exceed 35 per cent. The coarse aggregate shall satisfy the following requirements of grading:

REQUIREMENTS OF COARSE AGGREGATE

IS Sieve Size	**Per cent Weight Passing the Sieve**		
	40 mm	**20 mm**	**12.5 mm**
63 mm	100	-	-
40 mm	95-100	100	-
20 mm	30-70	95-100	100
12.5 mm	-	-	90-100
10 mm	10-35	25-55	40-85
4.75 mm	0-5	0-10	0-10

1.8 SAND/FINE AGGREGATES

For masonry work, sand shall conform to the requirements of IS : 2116-1980.

For plain and reinforced cement (PCC and RCC) or prestressed concrete (PSC) works, fine aggregate shall consist of clean, hard, strong and durable pieces of crushed stone, crushed gravel, or a suitable combination of natural sand, crushed stone or gravel. They shall not contain dust, lumps, soft or flaky, materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Motorised sand washing machines should be used to remove impurities from sand. Fine aggregate having positive alkali-silica reaction shall not be used. All fine aggregates shall conform to IS : 383-1980 and tests for conformity shall be carried out as per IS : 2386-1963, (Parts I to VIII). The Contractor shall submit to the Engineer the entire information indicated in Appendix A of IS: 383-1980. The fineness modulus of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

Sand/fine aggregate for structural concrete shall conform to the following grading requirements:

A.1.1

1.2 IS Sieve Size	**Per cent by Weight Passing the Sieve**		
	Zone I	**Zone II**	**Zone III**
10 mm	100	100	100
4.75 mm	90-100	90-100	90-100
2.36 mm	60-95	75-100	85-100
1.18 mm	30-70	55-90	75-100
600 micron	15-34	35-59	60-79
300 micron	5-20	8-30	12-40
150 micron	0-10	0-10	0-10

1.9 STEEL

2.9.1 Cast Steel

The use of cast steel shall be limited to bearings and other similar parts. Steel for castings shall conform to Grade 280-520N of IS : 1030-1998. In case where subsequent welding is unavoidable in the relevant cast steel components, the letter N at the end of the grade designation of the steel casting shall be replaced by letter W. 0.3 per cent to 0.5 per cent copper may be added to increase the corrosion resistance properties.

2.9.2 Reinforcement/Untensioned Steel

For plain and reinforced cement concrete (PCC and RCC) , the reinforcement/untensioned steel as the case may be shall consist of the following grades of reinforcing bars.

Grade Designation	**Bar Type conforming to governing IS Specification**	**Characteristic Strength fy MPa**	**Elastic Modulus GPa**
S 240	**IS: 432- 1982 Part I** Mild Steel Bar	**240**	**200**
S 415	**IS: 1786- 2008 High Yield Strength Deformed**	**415**	**200**

Grade Designation	Bar Type conforming to governing IS Specification	Characteristic Strength fy MPa	Elastic Modulus GPa
	Bars (HYSD)		

Other grades of bars conforming to IS: 432-1982 and IS: 1786-2008 shall not be permitted.

All steel shall be procured from original producers; no re-rolled steel shall be incorporated in the work.

Only new steel shall be delivered to the site. Every bar shall be inspected before assembling on the work and defective, brittle or burnt bar shall be discarded. Cracked ends of bars shall be discarded.

Fusion-bonded epoxy coated reinforcing bars shall meet the requirements of IS : 13620-1993. Additional requirements for the use of such reinforcement bars have been given below:

(a) Patch up materials shall be procured in sealed containers with certificates from the agency who has supplied the fusion bonded epoxy bars.

(b) PVC coated G.I. blinding wires of 18G shall only be used in conjunction with fusion bonded epoxy bars.

(c) Chairs for supporting the reinforcement shall also be of fusion bonded epoxy coated bars.

(d) The cuts ends and damaged portions shall be touched up with repair patch up material.

(e)The bars shall be cut by saw-cutting rather than flame cutting.

(f) While bending the bars, the pins of work benches shall be provided with PVC or plastic sleeves.

(g) The coated steel shall not be directly exposed to sun rays or rains and shall be protected with opaque polyethylene sheets or such other approved materials.

(h) While concreting, the workmen or trolleys shall not directly move on coated bars but can move on wooden planks placed on the bars.

When specified in the contract, protective coating prescribed by CECRI shall be provided in conformance to specifications given in *Appendix 1000/I*. The CECRI coating process shall be allowed to be implemented at the site of works provided a representative of the Institute is present throughout the duration of the coating process who shall certify that the materials and workmanship are in accordance with prescribed specifications developed by the Institute.

2.9.3 Grey Iron Castings

Grey Iron castings to be used for bearings shall have the following minimum properties:

(i)	Minimum ultimate tensile strength	370 MPa
(ii)	Modulus of Elasticity	147000 MPa
(iii)	Brinell Hardness	230 MPa
(iv)	Shear strength	370 MPa
(v)	Compressive Strength	1370 MPa

The testing shall be as specified in IS: 210.

2.9.4 Steel Forgings

Forged steel pins shall comply with clause3, 3A or 4 of IS: 1875-1992 and steel forgings shall comply with clause 3, 3A or 4 of IS : 2004-1991. Raw materials of the forging will be taken as per IS : 1875-1992 with minimum reduction ratio of 1.8:1. Alternatively, if forging is made from ingot a minimum reduction ratio between the ingot and forging will be 4:1. Forging shall be normalized.

2.9.5 Structural Steel

Unless otherwise permitted herein, all structural steel shall, before fabrication, comply with the requirements of the following Indian Standards:

IS: 2062-2011 : Hot Rolled Medium and High Tensile Structural Steel

IS: 2062-2011 : Weldable Structural Steel

IS: 1148-2009 : Hot rolled rivet bars for structural purposes

IS: 1161-1998 : Steel tubes for structural purposes

IS: 4923-1997 : Hollow Steel sections for structural use

IS: 11587-1986 : Structural weather resistant steel

IS: 808-1989 : Specifications for Rolled Steel Beam, Channel and Angle Sections

IS: 1239-2004 : Mild Steel Tubes

IS: 1730-1989 : Dimension for Steel Plate, sheet and strip for structural and general engineering purposes

IS: 1732-1989 : Dimension for round and square steel bars for structural and general engineering purposes

IS: 1852-1985 : Rolling and cutting tolerances for hot rolled steel products

The use of structural steel not covered by the above standards may be permitted with the specific approval of the client/Engineer-in-charge.

2.9.6 Stainless Steel

Stainless steel shall be austenitic chromium-nickel steel, possessing rust, acid and heat resistant properties conforming to IS: 6603-2001 and IS: 6911-1992. Mechanical properties/grade for such stainless steel shall be as specified by the accepting authority, but in no case be inferior to mild steel. Generally, stainless steel is available as per AISI grades. AISI 304 which is equivalent to grade 04Cr18Ni110 of IS: 6911 satisfies the requirements of mechanical properties of structural steel. Other grades of stainless steel for specific purposes may be provided as per specific requirements. For application in adverse/corrosive environment, stainless steel shall conform to AISI 316L or 02G17 Ni Mo2 of IS: 6911-1992.

1.10 WATER

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with sea water shall not be permitted. As a guide, the following concentrations represent the maximum permissible values:

a) To neutralize 200 ml sample of water, using phenolphthalein as an indicator, it should not require more than 2 ml of 0.1 normal NaOH.

b) To neutralize 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 normal HCI.

c) The permissible limits for solids shall be as follows when tested in accordance with IS : 3025:

Permissible Limits (max)

Organic	200 mg/lit
1.2.1.1 Inorganic	3000 mg/lit
Sulphate (SO_4)	500 mg/lit
Chlorides (CI)	500 mg/lit *
Suspended matter	2000 mg/lit

§ In case of structures of lengths 30 m and below, the permissible limit of chlorides may be increased upto 1000 mg/lit.

§ All samples of water (including potable water) shall be tested and suitable measures taken where necessary to ensure conformity of the water to the requirements stated herein.

d) The pH value shall not be less than 6.

1.11 TIMBER

The timber used for structural purposes shall conform to IS: 883-1994.

1.12 CONCRETE ADMIXTURES

2.12.1 General

Admixtures are materials added to the concrete before or during mixing with a view to modify one or more of the properties of concrete in the plastic or hardened state.

Concrete admixtures are proprietary items of manufacture and shall be obtained only from established manufacturers with proven track record, quality assurance and full fledged laboratory facilities for the manufacture and testing of concrete.

The contractor shall provide the following information concerning each admixture after obtaining the same from the manufacturer:

a) Normal dosage and detrimental effects, if any, of under dosage and over dosage.

b) The chemical names of the main ingredients in the admixtures.

c) The chloride content, if any, expressed as a percentage by the weight of the admixture.

d) Values of dry material content, ash content and relative density of the admixture which can be used for Uniformity Tests.

e) Whether or not the admixture leads to the entertainment of air when used as per the manufacturer’s recommended dosage, and if so to what extent.

f) Where two or more admixtures are proposed to be used in any one mix, confirmation as to their compatibility.

g) There would be no increase in risk of corrosion of the reinforcement or other embedments as a result of using the admixture.

2.12.2 Physical and Chemical Requirements

Admixtures shall conform to the requirements of IS: 9103-1999. In addition, the following conditions shall be satisfied:

a) “Plasticisers" and “Super–Plasticisers" shall meet the requirements indicated for “Water reducing Admixture".

b) Except where resistance to freezing and thawing and to disruptive action of deicing salts is necessary, the air content of freshly mixed concrete in accordance with the pressure

method given in IS: 1199-1959 shall not be more than 2 per cent higher than that of the corresponding control mix and in any case not more than 3 per cent of the test mix.

c) The chloride content of the admixture shall not exceed 0.2 per cent when tested in accordance with IS: 6925-1973.

d) Uniformity tests on the admixtures are essential to compare qualitatively the composition of different samples taken from batch to batch or from the same batch at different times.

The tests that shall be performed along with permissible variations in the same are indicated below:

- Dry Material Content: to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.

- Ash content: to be within 1 per cent of the value stated by the manufacturer.

Relative Density (for liquid admixtures): to be within 2 per cent of the value stated by the manufacturer.

e) All tests relating to the concretes admixtures shall be conducted periodically at an independent laboratory and compared with the data given by the manufacturer.

1.13 STORAGE OF MATERIALS

2.13.1 General

All materials may be stored at proper places so as to prevent their deterioration or intrusion by foreign matter and to ensure their satisfactory quality and fitness for the work. The storage space must also permit easy inspection, removal and restorage of the materials. All such materials even though stored in approved godowns/places, must be subjected to acceptance test prior to their immediate use.

2.13.2 Brick

Bricks shall not be dumped at site. They shall be stacked in regular tiers as they are unloaded, to minimise breakage and defacement. The supply of bricks shall be available at site at any time. Bricks selected for use in different situations shall be stacked separately.

2.13.3 Aggregates

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained. If necessary, the ground shall be covered with 50 mm plank.

Coarse aggregates, unless otherwise agreed by the Engineer in writing, shall be delivered to the site in separate sizes (2 sizes when nominal size is 25 mm or less and 3 sizes when the nominal size is 32 mm or more). Aggregates placed directly on the ground shall not be removed from the stockpile within 30 cm of the ground until the final cleaning up of the work, and then only the clean aggregate will be permitted to be used.

In the case of line aggregates, these shall be deposited at the mixing site not less than 8 hours before use and shall have been tested and approved by the Engineer.

2.13.4 Cement

Cement shall be transported, handled and stored on the site in such a manner as to avoid deterioration or contamination. Cement shall be stored above ground level in perfectly dry and water–tight sheds and shall be stacked not more than eight bags high. Wherever bulk storage containers are used their capacity should be sufficient to cater to the requirement at site and should be cleaned at least once every 3 to 4 months.

Each consignment shall be stored separately so that it may be readily identified and inspected and cement shall be used in the sequence in which it is delivered at site. Any consignment or part of a consignment of cement which had deteriorated in any way, during storage, shall not be used in the works and shall be removed from the site by the Contractor without charge to the Employer.

The Contractor shall prepare and maintain proper records on site in respect of delivery, handling, storage and use of cement and these records shall be available for inspection by the Engineer at all times.

The Contractor shall make a monthly return to the Engineer on the date corresponding to the interim certificate date, showing the quantities of cement received and issued during the month and in stock at the end of the month.

2.13.5 Reinforcement/Untensioned Steel

The reinforcement bars, when delivered on the job, shall be stored above the surface of the ground upon platforms, skids, or other supports, and shall be protected from mechanical injury and from deterioration by exposure.

2.13.6 Prestressing Materials

All prestressing steel, sheathing, anchorages and sleeves or coupling must be protected during transportation, handling and storage. The prestressing steel, sheathing and other accessories must be stored under cover from rain or damp ground and protected from the ambient atmosphere if it is likely to be aggressive. Storage at site must be kept to the absolute minimum.

a) **Tendon:** Wire, strand and bar from which tendons are to be fabricated shall be stored about 300 mm above the ground in a suitably covered and closed space so as to avoid direct climatic influences and to protect them from splashes from any other materials and from the cutting operation of an oxy–acetylene torch or arc welding process in the vicinity. Under no circumstances, tendon material shall be subjected to any welding operation or on site heat treatment or metallic coating such as galvanising. Storage facilities and the procedures for transporting material into or out of store, shall be such that the material does not become kinked or notched. Wire or strand shall be stored in large diameter coils which enable the tendons to be laid out straight. As a guide, for wires above 5 mm dia, coils of about 2 m dia without breaks or joints shall be obtained from manufacturer and stored. Protective wrapping for tendons shall be

chemically neutral. All prestressing steel must be provided with temporary protection during storage.

b) **Anchorage Components:** The handling and storing procedures shall maintain the anchorage components in a condition in which they can subsequently perform their function to an adequate degree. Components shall be handled and stored so that mechanical damage and detrimental corrosion are prevented. The corrosion of the gripping and securing system shall be prevented. The use of correctly formulated oils and greases or of other corrosion preventing material is recommended where prolonged storage is required. Such protective material shall be guaranteed by the producer to be non–aggressive and non–degrading.

Prestressing steel shall be stored in a closed store having single door with double locking arrangements and no windows. Also the air inside the store shall be kept dry as far as possible by using various means to the satisfaction of the Engineer. Also instrument measuring the air humidity shall be installed inside the store. This is with a view to eliminating the possibility of initial rusting of prestressing steel during storage. The prestressing steel shall be coated with water solvable grease. The prestressing steel should be absolutely clean and without any signs of rust.

All prestressing steel shall be stored at least 30 cm above ground level and it shall be invariably wrapped by protective cover of tar paper or polythene or any other approved material.

The Contractor should see that prestressing steel shall be used within 3 months of its manufacture. He should chalk out his programme in this respect precisely, so as to avoid initial corrosion before placing in position.

2.13.7 Water

Water shall be stored in containers/tanks covered at top and cleaned at regular intervals in order to prevent intrusion by foreign matter or growth of organic matter. Water from shallow, muddy or marshy surface shall not be permitted. The intake pipe shall be enclosed to exclude silt, mud, grass and other solid materials and there shall be a minimum depth of 0.60 m of water below the intake at all times.

1.14 TESTS AND STANDARD OF ACCEPTANCE

All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use.

Independent testing of cement for every consignment shall be done by the Contractor at site in the laboratory approved by the Engineer before use. Any cement with lower quality than those shown in manufacturer’s certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

2.14.1 Testing and Approval of Material

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site.

The Contractor shall set up a field laboratory with necessary equipment for testing of all materials, finished products used in the construction as per requirements of conditions of contract and the relevant specifications. The testing of all the materials shall be carried out by the Engineer or his representative for whom the Contractor shall make all the necessary arrangements and bear the entire cost.

Tests which cannot be carried out in the field laboratory have to be got done at the Contractor's cost at any recognised laboratory/testing establishments approved by the Engineer.

2.14.2 Sampling of Materials

Samples provided to the Engineer or his representative for their retention are to be in labelled boxes suitable for storage.

Samples required for approval and testing must be supplied well in advance by at least 48 hours or minimum period required for carrying out relevant tests to allow for testing and approval. Delay to works arising from the late submission of samples will not be acceptable as a reason for delay in the completion of the works.

If materials are brought from abroad, the cost of sampling/testing whether in India or abroad shall be borne by the Contractor.

2.14.3 Rejection of Materials not conforming to the Specifications

Any stack or batch of material(s) of which sample(s) does not conform to the prescribed tests and quality shall be rejected by the engineer or his representative and such materials shall be removed from site by the contractor at his own cost. Such rejected materials shall not be made acceptable by any modifications.

2.14.4 Testing and Approval of Plant and Equipment

All plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturer's specifications and shall be got approved by the Engineer before use.

1.15 STEEL REINFORCEMENT

2.15.1 Description

This work shall consist of furnishing and placing coated or uncoated mild steel or high strength deformed reinforcement bars (untensioned) of the shape and dimensions shown on the drawings and conforming to these Specifications or as approved by the Engineer.

2.15.2 General

Steel for reinforcement shall meet with the requirements of Section 1000 under road work specification**.**

Reinforcements may be either mild steel/medium tensile steel or high strength deformed bars. They may be uncoated or coated with epoxy or with approved protective coatings.

2.15.3 Protection of Reinforcement

Uncoated reinforcing steel shall be protected from rusting or chloride contamination. Reinforcements shall be free from rust, mortar, loose mill scale, grease, oil or paints. This may be ensured either by using reinforcement fresh from the factory or thoroughly cleaning all reinforcement to remove rust using any suitable method such as sand blasting, mechanical wire brushing, etc., as directed by the Engineer. Reinforcements shall be stored on block, racks or platforms and above the ground in a clean and dry condition and shall be suitably marked to facilitate inspection and identification.

Portions of uncoated reinforcing steel and dowels projecting from concrete, shall be protected within one week after initial placing of concrete with a brush coat of neat cement mixed with water to a consistency of thick paint. This coating shall be removed by lightly tapping with a hammer or other tool not more than one week before placing of the adjacent pour of concrete. Coated reinforcing steel shall be protected against damage to the coating. If the coating on the bars is damaged during transportation or handling and cannot be repaired, the same shall be rejected.

2.15.4 Bending of Reinforcement

Bar bending schedule shall be furnished by the Contractor and got approved by the Engineer before start of work. Reinforcing steel shall conform to the dimensions and shapes given in the approved Bar Bending Schedules. Bars shall be bent cold to the specified shape and dimensions or as directed by the Engineer using a proper bar bender, operated by hand or power to obtain the correct radii of bends and shape. Bars shall not be bent or straightened in a manner that will damage the parent material or the coating. Bars bent during transport or handling shall be straightened before being used on work and shall not be heated to facilitate straightening.

2.15.5 Placing of Reinforcement

a) The reinforcement cage should generally be fabricated in the yard at ground level and then shifted and placed in position. The reinforcement shall be placed strictly in accordance with the drawings and shall be assembled in position only when the structure is otherwise ready for placing of concrete. Prolonged time gap between assembling of reinforcements and casting of concrete, which may result in rust formation on the surface, shall not be permitted.

b) Reinforcement bars shall be placed accurately in position as shown on the drawings. The bars, crossing one another shall be tied together at every intersection with binding wire (annealed), conforming to IS : 280-2006 to make the skeleton of the reinforcement rigid

such that the reinforcement does not get displaced during placing of concrete, or any other operation. The diameter of binding wire shall not be less than 1mm.

c) Bars shall be kept in position usually by the following methods:

i In case of beam and slab construction, industrially produced polymer cover blocks of thickness equal to the specified cover shall be placed between the bars and formwork subject to satisfactory evidence that the polymer composition is not harmful to concrete and reinforcement. Cover blocks made of concrete may be permitted by the Engineer, provided they have the same strength and specification as those of the member.

ii In case of dowels for columns and walls, the vertical reinforcement shall be kept in position by means of timber templates with slots cut in them accurately, or with cover blocks tied to the reinforcement. Timber templates shall be removed after the concreting has progressed upto a level just below their location.

iii Layers of reinforcements shall be separated by spacer bars at approximately one metre intervals. The minimum diameter of spacer bars shall be 12 mm or equal to maximum size of main reinforcement or maximum size of coarse aggregate, whichever is greater. Horizontal reinforcement shall not be allowed to sag between supports.

iv Necessary stays, blocks, metal chairs, spacers, metal hangers, supporting wires etc, or other subsidiary reinforcement shall be provided to fix the reinforcements firmly in its correct position.

v Use of pebbles, broken stone, metal pipe, brick, mortar or wooden blocks etc., as devices for positioning reinforcement shall not be permitted.

d) Bars coated with epoxy or any other approved protective coating shall be placed on supports that do not damage the coating. Supports shall be installed in a manner such that planes of weakness are not created in hardened concrete. The coated reinforcing steel shall be held in place by use of plastic or plastic coated binding wires especially manufactured for the purpose. Reference shall be made to Section 1000 for other requirements.

e) Placing and fixing of reinforcement shall be inspected and approved by the Engineer before concrete is deposited.

1.16 BAR SPLICES

2.16.1 Lapping

All reinforcement shall be furnished in full lengths as indicated on the drawing. No splicing of bars, except where shown on the drawing, will be permitted without approval of the Engineer. The lengths of the splice shall be as indicated on drawing or as approved by the Engineer. Where practicable, overlapping bars shall not touch each other, and shall be kept apart by 25 mm or 1 ¼ times the maximum size of coarse aggregate, whichever is greater. If this is not feasible overlapping bars shall be bound with annealed steel binding wire, not less than 1 mm

diameter and twisted tight in such a manner as to maintain minimum clear cover to the reinforcement from the concrete surface. Lapped splices shall be staggered or located at points, along the span where stresses are low.

2.16.2 Welding

Splicing by welding of reinforcement will be permitted only if detailed on the drawing or approved by the Engineer. Weld shall develop an ultimate strength equal to or great than that of the bars connected.

While welding may be permitted for mild steel reinforcing bars conforming to IS: 432-1982, welding of deformed bars conforming to IS: 1786-2008 shall in general be prohibited. Welding may be permitted in case of bars other than S 240 grade including special welding grade of S 415 grade bars conforming to IS : 1786-2008, for which necessary chemical analysis has been secured ad the carbon equivalent (CE) calculated from the chemical composition using the formula:

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mg+V}{5} + \frac{Ni + Cu}{15}$$

Is 0.4 or less.

The method of welding shall conform to IS: 2751-1979 and IS: 9417-1989 and to any supplemental specifications to the satisfaction of the Engineer.

Welding may be carried out by metal arc welding process. Oxyacetylene welding shall not be permissible. Any other process may be used subject to the Engineer and necessary additional requirements to ensure satisfactory joint performance. Precautions on over heating, choice of electrode, selection of correct current in arc welding etc., should be strictly observed.

All bars shall be butt welded except for smaller diameter bars (diameter of less than 20 mm) which may be lap welded. Single-V or Double-V butt joints may generally be used. For vertical bars single bevel or double bevel joints may be used.

Welded joints shall be located well away from bends and not less than twice the bar diameter away from a bend.

Generally, shop welding in controlled conditions is to be preferred, where feasible. Site welding where necessary shall, however, be permitted when the facilities, equipment, process, consumables, operators, welding procedure are adequate to produce and maintain uniform quality at par with that attainable in shop welding to the satisfaction of the Engineer.

Joint welding procedures which are to be employed shall invariably be established by a procedure specification. All welders and welding operators to be employed shall have to be qualified by tests prescribed in IS: 2751-1979. Inspection of welds shall conform to IS: 822-1970 and destructive or non-destructive testing may be undertaken when deemed necessary.

Joints with weld defects detected by visual inspection or dimensional check inspection shall not be accepted.

Suitable means shall be provided for holding the bars securely in position during welding. It must be ensured that no voids are left in welding. When welding is done in 2 or 3 stages, previous surface shall be cleaned properly. Bars shall be cleaned of all loose scale, rust, grease, paint and other foreign matter before carrying out welding. Only competent and experienced welders shall be employed on the work with the approval of the Engineer. No welding shall be done on coated bars. M.S. electrodes used for welding shall conform to IS: 814-2004.

Welded joints shall preferably be located at points where steel will not be subject to more than 75 per cent of the maximum permissible stresses and welds so staggered that at any on section, not more than 20 per cent of the bars are welded.

Welded pieces of reinforcement shall be tested. Specimens shall be taken from the site and the number and frequency of tests shall be as directed by the Engineer.

2.16.3 Mechanical Coupling of Bars

Bars may be jointed with approved patented mechanical devices as indicated on the drawing or as approved by the Engineer e.g. by special grade steel sleeves swaged on to bars in end to end contact or by screwed couplers. In case such devices are permitted by the Engineer, they shall develop at least 125 per cent of the characteristic strength of the reinforcement bar.

1.17 TESTING AND ACCEPTANCE

The material shall be tested in accordance with relevant IS specifications and necessary test certificates shall be furnished. Additional tests, if required, will be got carried out by the Contractor at his own cost.

The fabrication, furnishing and placing of reinforcement shall be in accordance with these specifications and shall be checked and accepted by the Engineer.

1.18 MEASUREMENTS FOR PAYMENT

Reinforcement shall be measured in length including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in tonnes on the basis of IS: 1732-1989. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

1.19 RATE

The contract unit rate for coated/uncoated reinforcement shall cover the cost of material, fabricating, transporting, storing, bending, placing, binding and fixing in position as shown on the drawings as per these specifications and as directed by the Engineer, including all labour, equipment, supplies, incidentals, sampling, testing and supervision.

The unit rate for coated reinforcement shall be deemed to also include cost of all material, labour, tools and plant, royalty, transportation and expertise required to carry out the work. The rate shall also cover sampling, testing and supervision required for the work.

PART A – WATER PIPE LINE SPECIFICATIONS

The contractor shall Design and construct the pressurized 24/7 potable water system on continuous running basis, along with installation of valves, scour valves, air release valves, thrust blocks etc. as required. The Contractor shall furnish all required tools, plant, instruments, materials including water, electricity, labor, consumables, etc., and everything necessary for construction of the works, whether or not such items are specifically stated elsewhere in this bid. All valves shall be electrically actuated except air release valve.

The system shall be designed as closed loop system for efficient operations and shall be designed taking the concept of District Metering Area (DMA) with each DMA being isolated with valves and flow measured with an bull bore electromagnetic flow meter to each DMA.

In general, this work shall include designing, providing, laying, jointing and testing of all PE-100 HDPE/ DI pipes and specials/ fittings, interconnections, Valves, pump sets, house connections, metering, quality monitoring, instrumentation works, SCADA etc.

1.1 REFERENCES AND STANDARDS

1.1.1 Except where otherwise specified the works under this project shall comply with the requirements of relevant Indian Standards (IS), CPWD specifications and manufacturer's instruction manual. If required reference is not available, for any of the work(s) mentioned in the specifications and tender, in IS code(s) then relevant clauses of either British Standards (BS) or ISO Standards shall be followed. The following standards and the amendments made thereto till date and any other IS code provisions found to be applicable to this work shall be binding on the bidders (bidding and executing the work). All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions and amendments of the standards.

The bidders are therefore advised to refer and follow all relevant IS codes and amendments along with relevant ISO codes till date regarding supplying, testing, commissioning of DI/HDPE pipes and fittings, their testing, dimensions and measurement, composition of raw material, physical properties, mechanical characteristics, laying, jointing and their performance requirements, sampling and conformity criteria, marking and certification, etc.

1.1.2 If there are varying or conflicting provisions made in any one document forming part of the contract, the Accepting Authority shall be the deciding authority with regard to the intention of the document and his decision shall be final and binding on the contractor.

1.1.3 Action where no Specifications are specified

1.1.4 In the case of any class of work for which there is no such specification, such work shall be carried out in accordance with the Bureau of Indian Standards Specifications. In case there is no such specification in Bureau of India Standards, the work shall be carried out as per manufacturer's specifications. In case there are no such specifications as required above, the work shall be carried out in alls respects in accordance with the instructions and requirements of the Employers Engineer.

1.1.5 All materials and workmanship not fully specified herein or not covered by an approved relevant standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

1.2 DUCTILE IRON (DI) PIPES

1.2.1 Manufacture of pipe

DI pipes and fittings (Class K7) shall be in accordance with IS: 8329 and IS: 9523. The pressure rating of the pipes shall be governed by the design but in no case pipes of rating less than K-7 shall be provided. Pipes and fittings shall be procured from reputed manufacturers with Employer's Engineer's approval. The Employer's Engineer shall at all reasonable times have free access to the place where the Pipes and fittings are manufactured for the purpose of examining and testing the pipes and fittings and for witnessing the test and manufacturing.

All tests specified either in this specification or in the relevant Indian Standards specified above shall be performed by the Manufacturer/ Operator at his own cost and in presence of Employer's Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be given to Employer's Engineer If the test is found unsatisfactory, Employer's Engineer may reject any or all pipes and fittings of that lot. The decision of Employer's Engineer in this matter shall be final and binding on the Operator and not subject to any arbitration or appeal. The pipes and fittings shall be striped, with all precautions necessary to avoid warping or shrinking defects. The pipes and fittings shall be free from defects. Any defect in pipes and fittings in the opinion of Employer's Engineer shall be rejected and shall be replaced by new one.

In the case of spigot and socket pipes and fittings, the socket shall be without the centre ring. In the case of flanged pipes, the flanges shall be at the right angles to the axis of the pipe and machined on face. The boltholes shall be drilled and located symmetrically off the centreline. The bolthole shall be concentric with the bore and boltholes equally spaced. The flanges shall be integrally cast with the pipes and fittings and the two flanges of the pipe shall be correctly aligned.

1.2.2 Reference and standards

IS 8329 – 2000	"centrifugally cast (spun) Ductile iron pressure pipes for water, gas and sewerage – Specification"
IS 9523:1980	"Ductile iron fittings for pressure pipes for water, sewerage and gas"
IS 11606:1986	"Methods of sampling of cast iron pipes and fittings"
IS 13382:1992	"Cat iron specials for mechanical and push-on-flexible jints for pressure pipelines for water, gas and sewerage"
ISO 2531:1998	"Ductile iron pipes, fittings and accessories and their joints for water or gas application"

1.2.3 Materials

The materials used in the manufacture of pipes and fittings shall comply with requirements specified in IS: 8329 and IS: 9523.

1.2.4 Dimensions and Tolerances

The internal diameter, thickness and length of barrel, dimensions of pipes and fittings shall be as per relevant tables of IS: 8329/IS: 9523 for different class of pipes and fittings. Each pipe shall be of uniform thickness throughout its length.

The tolerances for pipes and fittings regarding dimensions, mass, ovality and deviations from straight line in case of pipes shall be as per IS: 8329/IS: 9523.

Coatings

Unless otherwise specified, DI pipes and fittings shall be coated with Bitumen in accordance with relevant IS Specifications. Coating shall not be applied to pipe and fittings unless its surface is clean, dry and free from rust. Pipe coatings shall be inspected at site and any damage or defective areas shall be made good to the satisfaction of the Employer’s Engineer.

Bitumen coating shall be of normal thickness of 75 microns unless otherwise specified. It shall be cold applied compound complying with the requirements of relevant Indian standards, suitable for tropical climates, factory applied in accordance with the manufacturer's instructions. Damaged areas of coating shall be repainted on site after removing any remaining loose coating and wire brushing any rusted areas of pipe.

Polythene Sleeving: Where polythene sleeving is specified to be applied in addition to bitumen coating, it shall comply with ISO 8180. Site applied sleeving shall be stored under cover out of direct sunlight and its exposure to sunlight shall be kept to a minimum. Pipes having a factory applied sleeving must be stored in the same conditions. Joints in the sleeving shall be properly overlapped and taped in accordance with manufacturer's instructions to provide continuous sleeving.

Cement mortar lining: All pipes and fittings shall be internally lined with cement mortar in accordance with relevant IS. The cement used shall be Sulphate Resisting Cement confirming to IS: 12330. No admixtures in the mortar shall be used without the approval of the Employer’s Engineer.

Pipe linings shall be inspected on site and any damage or defective areas shall be made good to the satisfaction of the Employer’s Engineer. Lining shall be uniform in thickness all along the pipe. The minimum thickness of factory applied cement mortar lining shall be as per IS: 11906.

1.2.5 Testing of pipes at manufacturing unit

During manufacture, tests on pipes shall be carried out in accordance with these technical specifications by the Third party inspecting agency.

1.2.6 Marking

Marking shall be done as per IS: 8329 and IS: 9523 or any other relevant IS codes approved by the Employer’s Engineer. The following information shall be clearly marked on each pipe,

a) Internal diameter of pipe.

b) Class of pipe.

c) Date of manufacture and

d) Name of manufacture or his registered trade-mark or both.

Carting & Handling

Carting and handling of D.I. pipes and fittings shall be in accordance with the specifications in this section.

1.2.7 Trenching

Trenching includes all excavation which shall be carried out either by hand or by machine and shall be carried out in accordance with all requirements of -Earth work excavations clause. Wherever a socket or collar of pipe or fitting / special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all-round the socket in order to make the joint, and the grip shall be maintained clear, until the joint has been approved by Employer's Engineer.

Wherever D.I. pipes are laid over pillar supports for nala crossings etc. the pipes shall be placed as per the construction drawings and as directed by the Employer's Engineer.

1.2.8 Bedding

The type of bedding (granular, concrete cradle, concrete arch etc.) shall be as per approved construction drawings and specifications in this section.

1.2.9 Laying of the pipe

Laying of DI pipes shall conform to the Code of practice of IS: 12288. Pipes shall be laid as per the requirement in the drawing and as directed by the Employer's Engineer. Laying of pipes shall be as per IS specified in Bill of Quantities and approved construction drawings. All pipes, fittings and material shall be tested and approved by the Employer's Engineer before being laid. Any pipes, fittings or material placed before they are tested and approved shall be removed and replaced with tested and approved material. Before laying the pipe, necessary bedding shall be provided wherever required. Polyethylene sleeves wounded pipes shall be used for water logged areas as per specification and as directed by the Employer's Engineer.

1.2.10 Jointing of pipes

Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings/gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS: 5382.

Spigot and Socket joints: These shall have sockets, which are integral with the pipe and incorporate an electrometric rubber ring gasket conforming to IS: 12820.The gaskets/sealant

used for joints shall be suitable for water conveyance. In jointing DI pipes and fittings, the Operator shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Operator shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, so that the rubber ring as per IS: 12820 and IS: 5382 is correctly positioned in line, before the joint is made. The rubber rings and any recommended lubricant shall be obtained only through the approved supplier and as directed by the Employer's Engineer.

1.2.11 Gaskets for Flanges

All gaskets used between flanges of pipes shall be of natural rubber conforming to IS: 638 of thickness 3 mm suitable for potable water conveyance and as specified by manufacturer. While conveying potable water, the gaskets should not deteriorate the quality of water and should not impart any taste or foul odour.

1.2.12 Flanged joints

These shall be of minimum PN 1.0 rating and shall comply with dimensions and drilling details as specified in IS: 8329. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. All material shall be supplied by a reputed manufacturer and shall be approved by the Employer's Engineer.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The recommended bolting torque to be followed for assembling flanges shall be as specified in manufacturer's instructions. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

1.3 HIGH DENSITY POLYETHYLENE PIPES (HDPE) Pipes

1.3.1 GENERAL:

This specification covers the requirements for successfully designing, manufacturing, supplying, laying, jointing and testing at works and site of High Density Polyethylene Pipes used for water supply.

1.3.2 APPLICABLE CODES

The manufacturing, testing, supplying, laying, jointing and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In Particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern. Others Codes not specifically mentioned here but pertaining to the use of HDPE pipes form part of these Specifications.

IS: 4984	High Density Polyethylene Pipes for Water Supply
IS: 2530	Methods of test for polyethylene moulding materials and polyethylene compounds

IS: 5382	Rubber sealing rings for gas mains, water mains and sewers. Methods for random sampling
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 7634	Laying & Jointing of Polyethylene (HDPE) Pipes
IS: 9845	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs
IS: 10141	Positive lists of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
IS: 10146	Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water.
IS 4905 : 1968	Methods for random sampling
IS 8360 (part- I): 1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – General Requirements"
IS 8360 (part- II) :1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Tee"
IS 8360 (part- III) :1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies – Specific Requirements for 90 Deg. Bends"
IS 8008 (part-I): 2003	"Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies –Specification – General Requirements for fittings"

1.3.3 DESIGNATION

Pipes shall be designated as per IS 4984, according to the grade of material, followed by pressure rating and nominal diameter, for example, PE-100 PN 10 DN 200 indicates a pipe pertaining to material grade 100 having a pressure rating 1.0 MPa and outside nominal diameter 200 mm.

• All HDPE Pipes of the same size, same pressure rating and same grade and also manufacture essentially under similar conditions of manufacture, shall constitute a lot. Materials

• The material used for the manufacturer of pipes should not constitute toxicity hazard, should not support microbial growth, should not give rise to unpleasant taste or odour, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the

manufacturers of raw material by any internationally reputed organization as per the satisfaction of the Employer's Engineer in charge.

1.3.4 RAW MATERIAL

Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427 for this a certification has to be given by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the following norms as per ISO 9080

The resin should have been certified by an independent laboratory of international repute for having passed 10,000 hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10MPa. Internal certificate of any resin manufacturer will not be acceptable.

Certificate for having passed the full scale rapid crack propagation test as per ISO 13478. High density Polyethylene (HDPE) used for the manufacture of pipes shall conform to designation PEEWA-45-T-006 of IS 7328. HDPE conforming to designation PEEWA-45- T-012 of IS 7328 may also be used with the exception that melt flow rate (MFR) shall not exceed 1.10 g/10 min. In addition the material shall also conform to clause 5.6.2 of IS 7328.

The specified base density shall be between 941.0kg/ m^3 and 946.0kg/ m^3 (both inclusive) when determined at 27°C according to procedure prescribed in IS7328 The value of the density shall also not differ from the nominal value by more than 3 kg/ m^3 as per 5.2.1.1 of IS 7328. The MFR of the material shall be between 0.41 and 1.10 (both inclusive) when tested at 190°C with nominal load of 5 kgf as determined by method prescribed in IS 2530. The MFR of the material shall also be within ± 20 percent of the value declared by the manufacturer.

The resin shall be compounded with carbon black. The carbon black content in the material shall be within 2.5 ±0.5% and the dispersion of carbon black shall be satisfactory when tested as per IS 2530.

1.3.5 ANTI-OXIDANT

The percentage of anti-oxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harm less and shall be selected from the list given in IS 10141

1.3.6 REWORKED MATERIAL

No addition of Reworked/ Recycled Material from the manufacturer's own rework material resulting from the manufacture of pipes is permissible and the vendor is required to use only 100% virgin resin compound.

1.3.7 EFFECT OF NATURE OF SOIL ON PIPE PERFORMANCE

The bidder shall provide certified information, as per IS code of practice about the performance of HDPE pipes, if laid in corrosive soils, below water table or under saturated conditions or rocky strata, etc. The necessary precautions, as per IS code of practice, to be taken like painting

or bitumen coating or providing special bedding or crossing any feature under hanging, etc to encounter such conditions shall be mentioned and accounted for in the bid cost by the bidder.

1.3.8 MAXIMUM OVALITY OF PIPE

The outside diameter of pipes, tolerance on the same and ovality of pipe shall be as given in table 2 of IS 4984. Ovality shall be measured as the difference between maximum outside diameter and minimum outside diameter measured at the same cross section of the pipe, at 300 mm away from the cut end. For pipes to be coiled the ovality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipes shall be carried out prior to the measurement of ovality.

1.3.9 WALL THICKNESS

The minimum & maximum wall thickness of pipe for the three grades of materials, namely PE63, PE80, and PE100 shall be as given in table 3, 4, & 5 respectively in IS:4984.

1.3.10 LENGTH OF STRAIGHT PIPE

The length of straight pipe used shall be more than 6 m or as agreed by Employer's Engineer in charge. Short lengths of 3 meter (minimum) up to a maximum of 10% of the total supply may be permitted.

1.3.11 COILING

The pipes supplied in coils shall be coiled on drums of minimum diameter of 25 times the nominal diameter of the pipe ensuring that kinking of pipe is prevented. Pipe beyond 110mm dia shall be supplied in straight length not less than 6m.

1.3.12 WORKMANSHIP / APPEARANCE

Pipes shall be free from all defect including indentations, delaminating, bubbles, pinholes, cracks, pits, blisters, foreign inclusions that due to their nature degree or extent detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in colour opacity, density and other physical properties as per relevant IS Code or equivalent International Code. The inside surface of each pipe shall be free of scouring, cavities, bulges, dents, ridges and other defects that result in a variation of inside diameter from that obtained on adjacent unaffected portions of the surface. The pipe ends shall be cut clearly and square to the axis of the pipe.

1.3.13 PHYSICAL, MECHANICAL, THERMAL AND OTHER PROPERTIES OF HDPE PIPES

The bidder shall provide the certified information (as per BIS) about the properties of PE-100 material as stated in the document for manufacturing the pipes for this project. Density, flexural strength, compressive strength, modulus of elasticity, short term and long term yield value, allowable circumferential stress in pipes intended for 40-50 years of service at normal temperature, volume resistivity, thermal conductivity, specific heat, linear coefficient of expansion, ignition by flame, burning rate, maximum operating temperature (under pressure) and any other properties which may effect the serviceability of pipe at project site.

1.3.14 MARKING OF PIPES

The internal and outer diameter, length, wall thickness, tolerances and other dimensions of pipes shall be as per relevant clauses of IS 4984:1995 (inc. all amendments) and any amendments made to till date. Each straight length of pipe shall be clearly marked and should cover the following:

(a) The manufacturers name and trade mark,

(b) Outside diameter,

(c) IS classification,

(d) Stiffness class

(e) Lot number / Batch number,

1.3.15 HANDLING, TRANSPORTATION STORAGE AND LOWERING OF PIPES

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole. The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

1.3.15.1 Handling

- Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks be used on PE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so permitted by the competent authority before installation.
- Whenever pipes have been transported one inside another, the inner pipes should always be removed first and stacked separately.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.

1.3.15.2 Transportation

- Vehicles for transporting HDPE pipes should have a clean flat bed, free from nails and other projections which might cause damage. When rigid bundles of pipes are being transported, in that case the overall height of the bundles should not exceed 2.5 m.
- Side supports should not be less than 1.5 m apart; they should be flat and have no sharp or rough edges.
- When transporting a mixed load of pipes, it is important that the larger, generally thicker-walled, and thus heavier, pipes are placed at the bottom. Pipes should not be allowed to overhang the vehicle.
- The truck used for transportation of the PE pipes shall be exclusively used of PE pipes only with no other material loaded – especially no metallic, glass and wooden items.

1.3.15.3 Storage

- Pipes may be stored in loose stacks up to a maximum height to 2 m.
- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60^0C.
- When pipes are stored outside in climates having high ambient temperatures (greater than 23 ^{0}C), the following is recommended:

  a) The height of the stacks should not exceed 1 m;

  b) All stacks should be shielded from continuous and direct sunlight and shall be arranged to allow the free passage of air around the pipes;

  c) Specials & fittings should always be stored in boxes or sacks manufactured so as to permit the free passage of air.

- When pipes are stacked in the form of rigid bundles, a maximum of three bundles having a height of 1 m each should be stacked on top of each other.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.

Damages during transit, handling, storage will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost as directed by the Employer's Engineer.

1.3.16 LOWERING, LAYING OF PIPES

Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Employer's Engineer shall be laid. While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same a backfill material. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M15, 15 cm or 20cm thick sand bed as approved by the Employer's Engineer may be provided

As PE pipes are flexible, long lengths of fusion-jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets. During the pipe laying of continuous fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc) and at branch connections.

Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal

(lower temperature times of the day.) For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom. The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved. The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.

The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque. Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint. PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern.

However, weights by way of concrete blocks (anchors) are to be provided so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away. Thus site conditions study is necessary to ensure the avoidance of flotation. Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% maximum dry density.

1.3.17 JOINTING OF PIPES

The pipe shall have a jointing system that shall provide for fluid tightness for the intended service conditions. Appropriate jointing for HDPE pipe as per IS 4984 shall be selected considering site and working condition, pressure and flow of liquids

(i) All joints shall be made as per relevant IS code, in practice, and manufacturer's installation manual or instructions. All joints shall be tested for their performance as per provisions made in relevant IS codes. Joints that show leakage will not be accepted. After backfilling and inspection, if groundwater infiltration is observed through joints into the laid water line, then such joints shall be sealed by the bidder at no extra cost to the owner.

(ii) Pipe surfaces to be joined must be free of dust, dirt, oil, moisture and other foreign material. If required, use of chemical such as dichloro-methane, methyl ethyl-ketone or mechanical cleaner may be carried out.

(iii) Jointing of pipes and fittings shall be done by Electro fusion/ Butt fusion welding to joint two ends of HDPE pipes. ISO 12176-1:1998 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 1: Butt fusion and ISO

12176-2:2000Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 2: Electrofusion shall be followed for the same.

However to join HDPE with other pipe/valves flanges/ mechanical joint compression fittings shall be used confirming to ISO 14236:2000 Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems.

1.3.18 BEDDING, BACKFILLING AND COMPACTION

1.3.18.1 BEDDING

In case of sandy strata no separate bedding is required. However the bottom face/ trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe.

1.3.18.2 BACK FILLING

Backfilling should be placed in layers not exceeding 15cm thickness per layer, and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth fill on each side should not be more to cause lateral movement of pipe. Most coarse grained soil are acceptable. This may comprise of gravel or sand. However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.

It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented. Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

1.3.18.3 COMPACTION

Vibratory methods should be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe should be usually done with hand tempers. The backfill material should be compacted not less than 95% of maximum dry density.

1.3.19 FITTINGS & SPECIALS

Injection moulded HDPE fittings shall be as per IS: 8008 (Part I to IX). All fittings/specials shall be injection moulded at factory only. General requirement of Injection moulded HDPE fittings conforming to IS: 8008 Part I.

1.3.19.1 BENDS

HDPE bends shall be conforming to IS: 8008 Part II Specifications.

1.3.19.2 TEES

HDPE Tees shall be conforming to IS: 8008 Part III Specifications.

1.3.19.3 REDUCERS

HDPE Reducers shall be conforming to IS: 8008 Part IV Specifications.

1.3.19.4 FLANGED HDPE PIPE ENDS

HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VI Specifications. Stub ends will be welded on the pipe. Flange will be of slip on flange type as described below:

1.3.19.5 SLIP-ON FLANGES

Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN10.

1.3.20 WELDING PROCEDURE

Jointing between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with fusion welding using automatic or semi-automatic, hydraulically operated, superior quality fusion machines which will ensure good quality fusion welding of HDPE pipes. If approved by the concerned Employer's Engineer, jointing with PP compression fittings may be carried out for smaller diameters of PE pipes (up to 110mm).

1.3.21 TESTS TO ESTABLISH PORTABILITY OF WORK

Pipe specimen shall be subjected to tests specified below in order to establish the suitability of these pipes for use in carrying potable water:

I) Smell of the extract

II) Clarity of the colour of the extract

III) Acidity and alkality

IV) Global migration UV absorbing material Heavy metals

V) Un-reacted monomers (styrens) and Biological tests

1.3.22 HYDRAULIC TESTING

Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per clause IS code. Hydro pressure testing shall be done on the completed pipe length for a minimum pressure of 1.5 times the designed pressure for retaining period of 4 hours, and as mentioned in IS 4984 – 1995 including its latest amendments. The acceptance criteria for hydrostatic test are no permanent deformation of any part of the pipeline fitting or equipment's and there shall not be any leakage through any of the joints. The hydro testing shall be done in the presence of

Employers Engineer and a report shall be made by the contractor and the same shall be signed by the contractors representative and Employers Engineer and submit the same to Employer after the successful completion of the hydro test.

All the necessary consumables, equipment, tools & tackles required for the testing & inspection shall be arranged by the contractor and no extra cost shall be paid for the same.

Hydro pressure testing has to be done for all the valves as per IS 13095 – 1991 including its latest, at the manufacturer's end and a report has to be submitted to Employer Engineer.

1.3.23 MEASUREMENT

The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. Specials shall be excluded and measured and paid separately under the relevant item. The portion of the pipe at the joints (inside the joints) shall not be included in the length of pipe work. Excavation, refilling, masonry and concrete work wherever required shall be measured and paid for separately under relevant items of work.

Payment shall be made as per relevant items in Payment Schedule

1.3.24 RATE

The rate shall include the cost of materials and labour involved in all the operations described above except for the items measured/enumerated separately under clause Measurements_, which shall be paid for separately.

1.3.25 JOINTING MATERIAL: DETACHABLE JOINTS

1.3.25.1 PUSHON JOINTS

For Push-on joints the rubber ring will be inserted through the chamfered spigot end of the pipe. The two pipes shall be aligned properly in the trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade. A penetration gauge shall be used to check each joint after assembly, to ensure that the rubber ring is properly seated. When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as per the instructions of the manufacturer and approved by the Employer's Engineer. It is important that in making the joint the pipes are maintained in a straight line and the deflection introduced after the joint has been assembled. However, it is preferable that such deflection will not exceed 75% of the permissible deflection at a single joint as stipulated by the manufacturer of the pipe.

1.3.25.2 MECHANICAL JOINTS

Bolts shall be tightened alternately on opposite ends of joint diameter and in rotation around the pipe. When properly assembled the gland shall be equidistant from the socket face at all joints. Under no conditions shall extension wrenches or pipe-over-handle or ordinary ratchet wrenches be used to secure greater leverage.

1.3.26 FLANGED JOINTS

Flanged joint pipes and fittings shall be firmly and fully bolted with machine bolts provided by the manufacturer. Standard flange drilling of flanged pipes and fittings shall be in accordance with IS: 1538. The nuts and bolts to be used for jointing shall be made of MS for size up to 27 x 120 mm and high tensile steel of approved make for higher sizes. Gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber of thickness between 2.5 mm to 3 mm in conformity with IS:3114. The fiber board shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per sqm shall not be less than 12 gram/mm thickness. Slip-on flanges shall be double welded to the pipe with a strength weld jointing the flange hub to the pipe and seal fillet weld inside the flanges at the pipe end. All flanges of the same diameter shall be compatible.

1.4 PROPERTY CONNECTION

Connection to the building shall be through a Electrofusion PP saddle and no direct connection shall be made on the MDPE pipe. This is necessary to prevent leakages and any contamination in the potable water network.

1.5 MS Pipes

This specification covers the requirements for procurement, supply, manufacture/fabrication, transportation, stacking at site of works, laying, jointing, testing and successful commissioning of all welded Mild Steel pipeline, appurtenances, specials, etc., below/above ground, including associated civil works required for the same.

1.5.1 Standards

Submerged Arc welded Hot finished mild steel Bevelled pipes to be manufactured supplied and delivered under the scope of this contract shall be manufactured in accordance and conforming to IS-3589 and/or IS-5504. Pipes shall be applied with Internal & External Protection as per technical specification and as per relevant IS codes (latest revision/amendments).

The following details, standards, and codes are part of this specification. All standards, specifications and codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

Special attention of the Contractor is drawn to the relevant sections and clauses of the National Building Code of India, CPWD specifications and BIS Codes (latest editions along with amendments) and the same should be followed strictly in addition to the specification and conditions stipulated in this section.

If for items for which specifications are not specified in this volume, CPWD specifications and IS specifications shall be applicable and in case of any discrepancy Employer’s Engineer decision will be final and binding.

The following list includes various Indian Standards which are referred to in the specifications and used in construction works. These standards are to be strictly adhered to unless otherwise as

applicable in the relevant context. These standards are to be followed both in respect of materials, equipment's, methods, procedures, etc., and for all the works included in the tender.

It is obligatory that only the latest edition of the standard is referred to and followed, along with all amendments and revisions issued with respect to the standard under consideration. This list is not exhaustive but contains only the standards that are very frequently used in the construction works. If a standard exists for a particular item of material or equipment or code of practice the same shall be followed whether the same is included in this list, specifications, other parts of the tender documents or not. Some Indian Standards are referred to in the specifications/drawings/other parts of the tender documents and they are supplementing this list if they do not find a place in the list.

IS : 2062	Hot Rolled Medium and High Tensile Structural Steel-Specification
IS : 814	Covered Electrodes for manual Metal Arc Welding of carbon and C-Mn steel.
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non- Alloy and Fine Grain Steel. Classification
AWS : A-5.1	Specification for Mild Steel Covered Arc Welding Electrodes.
IS : 3613	Acceptance Tests for Wire Flux combinations for Submerged – arc Welding
AWS : A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding.
IS : 1377 -	Technical Supply Conditions for Threaded Fasteners
IS : 1367	Technical Supply Conditions for Threaded steel Fasteners (Parts 1 to 3).
IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming-specification
IS : 102	Ready Mixed Paint, Brushing, Red Lead, non-setting, Priming.
IS : 816	Code of practice for use of Metal Arc Welding for General Construction in mild steel.
IS : 4353	Submerged Arc Welding of Mild Steel & Low Alloy Steels – Recommendations.
IS : 817	Code of practice for Training and Testing of Metal Arc Welders.
IS : 1182	Recommended practice for Radiographic examination of Fusion -Welded Butt Joints in steel plants
IS : 2595	Code of Practice for Radiographic Testing.
IS : 3658	Code of Practice for Liquid Penetrate Flaw Detection
IS : 5334	Code of practice for Magnetic Particle Flaw Detection of welds.
ASTM E 94	Guide for Radiographic Testing
ASTM E 165	Test Method for Liquid Penetrate Examination.
IS : 3600	Methods of Testing Fusion Welded Joints and weld metal in steel (Parts 1 to 9)
ASTM E 709	Guide for Magnetic Particle Examination.
IS : 4853	Recommended Practice for Radiographic Inspection of Fusion Welded Butt Joints in Steel Pipes.

IS : 3589	Seamless or Electrically welded steel pipes for Water Gas and Sewage (168.3 to 2540 Outside Diameter)
IS : 6631	Specification for Steel pipes for Hydraulic Purposes
IS : 7343	Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products
IS : 2598	Safety Code for Industrial Radiographic Practice
IS : 5822	Code of Practice for Laying of Electrically Welded steel pipes for water supply
IS : 1608	Metallic material-tensile testing at ambient temperature
IS : 9595	Metal Arc welding of Carbon and Carbon-Manganese Steels – Recommendations
IS : 2825	Code of unfired Pressure Vessels
IS : 5504	Specification for Spiral Welded pipes
IS: 10748	Hot-rolled Steel Strip for Welded Tubes and Pipes -Specification

1.5.2 Manufacture, Supply, Delivery & Jointing of MS pipeline

Manufacture, supply and delivery of submerged Arc welded M.S Pipe having beveled ends from Plates/Coil conforming to IS-3589 and/or IS-5504 with its latest revision/amendment with all type of specials, tees, bends & flanges, jointing the pipes with welding in position including hydro testing etc. complete with all taxes, insurance, freight charges, inspection charges, transportation, etc. complete including all labour & materials as per specification and to the satisfaction of Employer's Engineer.

1.5.2.1 Fabrication

Pipe shall be manufactured by continuous process, Spiral Submerged Arc Welding (SAW) facility with on line testing, dust free environment, X-ray, Ultrasonic testing, adequate Hydraulic testing, etc.

The contractor shall get the MS pipe fabrication at well established, proven, having adequate test facility, having pipe coating facility, having valid factory license. The contractor shall propose such manufacturing unit/s for with credentials of manufacturing unit/s approval by the department prior to placement of order. The department shall not be responsible for non acceptance of MS pipes manufactured/ being manufactured in absence of such approval from the department of particular manufacturing unit/s.

In no case manufacturing/ fabrication of MS pipes shall be permitted at site.

This manufacturing unit/s should have the following minimum set-up viz,

Continuous Plate bending machines for rolling.

SAW (Submerged Arc Welding) machine & Automatic welding machines (suitable for circumferential as well as longitudinal welding)- suitable for 1500 mm Dia pipes**.**

1.5.3 TECHNICAL ADVICE

The contractor shall be fully responsible for proper liaison with the department to evolve satisfactory welding procedure for fabrication & erection of pipe manufactured from the plates/coil supplied by them. The contractor on receipt of a request from the department shall without any cost to the department arrange to furnish manufacturer‘s technical details (with up to date instructions Booklet, technical literature etc. regarding any problem concerning fabrication in particular, suitability of welding, consumables weld grooves, design, heat treatment etc.) such advise shall be rendered till the expiry of contract.

1.5.4 ACCEPTANCE OF GOODS

At the time of delivery of materials, the manufacturer will have to provide test results in accordance with IS specification No. IS-2062-2011 or equivalent standard of the MS plates or IS 10748 for hot rolled steel coils supplied along with the challans. The material will not be accepted without test results of the manufacturer. If the test results of the respective lots will be found satisfactory with respect to relevant IS or equivalent standard specification and with no negative tolerance in thickness only then material will be accepted by the department otherwise rejected. Thus in case of non-acceptance and return of materials by the department, the department will not be responsible for the cost of materials and it‘s transportation or any other cost.

1.5.5 INSPECTION, SAMPLING & TESTING

To have the quality assurance of the materials, the Employer’s Engineer may arrange inspection of his third party inspection agency. The material unless inspected, passed and stamped for acceptance shall not be dispatched.

All materials will be subjected to inspection by the Employer’s Engineer, The inspection charges shall be borne by the contractor and are required to be paid directly to the inspection agency. All such incidents will be reported to the Employer’s Engineer in writing within a week. The Contractor shall notify the Employer’s Engineer, in advance of the production of materials and fabrication thereof, in order that the Employer may arrange for mill and shop inspection. The Employer’s Engineer may reject any or all materials or work that does not meet with any of the requirements of this specification. The Contractor shall rectify or replace such rejected material/performed work at his own cost, to the satisfaction of the Employer’s Engineer. The Employer’s Engineer shall have free access to those parts of all plants or any other premises and sites that are concerned with the furnishing of materials or the performance of work

under this specification. The Contractor shall furnish to the Employer's inspector reasonable facilities and space without charge for inspection, testing and obtaining of any information he desires in respect of the character of material used and the progress and manner of the work.

1.5.6 Testing of samples

Three samples shall be drawn per heat or from a lot of HR coils/MS plate whichever is less jointly as above by the Employer’s Engineer and authorized representative of the Contractor. Each sample will be given identification No. and a slip indicating identification No., date of sampling and signature of above representatives should be kept with the samples. Out of three samples drawn one sample will be sent for testing in accordance with relevant IS specifications

by the Inspection team / third party agency to any one of the following laboratories as per testing requirement or any other laboratory as may be decided by the Employer's Engineer.

1 State/ Central Govt. laboratory/ Government Engineering College.

2 State/Central Government/ BIS approved laboratory.

Out of remaining two samples, second sample will be kept by the department and third will be kept by the supplier as reference sample. The test result should be obtained within ten (10) days from the date of sampling positively without fail and furnish to the department duly countersigned by the authorized official of Inspection team/third party agency. The test result should indicate physical and chemical properties of the test samples in accordance with relevant IS specifications. The necessary Inspection & samples testing charges will also be borne by the Contractor. In addition to the above whenever necessary and suggested by Employer's Engineer, API or other relevant standards will be used for testing and collection of samples. The M S plates supplied under this tender should confirm to applicable requirements of the current edition of IS specification No. IS:2062 Grade-B killed quality and IS10748 for hot rolled steel coils.

The Inspection/ Testing note regarding the testing of the plates/ HR coils shall have to be furnished with all relevant test certificates/ documents to the Employer's Engineer and acceptance shall be given, if they are manufactured as per the standards.

1.5.7 Wall Thickness

The Pipe wall thickness shall be 8mm thick. No negative tolerance will be allowed.

1.5.8 Straightness of pipes

Finished pipes shall not deviate from straightness by more than 0.2% of the total length checking for straightness shall be carried out using as taut string or wire from end to end along the side of the pipe to measure, the greatest deviation.

1.5.9 Other Tolerances

As per IS-3589 and/or IS-5504 with latest version (Except for wall thickness). M.S. Pipes shall be welded either longitudinally or spirally. Before fabrication of pipes and specials/fittings is commenced, the copies of the mill sheets and the manufacturer‘s test certificates for plates and other materials required for fabrication shall be submitted by the Contractor to the Employer's Engineer for his approval.

When instructed by the Employer's Engineer, the Contractor shall supply free of charge to the Employer's Engineer for testing suitable samples of the materials to be used/used in the Works.

1.6 PIPELINE GENERAL

1.6.1 Disinfection of Water Mains

The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination

from workmen or their equipment of both and unavoidable foreign material present in the trench during construction.

Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction, relocated if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been completed, disinfection (using, sodium hypochlorite) should proceed by one of the recommended methods as described in the following-

- **Continuous Feed**

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of atleast 20 mg/1. A properly adjusted hypochlorite solution injected into the main with a hypo-chlorinator, chlorinator and if required, booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/1 chlorine residual should remain in the main. The Contractor is requested to provide photo and take a record of the value of chlorine residual at starting point and after 24 hours before completion of work. The Employers Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved. Waste chlorine residual water must be neutralized before it is discharged to any drainage, as per approval of Employers Engineer.

- **Slug Method**

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/1. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical. Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the

authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated and the results again tested before placing the main in service.

If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way.

The area or pipe line to be disinfected shall be fed with chlorine solution from up stream under flowing water condition, and then the area shall be blocked after make sure to reaching more than 20 mg/l. The chlorine solution fed in the pipeline needs to wait for 1 day before starting measurement of residual chlorine. After 3 days later, the chlorine residual value shall be tested at sampling points at up-stream and at downstream near to end to check whether the value is in range or not.

The Contractor shall provide photo and take a record of the value of chlorine residual at starting point and after 24 hours before completion of work.

The Employers Engineer sha`ll jointly check the test at sites. If the value is insufficient, the disinfection work shall be repeated until satisfactory results are achieved.

Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Employers Engineer.

1.6.2 Thrust Blocks

Thrust Blocks shall be provided, to counteract hydraulic thrust, at places wherever necessary by design as well as additional as directed by the Employer' Engineer. The Contractor shall indicate on his detailed drawings where thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawings and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the prior approval of the Employers Engineer.

1.6.3 Flanges

Flanges shall be provided at the end of pipes or special where valves, blank flanges, tapers/reducer, etc. have to be introduced. The flanges received from the manufacturers shall have necessary bolt holes drilled. The Contractor shall assemble the flanges in the exact position by marginal cutting if necessary, so as to get the desired position of the valves, etc. either vertical or horizontal and shall then fully weld the flanges from both sides in such a way that no part of the welding protrudes beyond the face of the flanges. In case the welding protrudes beyond the flanges and if the Employer's Engineer orders that such protrusions shall be removed, the Contractor shall file or chip them off. If required and when directed by the Employer's Engineer, the Contractor shall provide and weld gusset stiffeners, as directed on site.

1.6.4 Blank Flanges

Blank flanges shall be provided at all ends left unattended for the temporary closure of work and also for commissioning a section of the pipeline or for testing the pipeline laid. For temporary closure, non-pressure blank flanges consisting of mild steel plates, tack welded at the pipe ends may be used. For pipes subjected to pressures, the blank flanges or domes suitably designed as per Employer's Engineer's requirements shall be provided.

1.6.5 Flanged Pipes

The gaskets used between flanges of pipes shall be EPDM of min 5 mm thk. Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternately. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

1.6.6 Special Foundation in Poor Soil

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings to be prepared by the Contractor and as instructed by the Employers Engineer shall be constructed.

1.7 Valves : General

Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN 10. Valves shall have integral flanges drilled as specified in BS 4504 where applicable. Flanges to other standards shall be used only if approved and provided that any differences do not affect mating dimensions. Back faces of flanges shall be machined. Sluice valves and butterfly valves shall be suitable for flow in either direction.

Sluice valves shall comply with IS 14846 or BS 5150 or 5163 as appropriate

Butterfly valves shall comply with IS 13095 or BS 5155 / AWWA-C-504/1980

Reflux/check valves shall conform to IS 5312 -1986/2007 or BS 5153

Valves shall be suitable for frequent operation, and for infrequent operation after long periods of standing either open or closed.

Rubber used in valves shall be ethylene propylene rubber (EPDM or EPM) or styrene butadiene rubber (SBR). It shall comply with the requirements of IS 13095 or Appendix B of BS 5155, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

1.8 Sluice valves

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-40, 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 burried 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-P · it is a resi-coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C). The valves should be should be with electric actuators along with gearbox arrangement and SCADA system remote operations.

1.8.1 Material of Construction

Body, Bonnet	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12
Wedge (fully rubber encapsulated)	Ductile Iron GGG 40 (EN-JS- 1030) / Spheroidal Graphite Iron IS: 1865 Gr 400/12 encapsulated with EPDM rubber - W270 approved grade.
Spindle/Stem	SS: IS: 6603 12Cr13/22Cr 13;AISI 410/AISI 420
Stem Nut	Brass
Bonnet Gasket	EPDM rubber - W270 approved grade
Internal Fasteners	Stainless Steel SS316/304
Stem Sealing	Toroidal NBR sealing rings (Min 03 _O‘ Rings)
Coating	Inside & Outside epoxy powder coated; DFT minimum 250 micron, shade RAL 5005 (BLUE)

1.9 Butterfly valves

Manufacturing, supply and delivery DI D/F Resilient Seated Vacuum tight Butterfly Valve suitable for bidirectional flow with Body and disc made of DI GGG40. Disk shall conform to double eccentric with specially designed (Dove tail Shape) pressure supported sealing system made of EPDM approved by DVGW Clause W270. The Body seat shall be fusion bonded nickel chromium weld overlay and micro finished. Closed Disk Eye with dry shaft design made of Stainless steel with 13% chromium of grade 1.4021 connected with Medium free bearing of Bronze with double O-ring sealing of EPDM. The shaft shall be connected to the disc by riveted pin or taper pin with lock. The Valve shall be compatible for Buried application without chamber. The Coating and the rubber parts shall comply with DVGW and KTW standards. The gearbox shall be with self-locking, fully enclosed, maintenance-free lubricated for life, worm gear including mechanical position indicator. The Valve shall be according to EN593/IS 5163, the face-to-face length shall be EN 588-1, basic series 14/BS 5155(Long Body)/ IS13095 (Long Body) and drilling according to EN 1092-2/IS 6418. Epoxy Powder or liquid Epoxy coating with minimum thickness of 250 micron applied inside and outside of both body and disc. it is a resi-coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 deg C). The valves should be capable of integration with electric actuators and SCADA system remote operation.

1.9.1 Material of Construction

Body	Ductile iron to EN-JS 1030 (GGG-40)
Disc, Retainer Ring	Ductile iron to EN-JS 1030 (GGG-40)
Shaft	Stainless Steel 420 with 13% chromium (1.4021)
Shaft Bearing Bushes	Bronze
Seat	Integral Ni-Cr weld overlay, (Ni > 67% Cr = 19.5 %) micro-finished
Disc Sealing & O‘ rings	EPDM Rubber [W 270 Clause]
Surface Protection	Epoxy powder coating or epoxy liquid lacquer min. 250 microns thickness, colour RAL 5005 Blue

1.10 Electric Actuators

Actuators shall be suitable for the medium, climatic, environmental and pressure conditions of the system in which they are to be fitted. Actuators shall be provided with:

- AC Electric Motor.
- Reduction gear unit.

- Torque switch mechanism.
- Limit switch mechanism complete with set of limit switches and additional two spare sets for suitable position.
- Hand wheel, for manual operation.
- Valve position indicator.
- Hand-auto lever with suitable locking arrangement.
- 10 W single phase space heater in the switch compartment.
- Blinking light throughout the valve operation.
- Junction box for terminating power and control cables.
- With additional accessories for integrating with PLC system.
- Compatibility with SCADA

The actuator shall be suitable for operation on 415V, 3 phase, 50 Hz power supply. The motor winding insulation shall conform to class B as per relevant BS and motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1 1/2 times the required operator torque at the required time cycle of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at actuator end and one at valve end with universal couplings at suitable places. The required numbers of switch/contacts meet requirements for PLC system.

The electric motors shall be of the squirrel cage type as per IS 325 with insulation to IS 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 15 minutes. They shall also be suitable for operating on the specified electric supply and shall satisfactorily open and close the valve under variations of electric supply specified.

Motor shall be protected by suitable overload protection device.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating fed from a 110 Volt control transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be of 650/1100 volt grade PVC insulated stranded copper conductor of minimum 1.5 sq. mm for control circuits and of minimum 4 sqmm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC insulated/ sheathed, armoured cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose proof to IP 67 and shall be fitted with an anti-condensation heater, which shall be switched off when the motor is running.

The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed.

The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during the opening cycle or when the valve is fully open.

The mechanism shall facilitate adjustment of the torque at which the switches are required to operate.

Non-adjustable limit switches shall stop the motor and give indication when the disc has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired value position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to give an indication whether the valve is fully open, fully closed or in an intermediate position.

Settings and emergency operation shall be possible with the use of a hand wheel. The Hand wheel shall be of stainless steel and the drive mechanically independent of the motor drive and any gearing should limit the operating torque at the hand wheel to less than 15 kg and be such as to permit emergency manual operation in a reasonable time. During electric operation the hand wheel shall not rotate.

Actuators shall be adjusted at the manufacturer‘s works to ensure that they provide the correct, fully, open position and fully closed position. Mechanical adjustable stops shall be provided to prevent over-travel of the valve in the open and closed positions.

1.11 Kinetic Air Valve

The valve shall be capable of exhausting air from pipe work automatically when been filled. Air being released at a sufficiently higher rate to prevent the restriction of the Inflow rate. Similarly the valve shall be capable of ventilating pipe work automatically when being emptied. The air inflow rate being sufficiently high to prevent the development of a vacuum in pipeline. The valve shall automatically released air accumulating in pipe line work during normal working condition.

Air valve shall be of double orifice type with a large orifice for ventilation for exhaust of the pipeline and small orifice for release of air under working pressure. The valve shall be suitable for maximum working pressure in the system. All air valve shall be provided with isolating sluice valve and flanged end connection.

Air valve shall be design to prevent premature closure prior to all air having been discharge from the line. The orifice shall be positively sealed in the close position but float (Ball) shall only be

raised by the liquid and not by mixer of air and liquid. The sealing shall be design to prevent the floats striking after long period in the close position.

All branched outlets including outlets for Air valves will be with compensation pads (Dia of Main For branch Dia ratio greater than 3). Diameter of compensation pad will not be less than 1.75 times the O.D. of the branched outlet. Plate thickness for pads will be same a that of the main.

For outlets with above ratio less than three, then the joints will be of plate reinforcement type.

The aperture of valves must be properly designed for which the contractor shall submitdesign calculations for necessary approvals before the procurement of valves.

The air valve should be as per IS: 14845 of minimum PN 1.0 rating.

All branched outlets including air valve tee‘s will be provided with one 15mm BSP coupling duly plugged for measurement of pressure in due course. The closing plug will be in Stainless Steel (AISI 304 or equivalent) with Hex. Head. and will be provided with copper washer for sealing.

All flanges will be drilled as per I.S. 1538.

The gaskets shall be of nitrile rubber.

1.12 Spring Loaded Dual Plate Check Valve

The valve shall be of flanged type suitable for mounting on a horizontal pipeline.

Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

Dual plate check valves conform to API 594 and API 598. They shall have resilient sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition.

The minimum body-wall thickness shall conform to those given in Table 1B of API Standard 594.

The face-to-face dimensions of valves (including valves with ring-joint facings) shall conform to those mentioned in Table 2B of API Standard 594.

The spring of the valves shall be of SS 316 or better grade SS to ensure long life of valves up to at least 100000 cycles. The spring cycle test will be performed at manufacturer‘s works to confirm the quality.

The valves shall be of minimum PN 1.0 rating.

The valve body shall be furnished with a clearly visible cat, forged, machined-in, or die- stamped arrow to indicate the direction of flow through the valve.

1.13 Dismantling Joints

DI 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.

1.14 Ball Valves

Ball valves shall conform where applicable to IS 9890-2003 or BS5159.

Multi-piece bodies shall be used where work on the ball and seats when installed may be needed. If valves need removal for servicing, one-piece bodies may be used.

Seat materials shall be chosen for long life, with erosion and corrosion resistance. `

Ball supports shall be of the floating ball or trunnion type. If line pressure is too low to ensure a positive leak-free seal, built-in seat loading devices, or specially shaped seatings shall be used to ensure sealing

1.15 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. 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.

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 a V-Port Throttling Plug by bolting.

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.

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.

Valves shall be capable of maintaining a constant downstream pressure from a higher upstream pressure and they shall be drop-tight under no-flow conditions.

A pressure gauge shall be provided to indicate downstream pressure over the operating range of the valve. Valve operation shall be controlled by the interaction of the inlet pressure, outlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.

The pilot valve or relay system shall be actuated by a diaphragm connected to the outlet pressure on its underside and a constant pressure on its upper side, derived either from weights or from a spring.

Valves shall be flanged and drilled to BS 4504 for the operating pressure required.

1.15.1 Material of Construction

Component	Material
Body and cover	Cast iron
Internal valve	Gunmetal with bronze liner, cups and facing rings in leather
Relay valve	Bronze with stainless steel shaft and nylon valve face
Diaphragm	Reinforced synthetic rubber
Loading spring, If employed	Spring steel
Cylinder & weights, If employed	Cast iron
Lever	Steel with gunmetal pins and links

Connecting pipe work to cylinder	Copper
Cylinder	Mild steel epoxy lined with internal working parts gunmetal bushed

1.16 House Connection

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 Brass 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 Employer's Engineer including cost of required specials. Drilling charger, hydraulic testing, maintaining the same for the period under O&M. The house connection shall be provided with meter box with Weather resistant PE/ GRP box, press fitted Lid fixing & locking and locked with built-in or external lock.

1.17 Valve Chambers

All valve chambers shall be of an adequate size to facilitate ease in maintenance and operation. The base slab of valve chambers shall slope towards a cut-out in the slab which shall be filled with gravel so that water can percolate inside the ground and keep the chamber dry. All valve chambers shall be constructed in reinforced concrete. Minimum thickness of the base slab shall be 150mm. Chambers shall be equipped with removable SFRC covers, approach ladders/ rungs and valve supports as appropriate.

PART B - GENERAL MECHANICAL REQUIREMENTS

1.1. Introduction

This part of the Employer's Requirements sets out the general standards for mechanical equipment to be provided by the contractor within the existing pumping stations. Reference to any specific item does not necessarily imply that such plant is to be included in the Works. All machinery/ equipment used for the Works shall, unless otherwise specified, comply with the provisions of this chapter and shall always conform to the latest applicable codes and standards.

All pumps shall be energy efficient pumps with VFD drives.

1.2. CODES AND STANDARDS

The design, manufacture and performance of the pumps specified herein shall comply with the requirements of the applicable Codes and Standards, as follows, but not limited to

Sno.	Standard	Title
1	IS 6595 (Part II)	Horizontal centrifugal pumps for clear, cold and fresh water.
2	IS 9137	Code for Acceptance Tests for Centrifugal, Mixed flow and Axial pumps.
3	IS 13537	Standards of the Hydraulic Institute of USA.
4	ISO 5199	Balancing of impeller.
5	ISO 2373	Performance test of pumps
6	IS 5120	
7	IS 11732	

1.3. Features of Construction

1.3.1. IMPELLER

The impeller shall be an enclosed impeller, made in one piece and securely keyed on the shaft. The installation will include means to prevent loosening of the impeller during operation, including rotating in the reverse direction. The impeller shall be statically and dynamically balanced to prevent vibration, as per ISO 2373.

1.3.2. CASING RING

The pump shall be provided with a renewable type casing ring, to offer wearing resistance. Hardness of the casing ring shall be 50 BHN (Brinell Hardness Number Units), lower than the impeller ring.

1.3.3. IMPELLER RING

The pump impeller shall be provided a renewable type impeller ring on both ends. The material of construction of these rings shall be similar to that of impeller and these shall be hot push fit on impeller. The rings hardness shall be equal to impeller and 50 BHN more than the casing rings.

1.3.4. SHAFT

Single integral shaft, shall be designed to withstand the torque loads throughout the whole range of operating conditions, for the selected particular impeller diameter as well as all the impeller diameters covered between minimum and maximum impeller diameters when coupled to the motor shaft through flexible coupling. The shaft design should also include the possibility of running the pump with an electric motor of higher power rating meant for future expansion with increased impeller diameters.

1.3.5. SHAFT SLEEVES

Replaceable shaft sleeves shall be provided to protect the shaft where it passes through stuffing boxes. The end of the shaft sleeve assembly shall extend through the packing gland. Shaft sleeves shall be securely locked or keyed to the shaft to prevent loosening. Shaft and shaft sleeve assembly shall ensure concentric rotation.

1.3.6. STUFFING BOXES

Stuffing boxes at driving end and non-driving end shall be of such design that they can be re-packed, without removing any part, other than the gland and lantern ring. An axially split gland should be used to facilitate changing the gland packing. Sufficient space shall be available for maintenance purposes.

1.3.7. AIR RELEASE VALVES

Pump shall be provided with arrangement of valve to vent air, which may get accumulated in the pump.

1.3.8. SEALING

Self-sealing water connections should be provided.

1.3.9. FLANGES

Flanges shall be machined flat, with flange faces vertical and at right angles to the pump mounting surface. Cast iron flange drilling and thickness shall conform to IS 1538, (part IV and VI) for ID upto 1500mm and to IS 6392 for ID greater than 1500mm.

1.3.10. BEARINGS

Bearings shall be either grease or oil lubricated and should absorb the radial and axial thrusts, under all operating conditions. Anti-friction bearing shall be of standard type and shall be selected to give 20,000 hours continuous operation at rated operating conditions. The rise in bearing oil/grease temperature with continuous running of the pump shall be

within the allowable limits which shall not exceed 20°C for grease and 30°C for oil lubricated bearings above ambient temperature. Cooling arrangements shall be provided if required. Bush bearings will not be acceptable.

1.3.11. BASE PLATE

The common base plate for pump and motor shall be fabricated from mild steel sections and have sufficient rigidity to resist vibration and distortion. Suitable holes shall be provided for grouting and they shall be so located that the base will be able to be grouted in place, without disturbing the pump and motor. All pumps and motors shall be properly and accurately aligned, bolted and doweled to the base plate. Adequate space shall be provided between pump drain connections and base plate for installation of minimum 20 mm diameter drain pipe. Foundation bolts shall be complete with nuts and flat and shake proof washers.

COUPLING

A flexible pin bush type coupling shall be provided, duly bored and keyed to the pump and motor shafts.

The coupling and the pump shafts have to be designed so that the breaking load of the coupling system is slightly below that of the shaft.

1.3.12. ACCESSORIES

All specified accessories and any other standard accessories required for correct and safe operation of the pump shall be furnished with the pumps. All incidental piping (including valves) required for sealing, lubrication and cooling of stuffing box packing and/or pump bearing shall be furnished by the Contractor.

A mild steel fabricated coupling guard shall be provided to provide a safeguard against the open rotating parts of the pump and motor.

Eye bolts (as many as required for safety), shall be provided for ease of lifting and installation.

1.4. TECHNICAL PARTICULARS

1.4.1. MATERIAL OF CONSTRUCTION

MATERIAL OF CONSTRUCTION		
1	Casing	Cast Iron IS: 210, Grade FG260
2	Gland	Cast Iron IS: 210, Grade FG260
3	Impeller Material	Stainless Steel, AISI CF8M
4	Wear Rings/Interstage rings	Phosphor Bronze
5	Shaft	Stainless Steel SS410
6	Shaft Sleeve, Neck ring	Bronze
7	Packing material	Graphite Asbestos
8	Base plate	MS with Epoxy coated

9	All Fasteners including anchor bolts, foundation bolts, washers, nuts, etc. in both wet and dry areas.	Stanless Steel SS316
Note:	**Material Test certified shall be provided for all components**	

1.4.2. Drive Data

Sno.	Motor	TEFC Squirrel Cage Induction Motors, Foot mounted, IP:55 protection, continuous rated with Class "F" insulation confirming to IS: 325, suitable for site conditions and temperature of 50° C

1.5. Documents required from pump supplier during detailed engineering stage

During detailed engineering the Bidder shall submit the following:

- Complete filled up Technical Data sheet of Pump and motors provided with PR.
- Performance curves of individual pumps @ 50Hz frequency superimposed on system curve at rated rpm.
- Performance curves of individual pumps @ 53Hz frequency superimposed on system curve at rated rpm
- Pumps General arrangement drawing
- Foundation Detail arrangement
- Pump Cross section drawing
- Motor technical data sheet
- Motor performance curves
- Motor General arrangement drawing
- Motor cross section drawing
- DRIVER TORQUE VS SPEED SUPERIMPOSED ON LOAD TORQUE VS SPEED CURVE
- SPEED VS CURRENT
- WITHSTAND TIME VS MOTOR CURRENT
- EFFCIENCY VS % OF LOAD
- POWER FACTOR VS % OF LOAD
- TERMINAL BOX GA
- RESISTANCE VS TEMPARATURE

1.6. Accessories and scope of supply

The supply of pumps and accessories shall include the following but not limited to

- Pumps complete with casing and volute assembly and impeller, Motor, shafts, Shaft sleeves, Gland packing, Bearing assembly, Coupling, Coupling guard, Base plate,

Foundation bolts, fittings, Fasteners, Inserts, Name plates, Companion flanges etc. complete for successful commissioning of pumps.

- Consumables, Commissioning spares, lubricants, Mandatory spares, surface preparation, painting, shop testing, site testing, shop testing facilities
- Compound and Pressure Gauge: 150/200 mm Dia. of suitable range with stainless steel connecting pipes, gooseneck, cocks etc. complete.
- Priming Cock.
- Suitable piping for collection and leading off gland leaks etc. up to discharge point. Priming Cock.
- At least one working and one standby unit of vacuum pump + motor of suitable capacity and rating for priming arrangements of main pumps complete with all piping accessories and connection and potable water tank.

1.7. Pump Performance Guarantees

The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work and shall obtain approval of Engineer.

The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.

Each pump shall be tested at the manufacturer's factory in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.

This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

Where similar drive shaft arrangements have been installed by the Contractor and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the Engineer.

A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

Sufficient readings shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have Engineer’s approval. The Contractor shall have Engineer approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2 m less than the NPSH available under all working conditions.

In the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall take approval of Employers Engineer.

Test Certificates in duplicate shall be submitted to the Engineer immediately following each of the tests mentioned above. Performance curves shall also be incorporated in the Operation and Maintenance Manual.

(a) Single Pump Operation

(i) Head/quantity curve

(ii) Motor kW input/quantity curve

(iii) Overall efficiency/quantity curve

(iv) NPSH required/quantity curve

(v) Vibration and Noise dB (A) levels

(b) Parallel Pump Operation

(i) Head/quantity curves

(ii) Motor kW input/quantity curve

(iii)Overall efficiency/quantity curve

(iv) NPSH required/quantity curve

(v) Vibration and noise dB(A) levels

1.8. Electrically Operated Hoists

Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.

Electric hoists shall conform to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section.

Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 a wires per strand with minimum ultimate tensile strength of 1.6 x 106 KN / Sq.m.

Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch.

Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

1.9. Hand Operated Hoists and Trolleys

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

1.10. Manually Operated Travelling Crane

The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. Steel used shall be tested quality steel conforming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. They shall be double flanged type. The wheels shall have antifriction ball/roller bearings. The wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and

rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied by the Contractor.

Trolley and Chain Pulley Block

The chain pulley block shall be operated on the lower flange of the bridge girder.

The load chain shall be made of alloy steel as per IS: 3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

The hand chains for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. The hand chain wheel shall be made from pressed sheet steel and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS: 4460.

The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or C.I. and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

The travelling trolley frame shall be made of rolled steel conforming to IS: 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. The two side plates shall be connected by means of an equalising pin.

Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. They shall be of single hook type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per BS: 2903/IS: 3815

The brake for the lifting gear shall be automatic and always in action. It shall be of screw and friction disc type self-actuating load pressure brake. Brakes shall offer no resistance during hoisting.

Ratchet and Pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness.

1.11. Fire Extinguishers

Portable fire extinguishers are to be provided at all pumping stations as per the requirement of Tariff Advisory Committee (TAC) and/or meeting the requirement of local regulations whichever is stringent.

All the extinguishers shall have ISI mark / TAC approved.

1.12. Exhaust Fan

The fan should comply with IS: 2312.

The blades shall be of mild steel and properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a bird cowl for protection.

PART - C - SPECFIC SPECIFICATIONS AND STANDARDS FOR ELECTRICAL

2 Electrical Requirements

- All electrical requirements for the complete sewage treatment system including common effluent treatment plant shall be provided by the Contractor
- The equipment shall be supplied with local control panels, all electric motors, limit switches and proximity switches necessary for the safe and efficient manual and automatic operation
- The connections for all electrical equipment supplied shall be wired to the local control panel. All electrical sensors used shall be sealed switches of the inductive proximity type suitable for a wet corrosive environment
- All electrical works and all electrical motors supplied shall meet the requirements of appropriate Indian Standards or British standard.
- All design of electrical, instrumentation, monitoring and control system works shall incorporate an analysis of the personnel and equipment protection requirements. The level of protection to be provided shall be determined through a formal hazard identification and analysis process involving design, operations and maintenance personnel.
- Unless otherwise prescribed in this specification, building service shall be designed, procured, delivered , erected installed, tested and commissioned by the designated contractor to comply with the requirements stipulated in latest version of standards.
- It is not intended to cover all aspect of system design but to indicate the basic requirements only. Contractor shall ensure that detailed design and installation is carried out as per good engineering practices and shall meet requirements of safety, reliability, ease of maintenance & operation, aesthetics, scope for future expansion and maximum interchange ability of the equipment.
- The equipment and accessories shall be complete in all respects and any device not included in this specification but essential for proper operation of the plant shall be deemed to be within the scope of this specification whether specifically mentioned or not.
- It is the responsibility of the Contractor to visit and assess the site conditions for the purpose of this work.

I. Codes & Standards

The electrical equipments and complete installation offered shall comply with the relevant Indian Standards / Codes of Practices, this specification, statutory regulations and sound engineering practices.

The complete system shall conform to the latest revisions of the following:

- The Indian Electricity Act & Rules.
- The Indian Electricity (Supply) Act, 1948.
- Indian Standards.
- Regulations laid down by local statutory authorities and CEA / Electrical Inspectorate.
- The requirement of State Electricity Board.
- Fire advisory Committee Insurance Act / Fire Insurance Regulations
- IS 8623 : Factory built assemblies of switchgear
- IS 2675 : Specification for Distribution boards
- IS 4237 : General requirement for switchgear and central gear for voltage not exceeding 1000 volt.
- IS 4064 : Specification for heavy duty Air break switches.
- IS 2147 : Degrees of protection provided by enclosure for low voltage switchgear
- IS 375 : Specification for marking and general arrangement for switch- gear, bus bars, main connection and auxiliary wiring .
- IS 159 : Bus bar & Bus bar Connections
- IS 2516 : Specification for A. C. circuit breakers
- IS 1248 : Electrical indicating instruments
- IS 2705 : Current Transformers
- IS 2959 : A.C. contactors for voltages not exceeding 1000V
- IS 722 : Energy Meters

Obtaining approvals from statutory authorities for materials, plant design / drawings and complete installation shall be the responsibility of the contractor. The contractor shall get the approval from local electric supply company and Chief Electrical Inspector, wherever necessary.

Wherever Indian Standards do not exist, the relevant IEC, British or German (VDE) / IEEE / NEMA standards shall apply. Any other Standard which is considered equivalent to or superior than applicable Indian Standards may also be acceptable. The Tenderer however, shall have to substantiate equivalence or superiority.

2.1.1 Site / Ambient Conditions

All electrical equipment and installation shall be designed for the tropical climatic conditions and be suitable continuous operation under the site conditions as described below for design purpose:

- Maximum ambient temperature : 50 ° C
- Minimum ambient temperature : 3 ° C
- Design Ambient temperature : 50 ° C
- Relative humidity : 95%
- Climate : Tropical, dusty, Corrosive

2.1.2 Power Supply & Distribution Conditions

Available Power Supply By Client: 1 No. Power supplies cables of 11KV 3Ph, 4 wire, 50Hz shall be made available to the Contractor at the incomer of New Transformer yard/ HT panel.

Squirrel Cage Induction Motor, TEFC, IP-55, Continuous Duty (S1) rating, as per 325 and other relevant IS specification. Motors shall be Energy Efficient

The motors shall be suitable for outdoor installation with tropical insulation and Weather Proof to IP-55 as a minimum. All motors shall be started and stopped by push buttons at Local Control Stations located near respective motors. Starters shall be housed in PMCCs / MCCs with STOP / OVERLOAD Reset Push Button. Motors of rating 30KW and above shall be provided with ammeter at respective LCS. Motors of rating less than 7.5 KW shall be provided with Direct-On-Line starting provision unless otherwise specified and motors of rating 7.5 KW and above shall be provided with fully automatic Star/Delta Starters.

In outdoor areas cables shall be mostly buried directly underground with mechanical protection wherever applicable. In indoor areas, cables shall be laid in trenches through fabricated cable trays. Cables shall be so selected that voltage drop at consumer end does not exceed 3 to 4%. Cables having aluminum conductor shall not be less than6 sq.mm.

2.1.3 Maximum Voltage Drops

The maximum voltage drops in various sections of the electrical system under steady state conditions at full load shall be within the limits stated in the following table

System Element	**Max. Permissible Voltage Drop**
Cable between PMCC/PMCC and MCC or auxiliary switch board I) Aux Switch board near PMCC/MCC II) Aux Switch board situated remote	0.5%

from PMCC/MCC	2.0 – 2.5 %
Cables between PMCC/MCC and motors	3%
Cable between auxiliary switchboard and Lighting Panel	1-1.5%
Cable between lighting panels and lighting points	4%

During starting of heavy equipment the voltage may drop by a maximum of 15% for period of up to 45-60 seconds depending upon the duty of the driving equipment. All the electrical equipment shall, therefore, be suitable for trouble free and uninterrupted operation even during such voltage variation at the time of starting of heavy Equipment's.

2.1.4 MCC Room:

MCC room, wherever required shall be located in a safe area close to load centre. The building shall be sized to take care of present and future needs and to maintain adequate clearances between equipment for ease of maintenance. Clearance around equipment shall be maintained as per IE rules and equipment supplier's recommendations, whichever is higher. The minimum clearances shall be as follows:

Front clearance for all Sw. board panels	2000 mm
Rear clearance for panels requiring maintenance from rear	1500 mm
Side clearance between two switch-boards or from nearest obstruction	1500 mm (But not less than twice the width of each panel)
Wall mounted equipment from clearance	1000 mm
Vertical clearance measured from - Bottom of roof slab - Bottom of lowest roof beam	 1000 mm 500 mm

Battery Banks shall be located in a MCC Room with adequately

PART D – AMR METERS

AMR Ultrasonic Domestic Water Meters

Ultrasonic Automatic meter reading water meters are proposed to be installed under this contract. The contractor has to provide AMR meter with fixed network so that meter readings could automatically be read from the central control center. The water meters shall have the anti – magnetic properties / immunity, as specified in ISO: 4064 – 2014, when tested with385 mTeslato 400 m. Tesla magnet test is mandatory. The AMR trans-receivers shall be used (RF End units/ Wireless RF transmitter/Receiver) for communication and remote reading. The AMR system shall have facility to detect the reverse flow in water meters.

The AMR system shall have the facility to record the abnormalities like application of very high consumptions, water leakages etc. along with necessary alarms in HHU and in software The battery life of AMR water meter shall not be less than 10 (Ten) 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 and alert for replacement of battery if warranted of AMR water meter shall be displayed / indicated on HHU.

The AMR meters shall be capable of provide accurate readings, with no air measurement, no mechanical parts, no maintenance and longer life. The Least count shall be 2 ltr./ hr. flow. There shall be no reverse flow deduction in reading if the flow of water is reversed.

The manufacturer shall specify the frequency of the AMR operating system & shall possess the necessary license of said operating frequency, as per norms of Department of Telecommunication, Govt. Of India issued by Government of India (GOI) / Department of Telecom (DOT). The cost of the same will be presumed as included in the quoted price bid. In case, if bidder claims frequency of the operation in the free band, necessary documents / clearance from GOI / DOT shall be submitted, along with the offer. However, the Employer reserves the right for acceptance of offered frequency & Power subjected to the guidelines issued by DOT / WPC

The meters shall have Smart alarms for Leak, Burst, Dry, Reverse, Tamper etc..

TECHNICAL SPECIFICATIONS:

1. A battery operated inline Ultrasonic water meter with no moving parts.
2. Battery operated meter with a battery life of minimum 10 years. The life of battery of AMR water meter shall not be less than 10 years from successful installation of said AMR water meter along with its AMR system
3. Meter must comply to IP68 for indoor and outdoor operation, including fully submerged installations
4. The meter should be type approved and verified according to international water meter Standard OIML R 49 and or ISO 4064. The meter should be MID approved.
5. Accuracy Class 2 – +/-2% or better over typical operating range and temperatures. The Ultrasonic water meter should maintain its accuracy over its lifetime.
6. 3-Point calibration with calibration certificate available for each unit.
7. Dynamic Range (Q3/Q1) of Minimum of 100:1.
8. The water meter body shall be made of corrosion resistant material like brass, bronze, stainless steel, carbon steel or Engineered plastic.
9. Working pressure of ≤ 16 bars.
10. Environmental Temperature of 0 degree C to 50 degree C

11. The meter should be tamper proof with suitable data protection of calibration and revenue parameters.
12. The smart meter should have advanced diagnostics with active alarm(s) indicated on display
13. Display with ≥8 digits for main information. Index, menu and status symbols for dedicated information
14. The measuring units should be m^3 for volume
15. The Ultrasonic water meter should have inbuilt remote reading capability using point-to-point RF.
16. Tampering, Burst, Leakage etc.
17. The water meters shall have the anti – magnetic properties / immunity, as specified in ISO-4064:2005, when tested with 4000 gauss magnet. The AMR system shall remain unaffected with application of 4000 gauss magnet, as specified in ISO-4064:2005.

Meter Reading

1. The meters shall be read automatically from the central control centre with the help of fixed network.
2. The meter should be provided with remote Data collector / Concentrator with aerial / panel antenna for outdoor installation, 2G/3G/4G modems necessary Cabinet & Extra antenna wire for Outdoor installation, 4) Android app / Cloud base Meter Reading Software
3. The data concentrator/ collector should be capable of reading a minimum of 1000 households each and suitable number of signal repeaters shall be provided for areas with weak network without any additional cost to the employer..
4. The device shall show exact physical location of water meter on GPS Map as per location (coordinates) entered into the system after meter installation.
5. The Meter Reading software should display clearly active alarms for each meter.
6. The Meter Reading software should have capability to store full customer and meter information for each meter.
7. The Meter Reading software should be able to display the statistics of the reading route, including but not limited to read meters, unread meters,
8. The data transfer from the meter to the-reading software shall be via GSM/ GPRS.
9. The software shall alert the meter reader for unread accounts in a specific area.

AMR System:

1. The remote readings of AMR water meter should be obtainable by Fixed network' method.
2. The AMR trans-receivers shall be wireless and have IP 68 protection category i.e. no ingress of water after submerging AMR water meter
3. All AMR readings shall show the date and time of the reading recorded.
4. The AMR device of the water meter shall be tamper proof.
5. Meter manufacturing company will assure that the frequency is FREE TO USE and necessary documentation with Department of Telecom is available at the time of bidding the tender. The bidder shall submit necessary documents with the proposal.

6. The water meters fitted with AMR shall have the facility to transmit reading in submerged condition & the remote readings should be obtained with water meter in submerged condition
7. The AMR system should retrieve required data from every meter without reduction in battery lifetime and/or reading speed.
8. The AMR meters and all its related ancillary equipment shall be provided by the same manufacturer so that compatibility issues are not encountered.

AMR Software:

1. The software shall give output, at least in the CSV (Comma Separated Value)/txt/xls format
2. The software shall allow the PC operator to review and edit any account in AMR software database. In addition, the PC operator shall be able to generate groups as per zones or areas and activity reports.
3. The software shall alert the meter reader for unread meters.
4. The software shall enable the user to select the data for export from the database for transferring to billing system.
6. The software shall upload routes from the reading device through GSM/GPRS.
7. The software shall post the reading from the reading device onto appropriate accounts within the database.
8. The software should be able to display reading data on screen.
9. The software should manage GPS data of AMR Meters.

Specifications

1	Measuring Principle	A Battery operated in line non-Intrusive Ultrasonic water meter with no moving parts.
2	Power Supply	Battery operated for the sensor and calculator with a battery life of minimum 10 years to ensure recording at all times.
3	Meter Life time	Minimum 10 years
4	Protection Class	Must comply to IP68 Standard for indoor and outdoor operation, including fully submerged installations
5	Approvals and certification	The meter should be type approved and verified according to international water meter Standard OIML R49 and or ISO 4064.The meter should be EEC/MID approved. The bidder should provide a signed type approval certificate from FCRI
6	Accuracy	+/- 2 % or better over typical operating range and temperatures. The Ultrasonic water meter should maintain its accuracy over its life time
7	Calibration	3-Point calibration with calibration certificate available for each unit.
8	Dynamic Ratio(Q3/Q1)	Minimum of 100:1.See table1 of Ultrasonic water meter sizes and measuring range.
9	Material	The water meter body shall be made of corrosion resistant material like brass, bronze, stainless steel or carbon steel.

10	Pressure Rating	Pressure Rating of > 16 bars
11	Environmental Temperature	0 degree C to 50 degree C
12	Lockable Cabinet	Suitable as per Meter size & site conditions.
13	Connectors	Flanged connections
14	Data Protection and tamper proof	The meter should be tamper proof with suitable data protection of calibration and revenue parameters.
15	Self-diagnostics for error detection	The smart meter should have advanced diagnostics with active alarm(s) indicated on display.
16	Access to information	Display with.> 8 digits for main information. Index, menu and status symbols for dedicated information.
17	Measuring Units	The measuring unit should be m3 for volume.
18	Facility for Remote Communication interface	The Ultrasonic water meter should be configured with battery operated remote reading capability using point-to-point RF.
19	Installation	The water meter shall be approved for Class B installation in both the horizontal and vertical installation positions.
20	Facility for Remote Communication interface	The ultrasonic water meter should be configured with battery operated remote reading capability using point-to-point RF.
21	Remote Reading	The meter should be a complete and integrated with remote reading via fixed Wireless network. The data Communication from the meters shall comply with the European standard on wireless M- bus Communication. The frequency used shall be de-licensed band frequency in India as per Govt. of India regulations."

Warranty

All the supplied smart water meters, their peripherals and equipment, etc., must have a written warranty from the manufacturer covering not less than 10 years from the date of commissioning.

Maintenance liability

All the installed smart water meters, their peripherals and equipment etc. will be subject to a defect liability period of 10 year beginning from the successful commissioning date. This means that if there is a malfunction or breakdown within the period the contractor will be responsible for making good the same by repair/ replacement at his cost.

When there is a malfunction the contractor is expected that the problem will be resolved within 48 hours of receiving the information. In case a spare part has to be imported then the repair should similarly take not more than 21 days.

The contractor should do a classification of what malfunction/breakdown to be given 48 hours or 21 days. This should be in his tender. The list must be exhaustive and include all elements and how they can be detected.

Spare parts

The Contractor/supplier must show proof that spares for all the supplied/installed items are available and that they will continue to be produced for the next 10 years at the least. It will be preferable for the spares to be within the country, and full explanation given of their availability.

The equipment to be supplied will be installed and used in unfavorable weather conditions, such as in water, very humid, exposed to any external conditions etc. it is therefore required to supply equipment with all units of build standard to IP 68.

Serial Number:

On every meter body there shall be marked the nominal diameter of the meter *(e.g. DN 50 mm), the meter model, an arrow indicating the direction of flow in indelible marking cast in raised characters, in very easily visible position on the outer case of the meters, but NOT on the lid. The serial number of the meter must begin with the size of the meter e.g. DN50 for 2". The size shall be followed by meter number and end with the 2 last digits of the year of production The letter "GVMC" followed by the serial number should be engraved on the top part of the meter body and laser marked on the upper part of the totalizer in Number and Barcode, near the index, in big letters (5mm minimum) and not on any transparent part of the totalizer.

PARTE - ROAD RESTORATION

1. Road restoration is a critical activity which requires special attention of the contractor. Following guidelines should be followed:

a) The contractor shall have to restore the road up to WMM stage including refilling trench in layers, watering, rolling and compacting to within 10days after trenching is completed in a particular street/reach. The contractor shall ensure that uncovered WBM length in total does not exceed 5.0KM at any stage of work and will complete the bituminous work regularly.

b) Contractor shall erect informatory board at his own cost showing type of work, inconvenience expected & timeline for various construction activities going to take place in a particular street or a particular reach of road as per direction of Engineer in charge.

c) Contractor shall deploy a community outreach team headed by a qualified social expert (post graduate in sociology) having minimum 3 years experience of social activity work with government recognized NGO or other government institutes to make strong relation with public prior to start of work in a particular ward/ area.

d) The contractor shall have to do the sequencing of activities as per direction of engineer in charge to synchronize pipe line work to minimize the road excavation and restoration in the street which will have pipe lines.

e) The cutting of existing C.C. pavement shall be done by using mechanical cutter to ensure cutting in regular line and the laying of C.C pavement shall be done below 30 degree ambient temperature.

f) All Work shall be as per MoRTH specifications.

2. Provisions of road restoration :

(i) For laying water supply pipe on B/T Surface

a. For road width upto 4 m, restoration up to WMM stage in trench width and bituminous work (wearing surface) in full width of the Existing Road.

b. For road width 4 m to7 m, restoration up to WMM stage in trench width and bituminous work (wearing surface) in entire road width upto 7 m.

c. For road width more than 7 m, restoration limited to 7 m (2 lanes) to cover the trenches (may be one lane over each trench).

3. For laying water supply pipe on CC Road :-

a. For road width less than 4.0m, restoration up to PCC stage (lean concrete) will be in trench width & CC pavement of M-30 grade in full width.

b. For road width more than 4.0m, restoration by lean concrete and pavement in M-30 grade in trench width only.

4. In Bituminous road restoration, Use of Paver is mandatory for carriage way width above 3.75 m of road restoration.

5. Notwithstanding all which has been laid down on road restoration, Employer's representative with reasons recorded and prior permission of PIU in charge will be authorized to come up with the site specific solution based on prevailing ground situation.

PART F – INSTRUMENTATION AND AUTOMATION

1. Specifications for online water quality monitoring systems

This section covers the specification required for online water quality sensors to be provided under the contract. The system should be user friendly that operates & analyze in minimum interval without any need of reagents, chemicals, consumables with low maintenance and calibration requirement. It should be capable of integration with the SCADA system.

Online multi-parametric pH, Conductivity/TDS, Turbidity, free Chlorine at various points of water distribution and the reservoirs.

The system proposed should have adequate channels to accommodate above measurements and should have capacity to display up to total 10 parameters to future-proof the system as it is not envisaged to upgrade the controller for next few years.

The system should have capability to accommodate any additional sensors viz. ORP, Dissolved Oxygen, Nitrite as may be required by the project authorities from time to time.

Parameters will be monitored at different location as mentioned below:

Water quality monitoring station will contain the sensors and equipment to measure the below mentioned parameters.

1. pH
2. Turbidity
3. TDS
4. Conductivity
5. Residual Chlorine
6. Flow
7. Pressure

3 Multi-parameter Controller System Specifications:

It should be equipped with the following minimum features:

- USB-interface for data transfer, upgrading firmware etc.
- Control unit with keys and toggle switch for the quick selection of software functions
- With colour graphic display with backlight
- With integrated backup controller function
- Input voltage 90 - 264 VAC 50/60 Hz
- Line power consumption approx. 25 VA
- Max. power delivery 18 Watt
- 6 galvanically separated current outputs (0/4-20 mA) that can be assigned arbitrarily
- MODBUS communication protocol for the data integration with PLC and SCADA
- With Sensor ID recognition
- High EMC interference immunity
- Integrated lightning protection

- Should have the latest features of highly advanced Multiparameter Controller having capability of handling at least 4 sensors in a single controller configuration and more as and when required.
- Display should be with improved reading precision through special backlit graphic display
- Easy User Intuitive operating keys: including keys for functions such as: Measurement, calibration, set/system settings, additional keys for: confirmation/switching menu O.K. (OK), Escape (ESC) etc.
- Internal integrated Datalogger with minimum data memory for up to 500,000+ data sets
- The Controller should be able to power all the sensors and terminals or accessories attached to it without having to need any additional power sources in the system for increased protection against lightening and possible electromagnetic interference.

- The system should start automatically after the power is reset to the system (in case of power failure).
- The controller should be low power consuming with consumption of less than 5W.
- Sensors connected to the system shall be automatically detected and initialized.
- No extra system configuration should be needed for substitute / replacement sensors.
- The system should have Service mode for cleaning/calibration/maintenance activities.
- It should be possible to download the data via the USB interface an extremely fast data exchange to USB memory stick.

- The system should be fully programmable with multiple levels of access control with help of Electronic-Key for data security and protection against non-authorized access to avoid any tampering or changes to the system configuration by unauthorized access.
- The controller should store the sensor configurations and calibrations
- The controller should have Logbook to record the data
- The supplier should provide the firmware update free of cost as and when they are available for the life time of the system.
- The system should have a status LED that gives reliable and fast information regarding function and status of system. And the Controller/controller should show a LED for diagnostic purposes on the front. This LED should show normal and malfunctions of the system at a glance.
- Data Output to Control System: The System should have the capability to transmit the required 4-20 mA Analog Outputs as a minimum.
- In addition to above, the system should have ability to output Profibus, Modbus/RS 485, RS 232, LAN, GPRS, GSM compatible signals in future with addition of respective module as and when required.
- The system should be able to operate on AC Power (100-240 AC)
- Ambient Conditions Operating temperature: -4 °C … +55 °C
- Storage temperature: -10 °C … +65 °C
- Housing Material – Non corrosive e.g. Acrylonitrile-Styrene-Acryloesterpolymer or better
- Protection Rating IP 66 / equivalent to NEMA 4X for controller
- Electromagnetic Compatibility: EN 61326, Class B; FCC Class A, EMC for indispensable operation

· Integrated Lightning Protection: According to EN 61326 enhanced overvoltage protection for the entire system, implemented in each component

4 Sensor Specifications:

4.1 pH Sensor Specifications:

- Integrated temperature measurement and compensation should be provided in the pH sensor.
- Sensor check function to detect broken glass of the pH electrode.
- The pH sensor should have galvanically separated input.
- Calibration history should be stored automatically in the sensor.
- Sensor calibration can be done in the laboratory or field.
- The pH combination electrodes should require very little maintenance and there should be no electrolyte replacement.

Technical Specifications:

- Measuring Range: pH – 4.00- 12.00 at least considering the wastewater environment
- Signal Output –Digital
- Sensor Check function should be available in the pH sensor
- Power Consumption: less than 0.5 Watt
- Temperature Sensor should be integrated in the pH sensor
- Temp Compensation: -5 to +50 Deg C
- Transient Voltage Protection should be integrated in the sensor
- Sensor body: Stainless Steel or better
- protection type : IP 68 for both Sensor and Cable
- Sensor Cable Length: 7 meter

4.2 Conductivity/TDS Sensor:

§ The sensor should have high measuring accuracy 4-electrode design with no influence by polarization effects at higher conductivity values.

§ Should have measuring range of 0.00 µS/cm to 500 mS/cm.

§ TDS and salinity measurement should also be integrated.

Technical Specifications:-

- Measuring Range: Conductivity: 0-500 mS/cm; Salinity: 0-70; TDS: 0-2000 mg/l
- Signal Output –Digital
- Power Consumption: less than 0.5 Watt
- Temperature Sensor should be integrated with conductivity measurement.
- Temp Compensation: -5 to +50 Deg C
- Max Pressure for Sensor: 10 Bar
- Input Power: Powered by the Controller
- Transient Voltage Protection should be integrated into the sensor

- Sensor Body: Titanium or equivalent
- Protection type : IP 68 for both Sensor and Cable
- Sensor Cable Length: 15 meters

4.3 Turbidity Analyzer Specification:

Turbidity sensor to be connected to the multi-parameter measuring system;

Equipped with the following features:

- Automatic cleaning system or better maintenance less and consumables free cleaning system
- Scattered light measurement
- Scratch-resistant sapphire measurement windows
- Sensor monitoring function
- Integrated lightning protection
- With screw / plug connector for connection of the sensor connection cable

Measuring range (selectable): 0 to 4000 NTU
Process variation coefficient according to DIN 38402 part 51:
in the range up to 2000 FNU less than 1 %

Repeatability or repeating limit DIN ISO 5725 or DIN 1319:
less than 0.015 % or min. 0.006 FNU

Temperature range:
Operating range: 0 °C ... 60 °C
Storing range: -5 °C ... 65 °C

Material:
Measurement window: Sapphire
Enclosure shaft: V4A stainless steel 1.4571

Type of protection
IP 68 (with the sensor connection cable connected)

Power consumption:
1.5 watt

4.4 Residual Chlorine Analyzer specification:

Module for measuring free chlorine in Waste water for use on Sewage water panel with controller

Useable in media with constant pH between 6-8.

Chlorine electrode:

- Range: 0-10 mg/l

- Resolution: 0.01 mg/l

- pH-Range: pH 6-8

- Electrochemical principle

- Temperature range: 5 - 45°C

Material:

PVC, Silicone, Polycarbonate

Current of water needed:

In flow thru armature approx. 30 l/h.

Maximal pressure: Armature with electrode: max. 1 bar overpressure

4.5 Level Sensor:

Ultrasonic type level transmitters shall be microprocessor based and shall use digital signal processing technique for signal conditioning. The transmitter shall have facilities for storing the echo profile, manipulation of the echo profile to remove noise, multiple profile-averaging etc.

The transmitter shall have the capability to use statistical filtering techniques, wherever required, to compensate for rotating agitator blades or to suppress false signal due to heavy dust or fill-stream interference.

In very dusty applications or in silo/ bunker, etc. filling applications, high power and long range (i.e., low frequency) transducer shall be used to overcome the detrimental effect of the dust. This type of instrument shall not be used for level measurement in process medium consisting of particles of sizes (- 6 mm diameter).

Ultrasonic transmitter shall be have 4-20mA (24V DC loop powered) / Field bus compatible and possible to calibrate through hand held universal and field bus configurator also.

The sensor shall have in-built temperature sensor for ambient temperature compensation.

Chemical compatibility of the sensor material with the process material shall be ensured, to avoid corrosion.

In applications, where material build-up on the sensor is expected, the transducer shall have suitable build-up compensation (i.e. repetitive, pulsating displacement at its face shall be used to remove the material build-up).

Ultrasonic transmitters shall be supplied along with necessary calibration software, noise suppression software, plug connector, cable, profibus to RS232C modem etc. for calibration/ noise suppression through laptop / desktop PC.

Adjustable mounting arrangement shall be provided for proper aiming of ultrasonic sensors. Suitable protection box for ultrasonic level sensor shall be provided.

Provision for the nitrogen purging facility in the ultrasonic sensor shall be provided for cleaning the buildup of the material.

Pipe insert of min. dia 200mm shall be available for mounting the level transmitter on top of the tanks. Necessary mounting brackets for mounting the level transmitter in the tank shall be provided.

Range:	0 to 15 meters
Temperature:	-20 to +60° C
Temperature compensation:	Built-in -20 to +60° C
Spread:	3°, 6°
Enclosure:	IP 68 / NEMA 6P (submersible to 10 m / 30 ft. of water)
Measuring accuracy:	Better than 0.2%
Analog output:	Active 4-20mA galvanically isolated, max. loop resistance 500 Ohms
Digital output:	Two SPDT electromechanical relays. (max 50V DC / 1 A)
Transmitter Enclosure rating:	IP 65 / NEMA 4X

4.6 Electromagnetic flow meter:

Selection of Electromagnetic flow meters shall be decided based on the following:

All magnetic flow meters shall be SMART type. Magnetic flow meters, which are to be installed in the control, alarm & interlocking circuits, shall have 4-20mA DC output (24V DC loop powered) / profibus compatibility along with Data loggers and battery back up.

Liner material shall be selected based on service. Generally, for liner material PTFE shall be used.

If gases are entrained in the liquid, meter shall be installed in vertical process line.

While installation it shall be ensured that flow tube is always completely filled with liquid.

Straight length requirement of minimum 5D to 10D in the upstream and 2D to 3D in the downstream shall be provided for water services. However, for other services it shall be designed as per manufacturer’s recommendation.

The tube material shall be SS 316, with PTFE linner and SS-316 Electrode. The coil housing should also be of SS-316.

Installation of electromagnetic flow meters shall be avoided near large conducting surface e.g. metal surfaces. (Large surface may interfere with magnetic field of instrument thus affecting accuracy).

Pulsed DC excitation shall be provided for field excitation of Electro Magnetic Flow Meter. Power & signal circuits of magnetic flow meter shall be completely isolated from each other.

Minimum one no. of grounding ring for metallic pipelines and minimum two nos. of grounding rings for non-metallic pipelines shall be used for installing the magnetic flow meter.

Selection and sizing of electro-magnetic flow meters flow characteristics published by the manufacturers shall be followed. Allowable flow velocity shall be considered based on the specific merit of the service, allowable pressure drop, and cost effectiveness and as per manufacturers recommendation, however the size of flow meter shall not be less than the size of conduit where it is proposed.

Accuracy of magnetic flow meter shall be ± 0.3% or better. Local display shall be calibrated in engineering unit.

A bypass line with isolation valves shall be provided for the magnetic flow meters so that magnetic flow meters can be cleaned on line.

Sensor & transmitter of magnetic flow meters shall be mounted separately.

Magnetic flow meter shall be provided with built-in auto zero facility for ensuring stable zero point.

Separate earth pit shall be provided exclusively for earthing of magnetic flow meters. Preparation of such earth pits shall be governed by the general methodology as described in IS 3043, 1991 or relevant international standards.

Necessary calibration unit for checking the electronic unit of magnetic flow meter shall be provided.

Enclosure class of magnetic flow meters shall be IP 68.

Pulsed DC excitation for better accuracy and measurement signal stability shall be used. Power & signal circuits of magnetic flow meters shall be completely isolated from each other.

While installation, it shall be ensured that flow tube is always completely filled with liquid and at no time the flow meter shall be empty.

Flow meter shall be provided with necessary ground ring, fasteners, gaskets, reducer / expander, matching flange including straight line pipes (Inlet run: 5D min & Outlet run: 3D min / as per manufacturer recommendation). Also spool pieces of length flange to flange for replacing the flow meters during maintenance shall be provided.

Pressure data logger capable of transferring data via GPRS/SMS communication. Input pressure range of 0 - 20 bars, accuracy ± 0.5%, and repeatability ± 0.1%, with re-zero function for offsetting. Memory must be not less than 50,000 readings, and can be set in cyclic or start-stop (block). Logging interval can be set 1 second, 1 min, 15mins, 30mins, hourly etc. Capable to export data to comma-separated values (csv) file format or Excel spreadsheets. Software Supports statistical data (average, maximum, mean and standard deviations). Ingress Protection rating of IP68, with minimum battery life of 5 years.

Data loggers must be compatible with the Employer's telemetry software

Mounting: Flange

Materials: Housing: Painted carbon or stainless steel

Liner: Hard rubber, soft rubber or PTFE

Electrode: Stainless steel 1.4571

Built-in grounding electrode: required

Accuracy: Better than ± 0.25%

Temperature: 0 to 50° C

Enclosure: IP 67 (with gel potting IP 68)

Analog output: One active 4 - 20 mA, galvanic isolated (max. 800 Ω)

Digital output: One voltage-free, electromechanical relay (max. 50 V DC / 1 A)

One optically isolated (max. 50 V AC / V DC / 120 mA)

Transmitter Enclosure rating: IP 67

Power supply: 24 V AC

Data logger: Display 160,000 logs with date, time, value and daily totals

4.7 Communication and Data Presentation/ Display

The controller should be interfaced with a GSM/GPRS communication modem to seamlessly transmit the data from remote plants to a central location over a pre-defined interval.

The communication to the system should be two way for ability to view settings and make changes to the configuration over the air, as and when required.

The data should be received at a central location and should be displayed there in real-time in graphical and tabular format. The software as a minimum should have ability to print reports, archive data and make it available for export as a CSV file. The system should also have facility to generate alarm when set points are exceeded.

6. Automation

It shall provide an overview of the proposed system including systems architecture, diagrams, the approach to work, the proposed work schedule (Bar chart) indicating milestones and potential meetings, project personnel while submitting the System Improvement Plan (SIP) for approval of Engineer. It shall also include the project timelines for implementation of proposed central SCADA system and monitoring system with details of schedules which shall illustrate all major project milestones including the following:

1. Schedule for all subsequent project submittals.
2. Tentative dates for all project meetings.
3. Schedule of manufacture and staging of all instrumentation and control system equipment.
4. Schedule for Factory Acceptance Test.
5. Schedule for shipment of all instruments and control system equipment all peripheral devices.
6. Schedule for equipment start up.
7. Schedule Field Acceptance Test.
8. Schedule for all Training.

The Contractor should take note of the importance of this obligation and perform assessment of the system and objectives envisaged under this project.

Contractor shall be responsible to provide the following;

i. Design, and drawing for SCADA architecture and Report along with list of equipment with specs and makes
ii. P&I Diagram
iii. Installation sketches of instruments
iv. Catalogues and Data sheet of all instrument
v. CRMC and SCADA Control room layout drawing – GA, architectural, structural etc
vi. Layout drawings for each piece of equipment fabricated or assembled by the Contractor, showing the position of each component with required clearance where applicable, and with overall dimensions.
vii. Wiring diagrams indicating each component of the system and all wiring and cabling thereto, showing manufacturers, types, duties, ranges and nomenclature, referencing the P&I diagram where applicable, with inputs, output, cable wiring and terminal identifications clearly marked.
viii. PLC IO instrumentation drawings, cable along with sizings and cable layout trenches as per site condition.
ix. Communication details / protocol details for all communicating instruments viz. PLC, GPRS telemetry, SCADA, etc. shall be provided.
x. Data sheet and catalogues for PC, printers and DAMS software
xi. Details of communication protocol and data structure
xii. Screens of the PC based local SCADA system
xiii. Mimic video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points where applicable.
xiv. Control video displays in the form of hard copies or photographs which are clearly legible and are notated to indicate dynamic data and control pick points.
xv. 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.

xvi. Description of quality control methods and approvals.
xvii. List of spares for I&C system, PC based local SCADA system including power supply systems
xviii. All test certificates and Calibration certificates for all the instruments along with test procedures.
xix. Detailed works and acceptance test procedures.
xx. Programme for manufacture, delivery, installation and commissioning.
xxi. Appendices, as necessary, to include manufacturer's literature for each item of equipment supplied.
xxii. O&M Manual

7. GENERAL SPECIFICATIONS FOR AUTOMATION AND CONTROL SYSTEM

7.1. GENERAL

This section of specifications defines the requirements of Instrumentation and Control system to be installed at Control center and pipeline. 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 elsewhere, the Contractor shall be required to provide all equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic etc. to achieve the functional requirements described in the Bid Document. The civil and electromechanical work associated with installation of the instrumentation equipment shall be in the Contractor‘s scope.

7.2. PREAMBLE

The control systems for the Potable Water Pumping Station and Distribution network shall be based on the use of Programmable Logic Controllers (PLCs) and Remote Terminal Units (RTUs). The various modes of controls shall be Auto, Semi-automatic and Manual. Remote operation facilities shall be provided for operating the equipment from the local SCADA system. There shall be Central Control Centre local PLC based SCADA systems at 7-Hills campus. The local SCADA system, PLCs and RTU's shall be capable of interfacing / networking with this master SCADA system.
In the event of failure of the automatic controls or by operator choice it shall be possible to revert to semi-automatic or manual operation of each item of Plant independent of the PLC functions.
The field instruments shall also form an integral part of the control system.

7.3. REFERENCE STANDARDS

Unless otherwise approved, instrumentation shall comply with relevant quality standards test procedures and codes of practice collectively referred to as Reference Standards including those listed below in accordance with the requirements detailed elsewhere in this specification.

BS 89-2:1990, EN 60051-2: 1989, IEC 60051-	Direct acting indicating analogue electrical

2:1984	measuring instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO 3511/I-1977	Symbolic representation for process measurement control functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 4675-2:1978, ISO 2954- 1975	Mechanical vibration in rotating machinery. Requirements for instruments for measuring vibration severity
BS EN 60584-1:1996, IEC 60584-1:1995	Thermocouples. Reference tables
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flowmeter performance
BS 5863-1:1984, IEC 60381- 1:1982	Analogue signals for process control systems. Specification for direct current signals
BS 5863-2:1980, IEC 60381- 2:1978	Analogue signals for process control systems. Specification for direct voltage signals
BS EN 60654-1:1993, IEC 60654-1:1993	Industrial-process measurement and control equipment. Operating conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and

	practice
BS EN 60073:2002	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS 1553 (Various)	Specification for graphical symbols for general engineering

7.4. 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 once the contract has been awarded. Failure to do so will be treated as a non-responsive bid.
All standards which the Contractor intends to use but which are not part of the above Standards or other listed Reference Standards, shall be submitted to the Employers Engineer for consent before any design against that standard proceeds.

7.5. DESIGN REQUIREMENTS FOR INSTRUMENTATION, CONTROL, AUTOMATION AND SCADA SYSTEMS

The instrumentation, control, automation SCADA installations shall fully comply with design standards, regulations and the material and workmanship requirements of the Specification.
The electrical plant installations associated instrumentation control and automation systems shall also comply with and be tested in accordance with the latest edition of BS 7671 or equivalent Indian standards.
All equipment and materials incorporated in the system shall be selected, designed and rated to operate under the defined performance duties and specified site conditions and to maintain a high level of operational reliability.
The instrumentation control and monitoring system equipment and materials shall have an operational life of not less than 15 years, unless otherwise approved by the Employers Engineer.

7.6. GENERAL DESIGN REQUIREMENTS

Instrumentation and Control system shall be designed, manufactured, installed and tested by an experienced system integrator to ensure high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All I&C equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain and temperature variation from 0 to + 500 C. wherever necessary, space heaters, dust and waterproof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories. The control equipment installed inside the control room should be designed to work at 350 C and the instruments in sheltered place outside the control room at 450 C.

7.7. INSTALLATION REQUIREMENTS

The locally mounted instruments shall be installed on appropriate rigid supports, having minimum vibrations. The instruments shall be installed away from hot objects.
The instruments shall be protected against physical damage or liquid splashing by providing metallic/ fiber glass enclosures or canopies.
All transmitters / transducers shall be installed nearest to the sensing point and at a place convenient to get access for maintenance.

The field instruments i.e. the instruments mounted outside the control panel shall be mounted at a convenient height of approximately 1.5 m above grade platform.
While installing the instrument, provision shall be made to carry out in-situ calibration Isolation valves and drain valves shall be provided to the field instruments wherever required.
Instrumentation cables shall be separately laid, away from electrical cables. The instrumentation cables from the field mounted instruments shall be terminated on the control panel without any joints. Double compression glands shall be used for glanding the cable in field instruments and instrument control panel.
Metallic tag number plate shall be provided for each instrument.

7.8. INSTRUMENT POWER SUPPLY CABLES AND INSTRUMENTATION SIGNAL CABLES

Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.
Cable joints in instrument signals and power supply cables shall not be permitted.
Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.

Cables shall be capable of operating satisfactorily under a power supply system voltage variation of ±15%, a frequency variation of ±5.0%.

7.9. LAYING OF CABLES

A distance of minimum 300mm shall be maintained between the cables carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between HT cables and signal cables. In outdoor areas, the cables shall be directly buried. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.
All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. A loop of 1 meter shall be left near each field instrument before terminating the cable. Cables shall be complete uncut lengths from one termination to the other.

All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules. Identification tags shall be securely fastened to the cables at both the ends.

7.10. PROGRAMMABLE LOGIC CONTROLLERS

7.10.1. Codes and Standards

The design material, construction features, manufacture, inspection and testing of Programmable Logic Controllers (PLC) shall comply with all currently applicable statutes, regulations and safety Codes. The PLC shall comply with the latest applicable standards and codes. If any such standards are not applicable then the same shall comply with the available recommendations of professional institutes like NEMA, IEC, ANSI, ISA, IEEE, DIN and VDE.

7.10.2. Design and Construction Requirements

PLC shall be provided as a Hot-Standby configuration to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.
PLC Panel interrogation power supply should be fully redundant.
PLC shall comprise of necessary processors, input/output (I/O) modules, communication interface modules and man-machine interface (MMI) required to perform the desired functions.
Each PLC shall have memory protected built in historical archiving/data logging of system alarms & events and process variables. Data logger shall be able to log data based on time or an event. PLC shall have enough memory allocated to allow 200,000 time and data stamped discrete and /or analog values to be archived. The historical archive shall allow the oldest data to roll off the system as memory is used keeping the 200,000 most current data points available. Process point time stamping frequency shall be selectable within the configuration software. It shall be possible for the archived data to be exported in CSV format allowing use with standard spreadsheet and data software applications
PLC shall have the following attributes as a Hot-Standby configuration.
Carry out sequential logic implementation for operations of plant;
Carry out computation and interfacing for data acquisition, data storage and retrieval;
It shall accept downloaded program from a programmer;
It shall have different functional modules to perform the desired functions;
It shall scan the inputs in time cycles and update the status of its outputs.

7.10.3. Dual redundant processors

The master station shall be provided with two identical central processors configured such that they operate in Hot-Standby mode.
Redundant system with hot back up redundancy feature should be built in the CPU. Software engineered hot backup systems are not acceptable. CPU should have the memory expansion capability up to 7 MB. Both the CPU‘s should have separate backplane and associated hardware for redundancy.
CPU system should have built in WEB server
SCADA connectivity with the CPU will be on dual Ethernet network (10/100 Mbps with open Modbus TCP/IP protocol). On the event of hardware failure in primary system the standby system will provide dual connectivity with the SCADA.

Redundancy of switch for SCADA (industrial grade managed switch) connectivity is to be provided.

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 .External OPC servers will not be considered.
The system hardware, application software and database shall be sized to accommodate a total of 50% increase in signal capacity and up to 100% increase in an individual zone.
Sufficient plug in modules shall be provided and wired to terminals ready to accept future signals of up to 10 % for each IO card
Each IO card shall be able to accept at least two more I/O cards without requiring replacement of, or additions to, the original equipment.
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. PLC shall be of an approved type from a major international manufacturer. Refer Vendor list. The PLC shall be furnished with a dual redundant microprocessor. The PLC shall be open systems standard for all elements of communications and programming and shall be designed for ease of use and minimum configuration.
Application logic programs shall be fully compliant with all five logic development methods detailed in IEC 63331-3. 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 WindowsÔ 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.

7.10.4. 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 features shall be provided on a minimum
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.

7.10.5. 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.

7.10.6. 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. Deviation from this would be treated as a non-responsive bid and lead to technical disqualification. 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. The I/O modules shall 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. RIO‘s to have dual redundancy on network level connected to both the CPU. Even on the failure of one CPU backplane the other system should be available on dual network at RIO level. All the RIO rack should have redundant power supply modules for the backplane.
All I/O modules should be rack mounted type.
I/O modules shall be as follows:

- Inputs shall be up to isolated.
- filters shall be provided for noise rejection;
- output status shall be indicated by an LED;
- all outputs shall be fuse protected and have fuse failure indication the fuses may be mounted

  Externally from the output module;

- All the modules shall be of addressable type.

Ethernet I/O modules shall be connected to the PLC by on board Ethernet 10/100 BaseT connection port. Ethernet I/O modules shall support multiple communications including TCP/IP and Modbus ASCII and RTU allowing connection to any device supporting these protocols over standard Ethernet backplane.

7.10.7. 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%

7.10.8. Analogue Output Modules

They shall consist of signal conditioning unit and a digital to analogue converter (DAC). In addition, the following features shall be provided.
16 bits resolution minimum
Provision for monitoring of the DAC for overflow detection
Accuracy for analogue signals shall be 0.5%

7.10.9. Digital Input Modules

The following design features shall be provided.
Contact bounce protection;
Choice of type of contacts.
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 motorized 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. FBD logic
14. Flow Totalization/Integration
15. Intrusion Detection
16. Time of Day Control w/Lockout
17. Ramp Blocks
18. Data Logging

7.10.10. PLC Programming

Where ever possible PLC programming shall be carried out using FBD, based on the approval of the Employers Engineer. 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 complying with IEC 63331-3.
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.

7.10.11. Programming Unit

The programming unit shall be of the portable type, industrial model designed to be used during commissioning on site. A functional keyboard which supports different type of programming methods shall be included, as well as a CRT or TFT display.
At least the following functions shall be included on a minimum:
On-line programming
Off-line programming
Flexible corrections during input
Full screen editing functions
Absolute and symbolic programming
Input of comments and title blocks for complete documentation
Complete application software documentation functions. Printouts of application software logic functions shall preferably be in Ladder logic diagrams.

7.10.12. Load and transfer functions

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

Technical Particulars for PLC

Functions	As per the control logic and input/output list
Expandability	50% of installed capacity
Interposing relays	Shall be provided for all the digital outputs (DO) including spare DO and for digital inputs wherever required.
Optical isolation for all digital inputs and outputs and galvanic isolation for analog inputs	Required
Mounting	Inside the control panels with viewing glass on the door
CPU and power supply module redundancy	Required (In hot standby mode)
Diagnostic function performance	Required
Minimum 32 bit performance with floating point capability	Required
Memory module	To store programs, standard software to perform logic functions and diagnostic functions
Inputs and Outputs	Refer I/O schedule
System Loading	Max. 60% under worst loading Conditions
Power supply to sensor / transmitters	Required
Type of input	Binary, analog and pulsed as required
Outputs	Binary signals (Relay outputs for driving MCC Starter coils, driving motorized valves etc.); analog and pulsed as required
Spare I/O	20% of each type, wired to terminal block

Accessories	Laptop computer for programming along with all necessary adapter, laptop carrying kit, cables, connectors and accessories Proprietary PLC programming and documentation software along with all cables and connectors for loading on laptop computer and on local PC based SCADA system
Interface (Hardware and Software) to Local SCADA system	Required
Communication port to be provided for interface to Local SCADA system	RS 232/ RS 485 (with suitable converters as applicable)
Communication port for interfacing with temperature scanners (for pumping stations)	Required
Communication port for interfacing with Multifunction meters/ Motor Protection Relays	Required
Communication port for interfacing with flow indicator totalizers	Required

7.10.13. Default Values

Every operator selectable parameter shall be provided with a default value held in EPROM or EEPROM in the relevant PLC.
The default value shall be used if no other value has been entered through the local SCADA system or if the value entered through the local SCADA system has been lost. The default values shall be made available for interrogation by the local SCADA system at all times.
Sensible and logical default values shall be inserted prior to the start of system tests. The default values at the time of handing over the plant shall be those found operationally suitable during commissioning.
The PLCs shall make available for interrogation by the local SCADA for bits corresponding to the following PLC faults:
(a) Failure of PLC as indicated by the PLC watchdog relay;
(b) Failure of each I/O card;
(c) Failure of communication link
(d) Status of 24 V DC power supply for I&C system.

7.10.14. Software

The on line real time operating system supplied shall be proven for similar application and shall be able to support all the equipment/peripherals.
PLC programming shall be carried using latest available industrial standard formats for logic. The PLC programming shall be prepared using the PLC manufacturers recommended windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation. Ladder program will be preferred.
The PLC shall be commissioned using RAM memory storage modules which shall be replaced with an Erasable read only memory (EPROM) or electrically erasable read only memory (EEPROM) when testing is complete.

7.10.15. Operator Interface Unit (OIU)

a) OIU shall be provided for the PLC system on the front facia of the control panel.
b) The OIU shall consist of panel mounted industrial grade unit with Color LCD/LED screen and tactile key pad. It shall be environmentally protected and designed for plant room use with a wipe clean finish.
c) The OIU shall provide facilities to:
i. Display status of Plant in a graphical and tabular format (i.e. running, stopped, fault etc.)
ii. Display analog values on the appropriate graphic screen (displays shall change color when in fault conditions or when data is suspect);
iii. Annunciate alarms associated with the area of the plant concerned including details of the time the alarm occurred
iv. Provide facilities for the operator to:

- adjust process set points;
- select process modes;
- select number of running pumps;
- provide all other facilities required for operation of the Plant;
- acknowledge alarms;
- view a journal of unacknowledged alarms;
- View a journal of the alarms acknowledged and unacknowledged.
- Display process set points;
- Display a total running hour's log of local transmission pump drives.
- Provide real time and historic data
- Any additional features required to assist in the effective and efficient operation of the plants.
- Security systems shall be provided to prevent unauthorized adjustment of process set points. d) Graphic screens shall be provided as follows:

i. Main and subsystem menus;
ii. Pumping system overview (i.e. providing details of Nos. of pumps running, total flows, reservoir/ sump level, power supply status etc.)
iii. Transmission main local surge suppression equipment tabular status format screen;
iv. Screens to permit viewing and modifying of process set points
v. Tabular screen of pumping plant status and values
vi. Running hours log for pumping stations.

e) The screens shall display data commensurate with their size and the area of and the number of Plant items covered. The Contractor, in addition to the specific screen requirements stated above shall be responsible for providing any additional screens to ensure comprehensive coverage of the Works.

f) The software chosen shall have a comprehensive alarm handling capability with the ability to annunciate, acknowledge, sort and maintain a historic record of current and past alarms including details of when the alarm occurred, when it was acknowledged and when it returned to normal.

Tests for Programmable Logic Controller (PLC)

The following tests shall be carried out for the PLC

i. Scanning rate check for analog signals
ii. Scanning rate check for digital signals
iii. PLC cycle time check
iv. Processor redundancy check
v. Power supply redundancy check
vi. Power supply failure alarm check
vii. Power supply failure alarm check
viii. Card level failure detection check
ix. Failsafe output check on failure of output module
x. Sensor failure detection check
xi. Status indication check for healthiness of each input/output channel and module
xii. Status indication check for power supply for each module
xiii. Isolation check for input/output module
xiv. Input filtering check for noise level
xv. Processor – battery back-up check
xvi. Controller functioning check on under voltage and over voltage
xvii. Ladder logic program check by simulation of inputs and outputs

xviii. Functional check of programming units.

7.11. REMOTE TERMINAL UNIT

7.11.1. RTU system design

RTU shall be designed in accordance with this specification. The RTU shall be of proven design and suited for water supply and distribution SCADA applications.

In general the RTU design should aim to minimize power consumption and heat generation. It should be designed to work in remote installation by being of robust physical construction with immunity to electrical noise.

The RTU shall be assembled from modular units, for example, power supply module, CPU and communications module, communication interface modules and modules for input/output purposes. I/O and serial cards shall be able to be arranged in the RTU rack in any order.

Modules shall be interconnected via a suitably robust plug and socket method. It shall not be necessary to unscrew individual wires/cables, both internal RTU wiring and I/O wiring, to replace faulty modules. The failure of one module will not affect the performance of any other module.

A marshalling terminal area shall be incorporated with each RTU to provide terminations for field cables. This area can be located in the RTU cubicle itself for an RTU replacement

but for new locations there should be a separate marshalling cubicle. The RTU and marshalling cubicles shall normally be bolted together to form a 2-bay cubicle suite. A separation plate may be located between the cubicles.
The RTU and the cubicles shall be designed to accommodate the actual number of input/outputs and IEDs at the specific substation, plus spare capacity.

7.11.2. RTU spare capacity

The spare capacity, which includes equipped, wired and cubicle capacity, shall be supplied as described below. The supplier shall detail the steps required to activate the spare capacity.

7.11.3. Equipped capacity

Equipped capacity shall include all electronic cards and output terminals. To activate this capacity, an input/output connection shall be made to the designated field terminals in the marshaling cubicle. This additional capacity is generally provided to cover the initial substation design and commissioning. It includes rounding up the quantities specified to the modulus of the number of points per card. Unless this is otherwise specified, the initial equipped spare capacity shall be not less than 20% for each type of input and output used. Unless specified, any I/O lists or quantities given for a particular RTU shall not include spare capacity. Therefore these quantities will need to be increased by 20% to meet spare capacity requirements.

7.11.4. Wired capacity

Wired capacity means that a card slot is provided. To activate this capacity, in addition to connection of the field input, an additional input card or output card is required to be supplied and fitted, and wiring arranged from the I/O card to the terminals in the marshalling cubicle; the wiring is usually done by a preformed cable. This capacity is specifically provided to cater for some future known requirement, which may be 4-5 years away. Unless otherwise specified, this additional capacity shall be zero.

7.11.5. Cubicle capacity

Cubicle capacity is a requirement to provide adequate cubicle space capacity, such that additional card files and terminations could be retro-fitted at some stage in the future. This is to cater for expansions possibly 8-10 years or more away. Unless otherwise specified, this additional capacity shall be zero.

7.11.6. RTU I\O structure

The RTU I/O quantities shall be developed in accordance with requirements.
Performance requirements
Environmental conditions
The RTU shall be designed and supplied suitable for indoor equipment conditions. For RTUs installed indoors, the ambient temperature range is -5° to +55°C. RTUs installed in a cubicle in the field (outdoors) are required to work successfully in an ambient temperature range of -10°C to +65°C.

Heat dissipation calculations shall be provided to demonstrate the RTU‘s ability to comply with the temperature ratings of the equipment in the range specified.

7.11.7. Maintainability

It is a requirement that all RTUs require no routine or planned maintenance. Therefore, no fans or moving parts shall be used in the RTU to avoid any need for maintenance. To ensure this requirement is met the RTU should be constructed to resist the entry of dust.
A single technician shall be able to remove and replace for repair purposes, without special tools and test equipment, all equipment involved in the operation of an RTU. Restoration of equipment to full operational use shall be possible within 15 minutes (nominally) of repairs being completed.
It should not be necessary to dismantle (remove multiple pieces of) the RTU in order to replace a module.
Reliability
The supplier shall provide the predicted mean time to failure and the mean time to repair of the equipment. Where insufficient historical data is available, the supplier shall state the methods used to determine the reliability performance.
Predicted availability of equipment supplied should exceed the following:

System Function	System Availability
Control and monitoring of any one control valve.	99.99%
Monitoring of any one single alarm (High Pressure)	99.99%
Monitoring of any one analogue input (Flow meter value)	99.99%

For the purposes of these calculations:
• The availability of any interconnecting communication equipment or system supplied by others shall be assumed to be 100%
• An assumption of an average 2 hours for maintenance personnel to travel to site shall be made. Repair time shall be added to this travel time.

7.11.8. Service life

The equipment shall be capable of complying with this standard, including performing its intended purpose, for a minimum of 20 years from the date of supply.
The supplier shall indicate the following:
• The date at which the product was released for sale.
• The anticipated date at which the product will be withdrawn from sale, but support will continue to be supplied.
• The anticipated date that product support will be withdrawn, i.e. spares will no longer be available and technical support is no longer provided.

7.11.9. Interchangeability

RTU parts shall be interchangeable individually, and as a whole RTU. Any such change or replacement shall not reduce the capability of the equipment to conform to the requirements of this specification.

7.11.10. RTU power supply

The power supply to run the RTU shall be the responsibility of the contractor. However, at some locations, a general purpose 240VAC supply will be available to power the RTU. At these sites, the RTU is required to function for a period of at least 10 hours in case of AC supply failure. A combination battery charger and battery shall be provided by the supplier for this purpose. The RTU and its communication equipment are the only equipment to be powered from this source at these locations.
The batteries provided by the supplier shall be 12VDC. Batteries shall be of the sealed AGM (absorbed glass mat) or gel type lead acid, and shall be supplied in a separate wall mounted cubicle, with venting to atmosphere of approximately 10cm square.
The supplier is required to provide design calculations to demonstrate the battery capacity to be supplied. The calculation of the required battery capacity shall include a margin to ensure system integrity. This margin shall include a design allowance of 20% minimum, a temperature correction and an ageing factor for at least 4 years obtained from the battery manufacturer. The battery shall be suitable to be recharged from its design end-of-discharge voltage to full charge in 5 hours.

1.11.10.1. General

In all cases, galvanic isolation shall be provided on each power supply of the RTU that connects to the power supply source. Power supply isolation shall conform to applicable standards.

1.11.10.2. RTU CPU

The RTU shall be microprocessor based. Once power is supplied to the unit, it shall be designed to operate without manual intervention; additionally, it shall auto restart and be able to communicate with the master station without reporting spurious state changes on power resumption after a power failure. Suitable, reliable indicators such as LEDs shall be provided for personnel to readily ascertain the status of the RTU.

The processor shall monitor the health of the RTU with built in diagnostics, which are capable of remote interrogation including diagnostics for memory and bus errors, buffer overflows, local software routine health, communication ports status, input/output card health. Diagnostics shall also be supplied that shall permit complete testing of the RTU with a portable computer. Diagnostic checking of the communication ports shall be provided to permit checking by a portable computer.

Power supply and battery low volts or failure conditions shall be monitored.
The RTU shall possess memory to permit storage of a minimum of 2000 events (input changes) locally for subsequent transmission to the SCADA master station and these events shall not be lost on buffer overflow; an indication shall be provided of this latter condition. Events will be retained in the buffer until they are correctly read by the master station. As a minimum, separate buffers shall be provided for digital and analogue events.
To enable fault finding to occur, there shall be a separate event list to record internal RTU events such as health, time synchronization and any internal errors. This shall permit storage of up to 2000 events.

When memory is provided for the purposes of local control or communications routines, spare capacity shall be provided equal to the amount utilized.
The RTU shall have a real time clock, with a resolution of 1msec. It shall have the capability of time stamping events. The RTU clock shall be synchronized by the master station using DNP3 protocol every 5 minutes. In the advent that this does not occur, the RTU clock shall drift no more than 1 second in 24 hours.
Within the RTU, events shall be reported to an accuracy of +/-1msec.
The RTU shall be capable of programming in a high level language to implement local control and logic routines. It shall also be capable of being programmed using at least two IEC1131-3 programming languages.

7.11.11. Communication ports

The minimum requirement for communications is as follows:
• The RTU shall be equipped and configured to communicate via dual 10BaseFL Ethernet ports,
• RS-232 serial port
• RS-485.
• RS-232/RS-485 port
Isolation of all communications circuits shall conform to IEC 60870.2.1 Table 18 Class VW3. Galvanic isolation shall be provided for any port that is not based on a fiber interface.
The RTU must reply on whichever port it is scanned.
The SCADA Master Stations interface with the RTUs utilizing ISDN/GPRS modem.
RTU Input/ Output modules
This section relates to direct wired input/output equipment.

7.11.12. Digital inputs

Digital inputs shall comprise both active & passive types. Where passive inputs are nominated, the power shall originate at the input module. Active inputs shall be powered from external equipment. Both the active and passive inputs shall normally have identical voltage ratings & types.

Digital input signals shall conform to applicable standards, and galvanic isolation shall be provided.

Each input shall be provided with individual anti-bounce signal conditioning and noise filtering such that a value can be varied to adjust the sensitivity of the input from 0-30ms. This ensures compatibility with older equipment with contacts that do not make solid contact initially.
Each input shall be able to detect a minimum change, from High to Low or Low to High, of 4ms.
The threshold voltage shall be set such that an input will not change from Low to High unless the input voltage is at least 35% of the nominal battery voltage and it will not change from High to Low unless the input voltage is less than 65% of the nominal battery voltage.
Each group of inputs shall be protected by fuses (or equivalent). Fuse monitoring in groups shall be provided to detect whether fuses have failed, and alert the master station operator of this occurrence.

7.11.13. Digital outputs

Digital outputs shall comprise voltage free contacts rated for switching. Relays shall conform to IEC 60255-3 (formerly IEC 255-4).
Loads shall be typically:
240V AC 2 Amps
24V DC 1 Amp
Appropriate relays shall be selected for the specific type of load. The minimum contact whetting current shall be specified for the relays selected.
Digital output signals shall conform to applicable standards, and galvanic isolation shall be provided. The preference is to use voltage free contacts for the digital outputs. This applies to all controls which therefore require 2 wires in the field cabling for each control.

7.11.14. Analogue inputs

Analogue input signals will conform to applicable standards, and galvanic isolation shall be provided. Analogue inputs shall be bipolar, but normally configured to accept 4-20mA DC or ±20mA DC or ±10mA DC or ±2V DC using full resolution.
Each input shall be provided with individual software filtering.
The resistors used to convert the current loop to a voltage shall be precision resistors. The overall minimum accuracy of analogue measurement shall be 0.25% over the full scale and full temperature range. This includes resistors, ADC and software accuracy.

7.11.15. Diagnostic and configuration utilities

The RTU shall be supplied with a port that provides connection for a laptop PC.
The supplier is required to provide diagnostic and configuration software to run in these laptops and access the RTU. This software shall include facilities for:
• Monitoring of all inputs, control of all outputs and testing of calculation logic.
Monitoring of all inputs and logic at card level, logic level and DNP3 level.
• Display of communications statistics and eavesdropping of communications channels, including Ethernet, IP, DNP3, Modbus and Conitel/Baker.
• Download & upload of RTU software, database configuration and calculations, upload the complete configuration from RTU to modify and then download to RTU.
• On-line help.
• Display current firmware, software and configuration running in the RTU
• Configuration and diagnostic software must run on both Windows 2000, XP, Windows 7 and 8.
The diagnostic and configuration utility software shall be provided on a CD/DVD that is compatible with the laptop PC. The current version number of such software shall be provided. Any costs in upgrading to subsequent version numbers shall be included in the pricing.

7.11.16. RTU cubicle

Each RTU shall be supplied fully assembled, together with all ancillary equipment, including wiring terminals, mounting rails, wiring ducts & wiring, to form a complete system, subject only to connection of substation equipment to field terminals.

7.11.17. RTU marshalling cubicle

The RTU marshalling cubicle shall incorporate cable-marshalling terminals for all incoming field cables. Terminals shall normally be rail mounted vertically.
Terminals shall be provided for each core of all field cables. The individual cores of a field cable will be terminated in a row of adjacent terminals.
Adequate means of support for field cables shall be provided. This will typically be a section of cable ladder/tray/ducting to which the field cables can be tied for support. Normal field cable access shall be bottom entry into the marshalling cubicle.
Space shall be allocated between sections of terminals allocated to different cables to provide adequate space for labelling – a minimum label width of 9 mm shall be provided.
Wiring looms shall be provided between each RTU I/O module in the RTU cubicle and the terminals in the RTU marshalling cubicle.
Where ducting is provided for locating cables, the duct size shall be large enough to hold all the cables permitting the duct lid to be fitted when cables are installed.
The design of the marshalling cubicle layout shall be to Employers Engineers approval.
Factory testing
The RTU shall be supplied defect free.
An Inspection & Test Plan shall be submitted for approval, prior to the commencement of any tests.
Factory testing of each RTU shall be conducted at the manufacturer‘s premises. Provision shall be made for witness testing of all equipment.
Each RTU shall be fully assembled and configured for factory testing, prior to dispatch.
Tests shall include, but not be limited to:
• Point to point wiring check
• Serial numbers of all cards and modules shall be listed in an Excel spreadsheet
• Confirmation of all digital inputs & outputs, from the field terminal through to the diagnostic laptop
• Verification of analogue values received (at least zero, half full scale, full scale values and negative full scale values for bipolar analogues) using a DC current or voltage signal generator measured from the field terminals to the diagnostic laptop
• Confirmation of control functions from the diagnostic laptop to the field terminals, including exercising the dummy circuit breaker, and the controls isolate switch
• Confirmation of effective communications between the RTU and other devices using the specified protocols
• All powered tests shall be carried out at the specified power supply rating of the RTU
Test results for each RTU showing tests undertaken, results and any corrective action taken shall be provided in an approved format.
Documentation associated with the RTU equipment
Documentation comprises the supplier‘s standard manuals and customized drawings for each RTU.

7.11.18. Manuals

The Supplier shall supply descriptive manuals for design, configuration, installation, commissioning and maintenance purposes.

7.11.19. Drawings

It is preferred that drawings of input/output circuits be provided be in ―pro forma‖ form, such that they may be easily understood by field staff from a master set, rather than having multiple sets of drawings. Separate spreadsheets may be provided to contain additional information.
Drawings as follows shall be submitted for the approval, for each RTU:
• Inspection & Test Plans
• Cubicle or gear plate General Arrangements showing RTU layout
• Dimensioned cubicle and/or gear plate drawings
• Bill of Material for each cubicle/gear plate set identifying all parts
• Power Distribution Schematic Diagrams for each RTU
• Schematic Diagrams for Inputs and Outputs for each RTU (preferably using pro forma principles)
• Calculations for RTU and I/O power consumption: An Excel spreadsheet shall be provided that calculates the maximum power consumption of the RTU. Inputs shall be the numbers and types of I/O and communications cards. The calculations shall compute the power at the primary voltage level into the RTU allowing for any power conversion efficiencies.

7.11.20. Spare parts

A set of recommended spare parts not less than 10% of installed quantity shall be detailed and supplied for each RTU. The set shall be sufficient to cover the complete range of RTUs supplied. All spare parts shall be fully tested.

7.12. PLC BASED SCADA SYSTEM

7.13. SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEM (SCADA)

The SCADA shall be a fully integrated microprocessor based control and data acquisition system to monitor, control, display, record and trend all assigned plant inputs and outputs. The SCADA shall be a fully dual redundant server 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 (monitor) based process operator workstations that shall be located in the central control room.
SCADA/HMI system shall be Dual Redundant server system. The system shall be designed and implemented such that the failure of a central processor or HMI console does not inhibit continuous automatic control of the plant. In the event of such a failure, historical data shall be recoverable to a condition where a worst-case maximum of 15 minutes of historical data is lost.
Failure of a single outstation or communications to that outstation shall not affect control or operation of any other outstation, unless the failed outstation provides essential data to another outstation, in which case the non-failed outstations shall revert to a fail-safe mode.
An alarm shall be generated whenever a communications system failure occurs.

7.13.1. 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.

7.13.2. COMPUTER

The computer hardware shall be of current technology at the time of installation, Standard PC technology with modern hardware, Windows operating system and data transmission over Industrial Ethernet must be used for the engineering workstations.
It must be possible to install more than one engineering station in a system.
The engineering system must be an open system that, for example, permits the importing of project data from Microsoft Excel 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 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: The specs for computer hardware shown are indicative only. The contractor to select the appropriate hardware to suit the process requirements and data archiving.
Minimum clock speed shall be 2GHz
Hard disk drive: 500GB (Minimum)
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.

7.13.3. DATA STORAGE

A historical data storage system with removable media for archive and backup will be provided.
The data storage system shall store alarms and events, with the time of occurrence for one month and selected analogue signals connected to the system. All alarms and events shall be archived in a first in first out buffer, for a period of 40 days.
A high speed back up device with removable media, such as streaming tape cartridge or optical disk, shall be provided for each , suitable for backing up the whole system on a weekly basis. Data selected for archive shall be written to removable media which shall be sized to support at least 40 days' worth of archive data.
External portable hard disk along with at least one DVD write/rewrite/read with + R and -R capacity in addition to the historical data storage device in the Engineering Station should be provided.

7.13.4. VISUAL DISPLAY UNIT (VDU) / MONITORS

1. Visual Display Units (VDU's) shall be color monitor screens, capable of displaying information in alphanumeric, bar histogram, graphical and mimic diagram formats. Monitors shall simultaneously display a minimum of 256 colors, non-interlaced, low radiation, flat screen with no discernible flicker. Display of characters shall be legible and stable on a shadow mask tube, having a resolution of not less than 1024 by 768 pixels and a refresh rate of not less than 70

Hz. The units shall include all the necessary picture controls to adjust the sharpness, contrast and position of the image. VDUs shall be flat screen, LED type, minimum requirements: brightness 250 cd/m2, 500:1 contrast ratio, 1600 x 1200 pixels,
3. VDU‘s for MCC shall be 65 inch. (Minimum)
4. VDU‘s shall be fitted with a power management system to reduce consumption upon detection of a stand-by signal from the PC.
PRINTERS
Logging / Alarm / Report Printers – Continuous Feed:
1. Printers used for logging of system wide events and alarms shall comply with the following:-
A. print speed: 160 characters per second
B. print quality: letter print with optional draft mode
C. paper feed : adjustable width tractor feed mechanism
D. paper width: 18 to 38 cm fan fold
E. print pitch : 10 or 12 chi
F. print width : 132 characters at 10 chi
g. character set: Full ASCII
H. noise level : < 50 dBA.

7.13.5. COLOUR PRINTERS

Laser Jet printers shall be used for the production of color screen dumps and reports and shall have a sufficiently sized buffer memory such that system performance will not be degraded when the color printer is operational and comply with the following:
A. print speed: text, 80 characters per second
B. print speed: color graphics, 2 minutes per full page (max.)
C. colors : compatible with VDU graphics
D. paper feed : A3 and A4 with auto sheet feeder mechanism and minimum 50 sheets per tray
E. paper width: A4/A3
F. resolution : 600 DPI
G. RAM: min. 8 MB

7.13.6. SYSTEM OVERVIEW

The SCADA/HMI 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 optimization. The system will allow operators, technicians and engineers to issue commands to change system parameters, start and stop equipment, provide configuration tools and operate diagnostic facilities from Operator Workstations (OW) and Engineers Terminal (ET), after successful log-on by security password.
The System shall perform all the necessary functions for the optimum monitoring, control and operation of the entire system.

For each abnormal condition, Plant failure, Plant unavailable or failure to respond to a command within a given period, the MMI shall provide the appropriate alarm. Printed and archived alarms shall be time and date stamped for occurrence and acceptance. Alarms, logs and reports shall be output to separate printers. Alarms shall be in red. The ability to generate alarms within the system software based upon digital and / or analogue events and set points shall be provided.
An alarm horn with silence button shall be provided to alert the operator of an alarm condition.
Specific alarm, monitoring and control input / output requirements shall be determined from the particular control specifications and the Project Drawings.
SCADA/HMI system should be housed in an air-conditioned environment.

7.14. SCADA SOFTWARE FUNCTIONS

7.14.1. General:

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.
The computers shall utilise a real time multi-tasking and networked operating system with a proven track record in real time control applications.
The Operating System shall be on Windows OS, loaded with MS-Office latest licensed version suitable for interconnection with external networks in a Wide Area Network (WAN) configuration, where specified.
The Application Software shall provide communication with other industrial standard open networks. The Software shall support Object Linked Embedding for Process Control (OPC).External interfaces are not allowed for OPC.
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 SCADA software & Hardware 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 three 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 operator‘s 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 colour 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

7.14.2. 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
It must be possible to integrate standard Windows applications such as Microsoft® Excel, Microsoft® Word and Microsoft® Access by means of the standard mechanisms OLE/ActiveX, ODBC/SQL. Any user programs (e.g. individual data management, analysis, process optimization) must work together with the control system via the integrated C programming interface and then utilize both the control system data and the control system functions.
The control system must be OPC-compatible in order to allow cross-vendor communication. The different OPC standards (DA, HDA and A&E) must be taken into consideration here. Current process data regarding this should be made available to other computers and applications. In this way, any computer that is connected to the network should be able to access all of the control system's data. The use of a standard database (Microsoft® SQL Server 2000) is required to store (write-protected) all of the list-oriented configuration data such as lists of variables and message texts as well as current process data such as messages, measured values and user data sets in order to be able to access the database via the opened programming interfaces C-API or OLE-DB. Work steps in the engineering phase should be automated and the configuration environment should be individually expandable through the integration of the standard tool Visual Basic for Applications (this simplifies the generation of mass data).
It is critical that the control system should offer the capability of homogeneously integrating other applications and application blocks into the user interface for process operation. Both the application windows and the OLE Custom Controls (32 bit OCX objects) or ActiveX Controls can be integrated into the control system application as if they were the control system's own objects. It should be possible to use the ANSI-C script language and Visual Basic Scripting for dynamizing graphical objects.

7.14.3. 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.
Mimic displays.
Graphic displays.
Trend displays.
Alarm summary tables with date and time.
Event logs of past 72 hours with date and time.

Tabular display of data.
Inset windows showing 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.
Multi-level real-time auditing, advising of energy optimization process and diagnosis of Plant process performance Software (Operational Data Management Software)
SCADA shall support and include a multi-level real-time auditing and advising of energy optimization process and Real-time process performance software. The key benefits of a performance auditing system would be a more efficient plant, improved reliability & safety, and increased profitability.
Objective of the software in conjunction with SCADA:
Real-time process optimization resulting in energy savings /Cost savings
Reduce Downtime Due to Unnecessary Process Shutdowns
Reduce Process Information Overload on Operators & Engineers
Maintain Better Quality Control of the Desired Process & Products
Capture and Retain Process Knowledge Spread Across Plant Personnel
The optimization software shall support the following features on a minimum:
The real time process optimization software in conjunction with SCADA should comprise of a single source means for complete, multi-level real-time auditing and diagnosis of Plant process performance. It should continuously audit plant operation to identify areas and assets (instrumentation, control loops, equipment, unit operations, etc.) that are not performing properly.

7.14.4. Process Sensor Data Validation and Reconciliation

The software in conjunction with SCADA should use method of minimal evidence diagnostic logic to validate process sensors and audit unit operations
Single & Multiple Fault Analysis
The optimization software in conjunction with SCADA should use method of minimal evidence diagnostic logic to identify either single or multiple process sensor and unit operation problems or abnormal process conditions

7.14.5. Statistical Process Control Capability

The optimization software in conjunction with SCADA should incorporate SPC functionality (Exponentially Weighted Moving Average.-EWMA) with alert capabilities for either continuous or batch processes and for performance equations

The optimization software in conjunction with SCADA should also provide timely information for improved reliability, process optimization, product quality improvement, cost reduction and critical business (financial, operations, etc.) process reporting & evaluation

All screens (advisory, reports, and charts) should be auto-generating from the point list to be audited. This will eliminate any additional interface programming costs during initial setup and continued maintenance of the system.
The optimization software in conjunction with SCADA should be designed in such a way to reduce cost, time, and resource commitment required to install and maintain these applications, allowing for a quick return on investment.
It should be compatible with Industry standard technology (XLM, OPC) to take the data from the plant/process to the desktop, making it available for use by ERP, PLM, PAM and other applications
It should also provide redundant soft sensors that could be used via manual set point control if for any reason the actual meters are reading incorrectly.
The optimization software in conjunction with SCADA software should operate either as a standalone system or run as a web service with advice and information screens as web clients capable of messaging to pagers, cell phones, etc. The flexibility should allow it to be directly incorporated into most common distributed control systems and ERP systems.
It should also be self-documenting. The entire configured process should be able to be cross referenced in an HTML report.
It should also be web-based. It also needs to be secured using standard NT security to make remote access to data and information both easy and secure.
The optimization software should take tools that are normally used offline by these groups, such as Excel, SQL, crystal reports and incorporates them into a comprehensive online auditing and advisory suite. These tools include advising, charting, executive summaries, reporting, key performance indicators, and soft sensor.

7.14.6. Monitoring and Alarms

The operator shall be able to monitor all of the information at the workstation. He shall be able to view active equipment information on a series of VDU based graphical and tabular displays.
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.

7.14.7. Data Archiving

The Microsoft® SQL Server 2000 database system must be provided for managing the archives and the system parameters. In addition to the required scope of performance of the databases, the capability for modifying or creating new applications must be considered by the customer in the licenses offered. The selected database system and the tools needed by the contractor within the scope of the database application must be named in the bid.
Continuous process (analogue) data, digital event states, alarms and operator actions shall be archived to a removable media system. The archive media shall be sized to store logged analogue data, at a maximum sample rate of 15 minutes for a period of 15 months. Data recording shall be on dual media. The archive system shall generate an alarm when a file is 75% full.
Analogues will be stored at a rate selected by the operator in the range 1 second to 1 hour. The operator shall have the facility to select the way in which an analogue is stored. The system will provide any combination of the following:
a. Instantaneous value.
b. Average value.
c. Maximum value.
d. Minimum value.
e. Not stored.
Maximum, minimum and average values shall be calculated over a period set by the operator in the range 15 minutes to 24 hours, the default shall be 1 hour.
The logging of new data and reception of alarms must be carried out at the same time as the operator is viewing archived data. Any alarms received must be displayed as an overlay on the visual display unit.

7.14.8. Mimic Displays (Mimics)

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.

7.14.9. Trend Displays

Archived values (instantaneous values or compressed values) can be displayed as curves and in tables on the screen and in reports. The colors and pattern indicate, for example, overshot limits, substitute values, faults and time jumps. Like the message window, the curve window also has a toolbar for curve controls. A quick help explains the meaning of the individual icons. Individually designed keys can also be configured and saved with the associated operating functions. For authorized operators, it is also possible to change the parameterization online, i.e. to change the colors of the curves or to regroup the groups.
Access to the archives is supported by targeted, direct selection of measuring point groups, measuring points and individual measured values. The selection can be made via names or time windows. The values of an display section can be focused on in detail using the reading line and zoom function. The scaling of the time axis and value axis is adjusted accordingly and the curve values for the display are interpolated. For a curve window, a shared or separate axis can be configured for each curve with a different value range. Limit violations should be identified by a configurable color change when displayed in the curve window.
Horizontal and vertical "recording directions" of the curves can be set by the configurable direction of the curve display, which makes a recording function possible. Compared to the normal curve display, the x axis and y axis are interchanged by means of the recording function. The y axis is used as time axis. With the recorder function, you can also determine whether the current time is counted down on the upper or lower edge of the curve window. If several curves are displayed at the same time, the control system should also offer the facility for staggering the curves. This setting displays the curves that are to be displayed in a curve window one above the other. For each trend, a value range that is to be displayed can be set for the Y axis.
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.

7.14.10. Manual Data Entry

1. The system shall be provided with facility for entering data manually via the keyboard. This data will fall into two types:
a. Constants which will be changed infrequently. This data may have time and date associated with it. b. Maintenance related comments.
Manually Corrected Data
The system shall allow a person with authorized access to correct manually, erroneous data via the keyboard.

7.14.11. Reports

There shall be a real time spreadsheet facility supplied and installed by the Contractor in the master station. The users shall be able to transfer data from either the archive system or live data to the spreadsheet. The user shall be able to produce daily, weekly, monthly and annual reports using any data and a mixture of formats (tables, graphs, summaries, spreadsheets). It shall be possible to generate reports, either automatically at predetermined intervals, or manually on demand by the Operator. Typical reports on a minimum would be:

a. Flow rates and total.
b. Failures of equipment.
c. Analytical instrumentation parameters, Electrical parameters
d. Tank levels.
e. Discharge pressures.
f. Maintenance schedules.
g. Process alarm conditions.
h. Chlorination equipment status etc.

7.14.12. Profiling

From an average, typical or manually entered plot, it shall be possible to set an exception profile whereby readings within an upper and lower level are acceptable. Profiles shall be set graphically via OW. The user may select for the system to alarm if the reading is outside the profile and highlight such exceptions as part of a report, thereby reducing the need to examine all data, to ensure acceptability. The number of exceptions shall be logged.
Data Manipulation
It shall be possible to perform simple mathematical functions on any data, including the following functions:
a. Addition
b. Subtraction
c. Multiplication
d. Division

e. Square root
It shall be possible to log, display or use in a control loop, the resultant data.
Database Query Facilities
The system shall support the use of database relationships and wild card characters to provide database query facilities. It shall be possible for applications integration to configure queries easily and save them for future use. Support of Dynamic Data Exchange (DDE) or Structured Query Language (SQL), to permit data exchange between the DCS and external applications, including spread sheets and databases.
Data shall be presented in tabular format and contain any combination of fields from the main system database. It shall be possible to manipulate the data by specifying search and sort criteria to define data range limits. Once a query table has been created, it shall be possible to store the configuration and initiate successive look-ups, using a point and shoot technique.

7.14.13. Downloading IO Configuration

It shall be possible to download configuration to the IO's from the Engineer's terminal and the Portable Programming Unit (Laptop)

7.14.14. 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.

7.14.15. Security Access Levels

The functions available on the system shall be fully flexible so as to allow users access levels to be customized by the system operator, to suit individual user requirements.
Access to management and engineering levels shall be restricted by user selectable passwords or software key switch. The security systems shall be based on a set of privileges, which may be granted or denied to individual uses by the system operator.
The security/access levels would be divided between engineers, supervisors and operators.
The system shall be protected from un-authorized changes to the operating system and application programs.
The system shall prevent un-authorized users from re-booting the system or aborting or suspending system-related programs.

The system shall provide three levels of operator access to the system as a minimum, with the first level permitting access to viewing selected plant conditions as described below and the highest level intended for the system manager.
A mechanism shall be provided which prevents users operating at a lower level from accessing functions assigned to a higher level.
The system shall provide a password-protected, user log-on facility for definition of the user access level. It shall be possible to define a minimum of eight privilege levels.
Passwords entered during the log-on process shall not be printed or displayed.
The software shall monitor the actions of the user currently logged on at each node and shall log the current user off after a definable extended period of no operator interaction with the system and produce a printed log-off message.

Logging off of the user shall not shut down the system.
CTRL-ALT-DELETE function of the windows operating system should be disabled to prevent un- authorized use of 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 Employers Engineer:

7.14.16. Default level

The default level shall permit users to view all displays except those specifically assigned to a higher level of access.

7.14.17. Operator level

The operator level shall permit authorized 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.
System manager level
The system manager level shall permit authorized users to access default level and operator level activities in addition to the following:
(a) Modify alarm and control set points, dead bands and time delays;
(b) Enter or modify historical data;
(c) Add, delete or modify individual I/O points or point attributes;
(d) Add, delete or modify field device configurations;
(e) Create, delete or modify control algorithms;
(f) Create, delete or modify graphic displays;
(g) Create, delete or modify system reports;
(h) Configure trend displays;
(j) Access the operating system;
(k) Assign access levels and user passwords;
(l) Perform any other system maintenance function

7.14.18. Programming

The method of programming will depend upon the Manufacturers system requirements. However, the following standards shall be followed:
a. All programs 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 programs shall be tidy in format and logical to follow. Programs should be extensively annotated with comments and be self-documenting.
c. The system shall be supplied with programs that use a high level language for the OW.
Multilingual Configuration Environment

A software version of the PLC system and HMI must support at a minimum the language, English. The user must be able to change back and forth between the different languages supported in the configuration environment and operator production mode without having to retranslate his application for this.

7.14.19. Program – 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.

7.14.20. MIMIC Panel

A minimum 60‖ LED screen with necessary CPU shall provide an elementary full colour pictorial flow diagram display of the water supply scheme and treatment plant including points at which chemicals are injected. The mimic shall also include displays of process values e.g. reservoir levels, process flows, water quality etc. Mounting of LED mimic panel shall be as approved by Employers Engineer.
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 (i.e. the backwash of a particular filter)
Control Room Furniture (System Console)
In addition to the SCADA/MMI system equipment, the Contractor shall provide furniture (system consoles) to complement or match both the colour and styling of the equipment. Control room furniture shall comply with relevant IEC standards for ergonomic design. System console shall be so designed to house all servers, workstations. Monitors, interface equipment with cables having back entry. Details and design of system consoles shall be submitted to the Employers Engineer for approval.
Typically, The Contractor shall provide two fabric-covered upholstered swivel-type adjustable arm chairs with casters, a rigid and lockable steel cupboard for the storage of operating and maintenance manuals, drawings, logger paper, charts, disks and the like.
The visual display unit consoles or VDU desk shall incorporate at least one drawer unit with drawers for operator’s use and for standard files.

7.15. TESTS ON LOCAL SCADA SYSTEM

The following tests for various items of local SCADA system including power supply system shall be carried out as a part of FAT in addition to other tests indicated by Contractor in FAT document.

Functional

All cubicles shall be energized and the power supplies tested on the panel and internal lighting arrangements examined.

The boards shall be examined to check that there are no Status Error LEDs lit.

The peripherals like printers etc. shall be energized and proper operation of peripheral checked by self tests on equipments which have the facilities and others like VDUs, by connecting them to the system.

The system I/O shall be simulated and checked upto SCADA system database.

By varying the different inputs at random and checking to ensure that right status reporting is done on the SCADA system, the healthiness of all channels shall be checked with rated load connected.

Displays : The following shall be functionally checked

Mimic display: Symbols, colors, for correct/ approved format etc.

Control Operations: Simulated command operations from SCADA without any malfunctioning.

Status changes: Representation of open/close facility and mode of operation

Variables: Engineering units, updating representation

Events and alarms: Generating of alarms, events by verifying inputs at random, color code, formatting, and printing

Trend: proper selection, presentation under different time scales and printing

Reports: Reports shall be checked for correct/ approved format, logging intervals, printing intervals, data accuracy etc.

7.15.1. Response Time Checking:

System response time shall be tested after simulating the full I/O and Man machine interface system. Time taken from object status change to the presentation of object status on the display.

Time taken to generate and display single alarm and multiple alarms (upto 50) from the time of alarm condition.

- Time taken to display a complex picture with all variables from the time of calling the display.
- The accuracy of alarms on VDU and printer.
- Time stamping accuracy between SCADA and PLC times.

7.15.2. Other Tests on local SCADA

Fail safe operation of local SCADA system during total (including battery) backed power failure and restoration.

Fail-safe operation during on-line connection and removal of hand held maintenance unit, if any.

Check of detecting and reporting of failure of subsystem connected to the network on VDU status display.

Check of error free data transfer on Communication system along with modems/communication interfaces.

Check of hard copy unit functions by printing of process pictures.

Check of maintenance, backup (logic/programs, IO database, historical database, system configuration etc.) functions by connecting them to the system.

7.16. INSTRUMENT CONTROL PANEL (ICP) / CONTROL DESK

7.16.1. General

Control Panel shall be CNC machine prefabricated out of CRCA sheet steel of thickness not less than 2 mm, modular in construction, properly reinforced, powder coated and having rigid frame structure.

Internal mounting plate including the gland plate shall be 3 mm thick. The control panel shall have dimensions as per system requirement. However, the control panel height shall not exceed 2200 mm. The exterior corners and edges shall be rounded to give a smooth overall appearance with projections kept to a minimum.

Lifting lugs shall be provided for installation purposes and shall be replaced with corrosion resistant bolts after installation.
Control Panel shall be completely metal enclosed and shall be dust, moisture and vermin proof.
Control Panels and instrument enclosures shall provide a degree of protection as follows:
Indoor Installation: IP 52
Outdoor Installation: IP 65
Control Panel shall be free standing type. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation.
Metal sills in the form of metal channels properly drilled shall be furnished along with anchor bolts and necessary hardware for mounting the control panels. These shall be dispatched in advance so that they may be installed and leveled when concrete foundations are poured.
Cable entries to the panels shall be from the bottom with fire retardant spray compound sealing.
Control panels shall be provided with louvers along with washable micron filters AIRIN – AIROUT fans. The control panels shall be designed for front as well as rear access.
The CP shall provide separate areas for the PLC, internal power distribution, instrumentation, field cabling termination and for Surge protection devices (SPDs).

7.16.2. Mounting

All equipment on front of panel shall be mounted flush or semi-flush. In case of semi-flush mounting, only flange or bezel shall be visible from the front.
Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment.
Equipment mounted inside the panel shall be so located that terminals and adjacent devices are readily accessible without the use of special tools. Terminal markings shall be clearly visible.
Cut-outs and wiring for free issue items, if any, shall be according to corresponding equipment manufacturer's drawing. Cut-outs, if any, provided for future mounting of equipment shall be properly blanked-off.
Wherever required, panels/desks shall be matched with other adjacent panels/desks in respect of dimensions, color, appearance and arrangement of equipment on the front.
Earthing for Instruments

The panel shall be equipped with an earth bus securely fixed along the inside base of panel.
All metallic cases of relays, instruments and other panel mounted equipment shall be connected to the instrument earth bus.
Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken shall not be permitted. However, looping of earth connections between equipment to create alternative paths to earth bus shall be provided.
A separate instrument earth bus will be created which will be floating and all the cable shields will be terminated onto this bus. This bus will be connected to an electronic earth pit.

7.16.3. Frame Earthing

All metal parts other than those forming part of an electrical circuit shall be connected to a copper earth bar run along the inside bottom of the panel. The minimum section of the earth bar shall be 25 mm x 3 mm. A 15 mm diameter hole is to be provided at each end of the bar. Connection of the earth bar to the station earth shall be carried out by Contractor.

7.16.4. Space Heater

Strip type space heaters of adequate capacity shall be provided inside control panels to prevent moisture condensation on the wiring and panel mounted equipment when the panel is not in operation. The heaters shall operate on 230 V AC. Heaters inside the panels shall not be mounted close to the wiring or any panel mounted equipment. The operation of heaters shall be controlled by thermostats.

7.16.5. Interior Lighting and Receptacles

Each panel shall be provided with a CFL lighting fixture rated for 20 watt, 230V, 1 phase, 50 Hz supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by door switch or manual switch. Each panel section shall be provided with separate lighting.
Each panel shall be provided with 230V, 1 phase, 50 Hz, combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indication. The receptacle with switch shall be mounted inside the panel at a convenient location. If the panel has front and rear doors then maintenance socket shall be provided at both locations.

7.16.6. Voltage Level and Power Supply Units

The incoming power supply to the control panel shall be 230 VAC, 50 Hz. Contractor shall provide necessary transformers, converters, inverters and other associated hardware required to generate the requisite power supply. Generally, voltage levels for control schemes and power supply for instruments shall be 24 V DC. Power supply to all the instruments mounted outside the control panel shall be provided from the power supply units in the control panel. In case the instruments require power supply other than 24 V DC, the Contractor shall provide the necessary convertors. The power supply to all the instruments shall be without interruption and shall be continued even in case of failure of 230 V A.C. power supply. The battery and battery charger shall be provided for this purpose and sizing of the same shall be based on the entire load of instrumentation system.

7.16.7. Labels

All the equipment mounted on the front face of control panel as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Also the panel shall be provided at the top with a label engraved with panel designation.

7.16.8. Switches and Miniature Circuit Breakers (MCBs)

Each control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Miniature Circuit Breakers (MCBs).

Potential circuits for relaying and metering also shall be protected by MCBs. All such MCBs will be provided with an auxiliary contact to be used for providing MCB tripped alarm.

7.16.9. Intra-Panel (Panel Internal) Wiring

Connections within a panel, between panel mounted devices and terminal blocks or between two panel mounted devices will be made by 660 volt grade, stranded copper conductor insulated with PVC and designed for a minimum conductor temperature of 90 degrees centigrade. The wires shall be shielded, where necessary.
Panels shall be supplied completely wired internally, with a color coding scheme decided mutually between the Department and the Contractor, to equipment and terminal blocks and ready for external cable connections at the terminal blocks.
Wires within the panel shall be continuous i.e. without splicing and shall comprise stranded copper conductors. Internal wiring or wiring between the two assemblies shall be commensurate with mechanical safety. Prefabricated cables with moulded multipin connectors shall be used.
Wire termination shall be made with solderless crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules, marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit of breaker or device, shall be distinguished by the addition of a red colored unlettered ferrule.
Relay modules with plug-in type relays and having multipin connector facility shall be used.

7.16.10. Terminal Blocks

Terminal blocks for power connection shall be 660V grade, 20 amps rated, one-piece moulded, complete with stud type terminals, washers, nuts and lock nuts and identification markings. Terminal block design shall include a white fibre marking strip with clear plastic, hinged terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams. All control output terminals will be fused type and all other input signal terminals will be clip on shrouded type.

All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.
There shall be a minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be a minimum 250 mm.
Panel internal wiring shall not be looped directly from instrument to instrument. The same shall be looped through the panel terminal block only.
If accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

7.16.11. Cable Supports

All external cables shall present a neat appearance and shall be suitably braced, placed in troughing clipped or laced to prevent effects of vibration.

7.16.12. Terminal/ Identification

Every terminal and test plug shall be uniquely identified within the terminal cabinet by means of a terminal number. Appropriate labels shall be used to permit quick and unambiguous identification of each terminal and test plug.
Painting of Control Panel/ Control Desk
The steel sheets of the control panel shall undergo 7 tank treatments prior to powder coating.
a) All sheet steel work shall be phosphated in accordance with the following procedure:
I The pre treatment shall be hot process with running water for rinsing.
ii. Oil, grease and dirt and shall be thoroughly removed by emulsion cleaning.
iii. Rust and scale shall be removed by trickling with clean water followed by final rinsing with dilute dichromate solution.
b) The control panel shall be powder coated with minimum thickness of coating of 60 microns. QA test certificate shall be furnished for thickness adhesion and hardening of powder coating.
Instrument Control Panel (ICP) shall be subjected for the following dimensional checks
- Width
- Height
- Depth
- Cut-out dimension for each panel mounted instrument
- Spacing between the panel mounted instruments

(c) High Voltage (HV) test for ICP
The HV test of 1 kV AC for one minute duration shall be implemented between the ICP and the individual power supply feeder which shall be isolated from the respective power supply. Any reduction in voltage level or duration is not acceptable.
(d) Insulation test for ICP
Insulation test shall be carried out using a 500V megger as specified below (all instruments shall be disconnected from wiring)
i. Between individual terminal of terminal block and ground
ii. Between individual wire and ground
iii. Between adjacent terminals of terminal blocks

The acceptable indigenous makes for panel enclosures are Rittal , Enclotek. The acceptable control panel manufacturers are Siemens, Sai Technologies, Schneider, Tata Honeywell or equivalent as approved by Employers Engineer.

7.17. CONTROL SYSTEM

a) The control systems shall be designed for fully automatic operation of the pumping systems and water supply system. However, in the event of failure of the automatic controls or by operator choice it shall be possible to revert to either semi-automatic or manual operation of each item of Plant independently of the PLC function. Facilities shall be provided in the control system for remote operation of equipment.
b) The control systems shall be designed to recover fully to a normal operational state on restoration of power, following a power failure, without manual intervention. This requirement includes recovery from the H.T. failure as well as the control system power failure.
c) The site instrumentation shall also form an integral part of the control system and shall be executed on a turnkey basis by an system integrator.

7.17.1. DUTY / STANDBY DRIVES

The duty pump for each duty / standby pair shall be selected at the local control panel and the Plant HMI.
The control logic shall automatically start an available standby in the event of the duty drive failing. The new duty drive shall take on the role of duty drive in all respects and shall continue to run as duty until manually reselected to standby or it fails.

7.17.2. INTERLOCKING

Hard wired interlocking shall be provided for safety circuits such as:
Motor protection;
Run dry protection;
Emergency stop circuitry;
Rotation monitor.

In addition drives stopped as a result of the action of hardwired interlocks shall in addition have a fault signal conveyed to the drive in order that the PLC drive run output is removed. Soft wired interlocking is provided by the PLC for process control and for safety trips when the signal is derived from a remote source.

7.17.3. CONTROL PANEL POWER SUPPLY

The primary power supply for the control panels for control centre shall be derived from the respective LV switchboard at 240 V AC. The voltage level for control schemes and power supply for the instrumentation and control system shall be 24 V DC. The 24 V DC shall be derived from 230 V AC from LV switchboard. The 24 V DC power supply system at central control centre shall cover the following items:
(a) Sealed maintenance free (SMF) batteries
(b) 24 V DC rectifier unit with float cum boost charger for 24 V DC battery

(c) DC distribution board.

The batteries shall be sized to provide sufficient power to maintain the instrumentation and control system of the pumping stations / water treatment plant equipment functioning for a period of 1 hour. The battery shall have maximum recharge time of 8 hours. The control supply voltage for all the control panels and field instruments shall be derived from the battery and battery charger. For detailed technical specification (except the output voltage level) of battery and battery charger refer electrical specifications.

7.17.4. UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

a) Contractor shall provide Online Uninterruptible Power Supply (UPS) System with One Hour back-up time at full load for the local PC based SCADA systems. Contractor shall clearly indicate the offered UPS rating in the bid document.

b) The UPS shall be floor mounted, self contained and metal clad.

c) The UPS shall be incorporating a six pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch that shall operate in event of UPS failure, overload or manual initiation in order to transfer the output supply to mains without disturbance to the output supply.

d) The batteries used for power supply system shall be rechargeable, Sealed Maintenance Free (SMF) Lead Acid type. The battery supply to the UPS shall be via a fused load break switch dis- connector circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load.

e) The various alarms and status parameters of UPS system shall be made available to the local SCADA system(s) for monitoring purpose using RS-232 serial communication port provided in UPS offered.

f) Software for shutdown of the PC in case mains power supply is not restored shall be provided as a part of the UPS.

g) Total Harmonic Distortion (THD) of UPS shall be less than five percent and any single harmonic distortion shall be less than three percent.

h) After a dip or failure of the supply, the rectifier controller shall ramp up the DC voltage slowly.

i) Designing of all power supply items shall be as per the latest national/international standards such as IS, BS and IEC. Employer has right to reject the system at any time, if standards are not met by the Contractor. Contractor shall clearly indicate the standards.

j) Power supply scheme and all design calculations for selection of UPS and Battery capacity shall be furnished by the Contractor in detail along with the bid document.

k) Based on the three phase 415 VAC power supply available at site all required AC/DC voltages for SCADA and Communication system etc. shall be derived from this supply and proper isolation, earthing and safety requirements as per Indian Electricity (IE) Rules shall be complied by the Contractor.

l) Contractor shall provide required and sufficient nos. of AC and DC feeders for the PC based local SCADA system. At least 2 nos. of spare feeders shall be provided in AC, DC system.

m) The Uninterruptible Power Supply (UPS) System with SMF Lead Acid battery shall conform to the minimum following specifications:

Sr. No.	Description	Technical Particulars
1.0	UNINTERRUPTIBLE POWER SUPPLY SYSTEM (UPS)	Required for SCADA and Communication systems
1.1	Rated Power at PF = 0.7	Contractor to design and indicate
1.2	Input Voltage	240 VAC Single phase to be made available by Contractor from 415 VAC +/- 10 %, 3 Phase, 4W, 50 Hz +/- 5 Hz made available at one point at site
1.3	Allowable variations in input	
a)	Voltage	+/- 10 %
b)	Frequency	+/- 5 %
c)	Combined voltage and frequency	+/- 10 %
1.4	Output	
a)	Voltage	230 VAC, Single phase
b)	Frequency	50 Hz +/- 0.5 % (free running) and +/- 3% (Sync mode)
c)	Regulation	Less than +/- 1 %

7.17.5. TESTS ON UPS SYSTEM:

UPS system of local SCADA system shall be tested at manufacturer‘s work and also at site for its performance, functional and operation requirements.

Following are the tests to be carried out.

Voltage regulation 0-100 % of load

Load test, current limiter operation
Output voltage variation
Ripple and harmonic measurement
Efficiency and power factor
Megger and HV test for insulation
Heat run
Functional tests
Alarms and self diagnostics tests
Communication with local SCADA system

7.17.6. CONTROL SYSTEM VOLTAGES

Description	Voltage
Instrumentation power supplies	24 V DC
PLC input-output modules	24 V DC
PLC input-output circuits/loops	24 V DC
SCADA System	230 V AC (UPS)

7.17.7. CONTROL SYSTEM PROTECTION

All circuits shall be protected against short circuit by the provision of adequate numbers of miniature circuit breakers.
For ease of maintenance and system security power supplies to each instrument loop and each PLC module shall be protected with an individual MCB.
Suitable earthing shall be provided for all the control panels. The same shall be connected to electrical earth.
Earthing shall be provided for electronic equipment and shall be connected to electronic earthing arrangement. The same shall be separate from electrical earth.

7.17.8. Cabinets for Field Instruments

Cabinets shall be provided for enclosing instruments and associated accessories which are mounted outside the control panel such as transmitter, SPDs, terminal blocks etc. at all measurement locations. It shall be fabricated from cold rolled steel with powder coating sheet of standard gauge and shall be suitable for wall mounting or pedestal mounting as required.
The cabinet shall be properly powder coated from inside by white paint and powder coated from outside by shade RAL 7032.
The cabinet shall conform to IP-65 protection and shall have built in locking facility. The cabinet shall be earthed properly. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

Instrument Power Supply Cables and Instrumentation Signal Cables
Contractor shall include in his scope the supply and laying of instrumentation signal and instrument power supply cables and associated civil / mechanical work required for completing the system.
Cables shall be capable of satisfactorily withstanding without damage, transportation to site, installation at site, and operation under normal and short circuit conditions of the various systems to which the respective cables are connected when operating under the climatic conditions prevailing at the site as indicated in this specification.
Cable joints in instrument signals and power supply cables shall not be permitted.

Cables shall be capable of satisfactory performance when laid on trays, in trenches, conduits, ducts and when directly buried in the ground.
Cables shall be capable of operating satisfactorily under a power supply system voltage variation of ±15%, a frequency variation of ±5.0%.

7.18. INSTRUMENTATION CABLES

7.18.1. CABLES FOR DIGITAL SIGNALS

660V/1100 V grade multicore cables, multistranded high conductivity annealed 1.0 sq.mm stranded tinned copper conductor, extruded PVC insulated, overall screened with braided wire or with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium tape, inner sheathed with extruded PVC, armoured with galvanized steel wire overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

7.18.2. CABLES FOR ANALOG SIGNALS AND SIGNALS FROM TEMPERATURE SENSORS 660 V/1100 V

annealed, tinned, high conductivity 1.0 sqmm stranded copper conductor extruded PVC insulated two/ three cores twisted into pair/ triad, laid up collectively, individual pair/ triad shielded and overall shielded with wire braiding or aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanized steel wire, overall sheathed with extruded PVC conforming to IS:1554 and IEC:189 Part II.

7.18.3. LAYING OF CABLES

A distance of minimum 300mm shall be maintained between the cables carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between signal cables and HT cables. In outdoor areas, the cables shall be directly buried. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for Employer's Representatives approval.

All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. A loop of 1 meter shall be left near each field instrument before terminating the cable.
Cables shall be complete uncut lengths from one termination to the other.
All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules. Identification tags shall be securely fastened to the cables at both the ends.
Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.

7.19. JUNCTION BOXES

In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes.

The junction boxes shall have weather protection suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled. Junction boxes shall be constructed of die cast aluminium / CI and provide degree of protection IP 65. Separate cables shall be used for digital and analog signals.
Wires and terminals for the digital and analog signals shall be segregated within junction boxes. Also wires and terminals for AC and DC signals shall be segregated within the junction boxes.

7.20. CCTV SYSTEM

Proposed CCTV system shall be an open standard based integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.
System shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors at Central Control Room/local control rooms and simultaneously record all the cameras after compression using MPEG 4 or better standard. Joystick or Mouse-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.
System shall have combination of Digital CCD Colour video Cameras with individual IP address, analog CCD Colour Video Cameras with Fixed or P/T/Z Lens, encoders / decoders, Network Video recorders (NVR/CAMERA SERVER), Network attached storage (NAS) / Raid backup device for recording, Application software, Colour Video Monitors, Keyboards with Joystick controllers / Mouse-Keyboard, software based Video Matrix Switcher, workstation for System Administration / Management / Maintenance etc.
The NVR / CAMERA SERVER can be embedded type or server based. However the NVR / CAMERA SERVER software shall run on common off the shelf available servers (Camera server & Database server). Each NVR / Camera Server shall be able to handle 12 or more cameras.

Network Video Recorder shall offer both video stream management and video stream storage management. Recording frame rate & resolution in respect of individual channel shall be programmable.
System should ensure that once recorded, the video cannot be altered, ensuring the audit trail is intact for evidential purposes.
System shall provide sufficient storage of all the camera recordings for a period of 30 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras (extended capacity of cameras i.e. present capacity + 25 %).
System shall use a combination of IP enabled cameras & analog CCD cameras with external encoder. The video shall be compressed using MPEG-4 or better standard and streamed over the IP network.
Encoders shall digitize analog video, compress the digital video using various compression algorithms (MPEG - 4 or better standard), and transmit the compressed digital video over packet- based IP network. Encoders shall have less than 200 ms of latency and shall support dual stream – MPEG 4.
The recording resolution and frame rate for each camera shall be user programmable.
The Area under surveillance shall be monitored and controlled from Central/Local Control Room(s) through workstations and Joystick controllers.
Surveillance CCTV System shall operate on 230 V, 50 Hz single -phase power supply.
Power for all the equipment shall be conditioned using on-line UPS with minimum 30 minutes or more back up. If any equipment operates on any voltage other than the supply voltage and supply frequency, necessary conversion/correction device for supply shall be supplied along with the equipment
All the control equipment e.g. servers, NVR/CAMERA SERVER, NAS/Raid backup device, decoders etc. shall be provided in standard Racks.
All the indoor cameras & control equipment shall be suitable for operation from 100 C to 400 C and relative humidity up to 80 % non-condensing.
Cameras & other equipment, meant for outdoor installations, shall be suitable to work from (-) 10o C to (+) 50o C with RH up to 90% non-condensing.

7.20.1. System requirements

Camera with external encoder or IP Camera shall be used for image capture.
Indoor cameras shall be either with fixed focal length lens or with Pan/Tilt & Zoom lens as per site requirement. All outdoor Cameras shall be Day/Night cameras.
Housing of cameras meant for indoor use shall be of IP 42 rating whereas outdoor camera housing shall be of IP 66 or better rating. These must be integrated by the camera manufacturer.
System must provide built-in facility of water marking or Digital certificate to ensure tamper proof recording so that these can be used as evidence at a later date, if so desired. The recording shall support audit trail feature.
All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.
Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.
Facility of Camera recording in CIF, 2CIF, 4 CIF as well as in any combination i.e. any camera can be recorded in any quality – Selective or Group of cameras must be available in the system.

System shall have facility of additional camera installation beyond the originally planned capacity.
In order to optimize the memory, while recording, video shall be compressed using MPEG-4 or better standard and streamed over the IP network. Once on the network, video can be viewed on a Control room workstation or on analog monitor using a hardware decoder (MPEG-4/compatible standard Receiver) and shall be recorded on NVR/CAMERA SERVER and shall be backed up on NAS/RAID Backup device.
System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.
The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

PTZ Cameras shall have 64 or more pre-defined positions, to be selected through suitable input alarm.
System shall have provision of WAN connectivity for remote monitoring.

7.20.2. System design

Each camera should be connected to a Hardware Encoder, through cable, which shall support minimum dual streams. Alternatively, the camera shall be IP based, UTP ready. The encoders should be capable of producing streams @ 25 fps for each camera for viewing on LAN and on monitors and also recording into the NVR/CAMERA SERVER/Camera servers and NAS box/Raid backup device @ 25 fps or lower frame rate, user selectable as per requirement, for each individual camera.
Encoders shall be Power over Ethernet (POE) compliant and connected to Layer 2 or Layer 3 switch as per system design using UTP CAT 6 Cable or fiber optic cable and the required connectors as per standards.
For monitoring purposes, Video monitors/Plasma monitors/Video wall shall be setup with suitable mounting arrangements, as per user requirements. Facility for viewing and controlling all the cameras
at various other locations, as required, shall be provided.
Monitoring at Local control rooms may be restricted to operation of certain cameras only & system administrator should be able to configure the system, accordingly.
There shall be a Control System with Video Control Software to manage all the video surveillance devices.

7.20.3. Video Surveillance Application Software

The software shall operate on open architecture for integration with perimeter safety, access control, PA and fire / safety systems based on open standards.
Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoders, video decoders, PTZ controller, NVR, NAS boxes/Raid backup device etc.
The software should have inbuilt facility to store configuration of encoders / decoders and cameras.

The software should Support flexible 1/2/4 Windows Split screen display mode or scroll mode on the PC monitor or on preview monitor as per site requirement.
The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.
The software should have user access authority configurable on per device or per device group basis. The user shall have the facility to request the access of any camera and can control the camera for a reservation period. Control of camera is released after the reservation period.
The system shall provide User activity log (audit trail) with user ID, time stamp, and action performed, etc.

The administrator should be able to add, edit & delete users with rights. It shall be possible to view ability / rights of each user or the cameras which can be viewed & controlled as per the permission assigned by the administrator.

It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.
Retrieval: The CCTV application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 30 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like CD/DVD/Blu ray Recorders or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system which can be audited at a later date.

7.20.4. DETAILED TECHNICAL SPECIFICATIONS

Image Device	Interline transfer 1/4" or better format CCD sensor
Focal length	4 mm to 72 mm or better
Optical zoom (For Indoor Camera)	
Optical zoom (For Outdoor Camera)	
Number of Pixels	720 X 576
Scanning System	PAL
Resolution	480 TVL or better
Illumination (For Indoor camera)	1.0 Lux (Color), 0.1 Lux (B/W) or better
Illumination (For Outdoor camera)	1.0 Lux (Color), 0.05 Lux (B/W) or better

Pan Travel	360º Continuous
Tilt Travel	0 - 90º
Manual Tilt Speed	0.5°/SEC to 90°/SEC
Manual pan speed	0.5°/SEC to 90°/SEC
Preset Tilt speed	0.5°/SEC to 90°/SEC
Preset Pan Speed	0.5°/SEC to 300°/SEC
Preset positions	Min. 64
Iris Control	Auto
Focus	Auto
White balance	Auto
Electronic shutter	Auto
S/N ratio	>= 48 dB
Power supply	As per OEM's design, however generally AC 230 V @ 50Hz/12V or 24 V AC Rectifier and SMPS if DC supply

7.20.5. MPEG4 ENCODER (HARDWARE BASED)

The encoder shall be built on embedded processor and real time operating system. The Encoder should convert Analog Composite/S-Video input into good quality digital stream on real time basis and shall be able to transmit as Unicast /Multicast IP packet with low latency (less than 200 msec.) for live viewing as well as for recording.
The video resolution should be configurable at either of 4 CIF, 2 CIF, CIF @ 25 fps or at lower frame rate per camera, user selectable.
The encoder should generate MPEG4 video stream Compliant with ISO/IEC 14496 standard. The encoder should be interchangeable with any standard encoder of any other make, which generates MPEG4 video stream Compliant with ISO/IEC 14496 standard.
The Encoder should have the following specifications or should match with the requirement.

Format	PAL color, B/W, composite, 25 fps, 2:1 interlaced
Resolution (H x V pixels)	4 CIF 704 x 576, 2 CIF , CIF, QCIF
Frame Rate	25 fps (PAL) and lower
Encoding	MPEG-4 Compliant with ISO/ IEC 14496 Standard

Video Parameters	Brightness, contrast, hue, sharpness, and sizing selectable
Video Latency	Less than 200 msec.
Connectors	BNC for Composite Video for input, suitable connectors for Power, Alarm in, and Alarm out, RJ-45 for Ethernet 10/100 Base-T output.
IP Address	Static IP Address or as per System requirement.
MPEG4 standard	Compliant with ISO / IEC14496
IP Packets	Unicast and Multicast
POE	Compliant
Power supply	As per OEM's design

7.20.6. NETWORK ATTACHED STORAGE

NAS box/RAID backup device shall be used to record video streams based on the configuration assigned by administrator. Workstations & Servers within the LAN should be able to access the recorded video streams. The NAS/RAID backup device should support simultaneous play back and recording at full duplex operation.
It shall provide a high quality recording storage and play back of images. It should support integration with LAN to provide Centralized Management and shall operate on Windows / Linux OS. Support of user management for security level control and authentication required.
The minimum capacity of storage device shall not be less than 2TB.

7.20.7. Camera Housing & mount

The camera mount should be:

- Of the same make as that of camera and suitable for the model number offered as specified by the manufacturer and should be an integrated unit.

- Should be compact and indoor / outdoor type as required. Should support the weight of camera and accessories such as housing, pan & tilt head in any vertical or horizontal position etc.

7.20.8. Speed dome controller/PTZ controller

Speed Dome Controller should have variable speed joystick, LCD display for Programming and it should be able to control the speed dome for PAN / TILT / Zoom.

7.20.9. Cables

Sr. No.	Connectivity	Cable Type
1	Camera to Video Encoder	Coaxial RG 6/U / CAT 6 / Fibre Optic
2	Video Encoder to Switch in control room	UTP CAT 6 / Fibre Optic
3	Switch to Video Wall Switches	UTP CAT 6 / Fibre Optic
4	From switches to NAS Box	Fibre Optic
5	Hardware Decoder to monitor	Composite signal cable

7.21. DRAWINGS FOR INSTRUMENTATION AND CONTROL AND LOCAL SCADA SYSTEMS

The following drawings for the instrumentation and control, SCADA and associated communication and power supply systems covered under this specification shall be submitted for review of Employers Engineer along with tender / BID and after the Award of Contract.

Sno.	Description	To be submitted with the Tender	To be submitted after the Award of the Contract
1	P&I Diagram	* (Preliminary)	* Final
2	Instrument list with tag numbers, range, sizes, makes and model numbers	* (Preliminary)	* Final
3	Data sheets and catalogues for all instruments, alarm annunciator and instrumentation and control cables	* (Preliminary)	* Final
4	Control Panel		
5	Overall dimensional drawing, fabrication details and Bill of material for the instruments mounted on the front facia and inside the control panel		* Final
6	Front facia layout showing all instruments with cut-outs and bezel dimensions, construction details and interior G.A. drawings for control panels/ consoles		
7	Wiring diagram with terminal details of each component, terminal block details, power supply distribution scheme with loads and bill of quantities of all panel mounted instruments for control panels/ consoles.		
8	Bill of material for the instruments	* (Preliminary)	

	mounted on the front facia and inside the control panel.		
9	Loop diagrams for all field mounted instruments. (The loop diagram shall contain tag numbers, terminal number, I/O address, cable no. etc.)		
10	List of alarms provided on alarm annunciator		
11	PLC & RTU System		
12	Input / Output list for PLC & RTU indicating grouping of various signals in each module		
13	PLC & RTU system configuration indicating interfacing	* (Preliminary)	* Final
14	PLC block logic diagram with descriptive control logic write-up and software program listing		
15	System hardware details along with bill of material for PLC & RTU system	* (Preliminary)	* Final
16	Screens of Operator Interface Unit (OIU)		
17	Installation sketches of instruments		
18	Battery and Battery Charger		
19	Front facia layout, overall dimensions, wiring diagram, indicating terminal details and bill of quantities for battery charger panels		
20	Calculation of Ampere Hour capacity for the battery backup		
	Catalogues and Data sheet	* (Preliminary)	* Final
21	I&C system configuration drawing indicating instruments, PLCs, RTU‘s and PC based local SCADA system	* (Preliminary)	* Final
22	Functional Design Specification containing summary of the Contractor‘s proposal for the sequence of operation and design intent	* (Preliminary)	* Final
23	PC based local and Master SCADA system		
24	Data sheet and catalogues for PC, printers and DAMS software	* (Preliminary)	* Final
25	Details of communication protocol and data structure		
26	Screens of the PC based Master and local SCADA system		
27	Catalogues, data sheet and sizing		

	calculations for UPS and battery for PC based Master and local SCADA system		
28	Detailed cable installation layout drawings indicating route of cables, type of laying, etc.		
29	Cable Schedules and Interconnection cable schedules		
30	Operation and maintenance manuals for PLCs, local and Master PC based SCADA system, battery and battery charger panel, UPS and all instruments		
	Control room layout drawing	* (Preliminary)	* Final
	Data sheets, catalogues, control wiring drawings with terminal details for motorized valve actuators.	* (Preliminary)	* Final
31	List of spares for I&C system, PC based Master and local SCADA system including power supply systems		
32	Operation and Maintenance and Instructions Manuals		
33	As built drawings		
34	Documents for system training		

7.22. INSPECTION AND TESTING REQUIREMENTS

7.22.1. INSPECTION, TESTING AND SETTING TO WORK — GENERAL

Each item of plant shall be subjected to the manufacturer‘s own tests which shall be certified. Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture. The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Employers Engineer, the correct operation of any item of plant and the Employers Engineer may witness any test. Tests which, in the opinion of the Employers Engineer, were failed or not performed correctly shall be repeated.
Before any test is made, the Contractor shall submit to the Employers Engineer a full list of test equipment to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Employers Engineer. Test equipment shall be checked frequently during the period of the tests.

The Contractor‘s staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense. The contractor

has to get approval from the client‘s representative for the training personnel to be employed by the contractor.
Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Employers Engineer before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

7.22.2. PRELIMINARY INSPECTION AND TESTING AT THE PLACE OF MANUFACTURE

7.22.3. FIELD-MOUNTED INSTRUMENTS

After the successful completion of the manufacturer‘s own inspection and testing of instruments supplied under the Contract, similar tests shall be carried out in the presence of the Employers Representative and the Contractor, if requested. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points.

7.22.4. INSTRUMENT PANELS, ENCLOSURES AND MOUNTING BOARDS

The manufacturer shall not present instrument panels, enclosures and mounting boards (assemblies) for inspection and testing until the manufacturer‘s own tests and inspection has been completed. A preliminary inspection and test of these assemblies may then be witnessed by the Employers Representative. The Contractor shall give not less than 7 days notice in writing that he has completed his tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.
The witnessed inspection and testing shall include the following:
a) A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
b) A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
c) That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
d) Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation; e) Power-isolation facilities meet the Specification;
f) The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
g) The output of all power supply units again at the beginning and end of the testing with results being recorded;
h) The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
i) The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the

insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
j) That the clean earth bar is isolated from main frame of the panel. Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification. Spare capacity within the panel(s) shall be checked to that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunkings and provision for additional cable entry.

7.23. FUNCTIONAL TESTING AT THE PLACE OF MANUFACTURE

7.23.1. General requirements

Once the preliminary inspection and testing is complete to the satisfaction of the Employers Representative, functional testing shall commence. The purposes of the functional tests are to demonstrate that instrument panels enclosures and mounting boards (assemblies) conform to requirements of the Specification.
Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Employers Engineer, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and witness signatures. All applicable drawings and data shall be provided at the place of inspection by the Contractor.
The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.
The following is a typical list of the equipment required:
• Switch boxes;
• Indicator light boxes;
• Analogue signal sources;
• Dummy loads;
• Meters;
• Simulators;
• Desk-top computers;
• Programmers for DCS or outstations;
• Insulation test equipment.
All tests as required, both at the factory i.e. Factory Acceptance Test (FAT) before dispatch, and at site after installation i.e. Site Acceptance Tests (SAT), shall be carried out. Detailed Test reports and certificates shall be submitted. Test reports and test certificates for bought out components shall be submitted for approval. These components shall also be included in the integrated FAT.
The list of tests to be carried for both FAT and SAT along with test instruments to be used shall be furnished with the Bid for review by the Employers Engineer. Contractor shall indicate the place of FAT and the test facilities available.
Prior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employers Engineers who would witness the testing.

In addition, testing done during manufacturing and assembly in the factory such as heat run, component testing, circuit testing etc. for similar equipment shall be demonstrated to the Employers Engineer.

7.24. Instrumentation and Control:

To ensure that a well-engineered and contractually compliant system is delivered by the Contractor, the Factory Acceptance Tests (FAT) shall be performed
Factory Acceptance Test (FAT-Applicable For Inspection Category A)
(a) A Factory Acceptance Test, which shall be witnessed by Employers Engineer, is required for the system. No equipment shall be shipped without written confirmation by the Employers Engineer that the system has successfully passed its factory acceptance test.
(b) The purpose of the FAT is to qualify the system as meeting all contractual requirements. The test shall verify the performance and functional integrity of the individual subsystems, including active interfaces between subsystems and shall demonstrate the proper operation of equipment/systems.
(c) Factory Acceptance Tests shall be conducted according to test plan with detailed test procedures. The test plan and procedures shall be submitted by the Contractor for review and shall be subject to approval by the Employers Engineer.
(d) In order to ensure that the FAT will be successfully and expeditiously completed, it shall commence only after the successful completion of a preliminary FAT (Pre FAT). The intent is for the Contractor to detect and correct most design, integration and performance problems before the Employers Engineer come to the factory for the FAT. The Pre FAT shall be supervised by the person designated to serve later as the Contractor's Inspector of the FAT, and each test shall be formally signed off by that person. The signed off test results shall be sent to the Employers Engineer for review before the Employers Engineer comes to Contractor's factory for FAT.
(e) A complete set of system documentation, including design and maintenance documents, user manuals and the test plan and procedures shall be available during the FAT.
(f) The list of tests to be carried for both Factory Acceptance Test (FAT) along with test instruments to be used shall be furnished for review by the Employers Engineer. Contractor shall indicate the place of inspection and the test facilities available.
i) The testing of all the equipment and accessories shall be carried out as per latest applicable Indian/International standards recommendations.
ii) Prior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employers Engineer‘s who would witness the testing.
iii) The FAT to be performed in the factory shall include but not be limited to following:
a) Tests for guaranteed technical parameters
b) Integrated functional tests
c) Burn-in tests
d) Hydrostatic tests
e) Calibration tests
f) Power supply variation test
g) Alarm/Diagnostic check

7.24.1. TESTS ON INSTRUMENTATION SYSTEM:

(a) Type Tests

The Contractor shall submit the test certificates for the 'Type Tests' to the Employers Engineer for approval. The type tests (as applicable) for the instruments shall be as follows:
'Burn In' test for electronic components
Humidity test for electronic instruments
Weather protection as per IS 13947
Hysteresis test
High voltage test
Short circuit protection test
Material test

(b) Routine Tests

All instruments shall be subjected to the routine tests (as applicable) mentioned below at the manufacturers works (Factory Acceptance Tests) to ensure correct functioning.

i. **Calibration of the instruments**
All the instruments shall be calibrated for accuracies as per applicable standards. The calibration shall be carried out at 0%, 25%, 50%, 75% and 100% of the range of the instrument in both increasing and decreasing directions. The instrument shall be acceptable if the accuracy and repeatability are better than those specified. The instrument used for testing shall hold a valid calibration certificate from a recognized laboratory.

(c) Over range protection test
All transmitters, digital panel meters, digital flow indicator cum integrator shall be subjected to the over range protection test.

(d) Performance test
All the instruments shall be tested by connecting to the specified power supply for the performance test.

(e) Power supply variation test

All the instruments shall work satisfactorily for the specified power supply variation. Accuracy and linearity shall not change.

(f) Hydrostatic test

All flow sensors and pressure sensors shall be tested to withstand 150% of the rated pressure. The sensitivity, accuracy and calibration of the sensors shall not deteriorate at this over-range. There shall not be physical damage.

(g) Repeatability test

All instruments shall be subjected to repeatability test over the full range at 0%, 25%, 50%, 75% and 100 % of the full range in both increasing and decreasing directions. Readings for each measurement mentioned above shall be taken for establishing the repeatability.

(h) Dimensional check

The dimensions of all the instruments shall be checked thoroughly and shall be tabulated in a good format.

i. Wherever applicable, following dimensions shall be checked/ noted

- Total length
- Insertion length
- Diameter
- Mounting head
- Process connection size etc.

ii. For panel mounted instruments and transmitters following dimensions shall be checked

- Width
- Height
- Depth

Bezel dimensions and cut-out dimensions for panel mounted instruments etc.

7.25. QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

QA/QC shall comply with the Contract, with particular requirements specific to the equipment or service being provided as outlined below for PLC 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.

7.26. TRAINING

The Contractor/ system supplier shall conduct training courses for personnel selected by Employers Engineer. 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 program, including reasonable per diem expenses to cover meals, lodging, transport and similar expenses for all the 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 program for approval, prior to shipment of the equipment. This submittal shall include a course outline; time required, course schedule, sample workbook and instructor qualification information for each level.

The 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 Employers Engineer in advance with the Contractor/ system supplier so as not to disrupt the Employer‘s ability to operate the plant.

7.26.1. OPERATIONS AND MAINTENANCE TRAINING

Training shall be provided for Ten (10) of the Employer‘s personnel or their representative at the Contractor/ system supplier facility on operations and maintenance of all Instrumentation & control components. The training program shall be divided into two segments and shall consist of at least 7 (Seven) working days, each of 8 (eight) hours duration.
The maintenance training program shall be developed for personnel that have instrument & 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
- 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
- Creation and editing of graphic operator display screens.
- Loading of any required software into the system.

7.27. INTERCOM SYSTEM

An EPABX system shall be provided at a control room for voice communication. Following locations are to be covered using single EPABX system:

- Main Control room in the Administration and Control Building
- All rooms within the Administration and Control Building
- The filter control block
- The laboratory

- The chemical house (chlorine room, point close to the chlorine storage area)
- The platform on the mixing chamber / main distribution chamber
- The filter operation gallery
- The pipe gallery of the filter house
- Bulk Chemical Storage Building
- The Clarifier control block
- Garage section / Parking
- Duty Rooms
- Canteen
- Security Cabins at the entrance of the campus
- Security Cabin at the entrance of the staff quarters
- Switchgear room
- PLC room

All instruments located for outdoor applications shall be _weatherproof type‘.
Following paragraphs describes the minimum requirements for the design, manufacture and application of the EPABX System. The purpose of this specification is to ensure consistency in selection, design and application of the EPABX System. Minimum hardware and application software requirements of these systems are defined. Contractor shall design, manufacture, test, supply, install, and commission the EPABX system in control room. Bidder shall make his own estimate of quantities for all items and subsystems such as cards, MDFs, IDBs, cabling, conduits, capping and casing, earthing, lighting protection, UPS, batteries auxiliary power distribution, labour work etc. it should be clearly understood that the Contract will be on turnkey (lump sum) basis and no variation will be allowed for items of works not foreseen or omitted by the Bidder. It is the responsibility of the Contractor to provide all labour, materials, equipment and services necessary and required to furnish and install a complete and operating

EPABX system. Any material not specifically mentioned in this specification, but required for proper performance and operation shall be included.

7.27.1. APPLICABLE STANDARDS

EPABX system shall comply with the requirements of International Telecommunications Union (ITU-T) - Telecommunication recommendations and relevant Indian/International applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

7.27.2. SYSTEM REQUIREMENTS

The proposed EPABX, power supply, all type of cables and accessories required to make the system complete shall cater to the voice and data requirement of the CRMC. Public Switched Telephone Network (PSTN) cables (suitable multi-core cable) from nearest PSTN exchange to CRMC will be arranged by the Employers Engineer and terminated on Main Distribution Frame (MDF). Contractor will terminate this telephone cables and Telephone cabling from MDF (including MDF) to EPABX and their distribution and termination up to extensions shall be in scope of Contractor.

The EPABX shall support analog, digital and ISDN extension, analog lines from PSTN, BRI level DID lines from PSTN, and BRI ISDN lines from PSTN.
EPABX shall be suitable for:

		Capacity	Equipped
a)	Call Office (CO) analog lines	8 numbers	3 numbers
b)	Call Office BRI ISDN lines	1 numbers	Nil
c)	Analog extensions	64 numbers	40 numbers
d)	Digital extensions	8 numbers	4 numbers
e)	Operator console	1 numbers	1 number
f)	Multi function interface card (PA system, relay and voice system)	1 card	Nil

g) EPABX offered shall support the voice mail system (min. 4 port PC based or 4 port in skin card based voice mail system, to be procured in future by Employer, if required). However, the offered EPABX system presently need not be fully equipped for voice mail
EPABX is planned for intercom purpose. The EPABX shall have centralized architecture. EPABX shall cater to the voice and data requirement within the CRMC premises and through trunk line from BSNL to outside world.

7.27.3. SYSTEM DESCRIPTION

The Exchange shall be modular and fully digital, using Pulse Code Modulation (PCM) and Time Division Multiplex (TDM) techniques conforming to ITU-T recommendations and shall be of Stored Program Control (SPC) type.
The Exchange shall support Integrated Services Digital Network (ISDN) and BRI level DID Extensions. EPABX shall also be capable to support VHF voice communication system, supporting
radio paging and calls on mobile phone. Limitation, if any, regarding maximum number of ports/cards supported shall be clearly brought out by the Bidder. All systems must have provisions that enable connection to Employers Engineer provided peripheral equipment such as a music-on-hold system, paging amplifier/speaker sound system, and automatic telephone answering equipment. The bidder is requested to specify all other peripheral equipment that may be connected to the system
The system platform shall be based on open system architecture. The EPABX shall accept DP (Pulse Dialing), DTMF (Dual Tone Multi Frequency), Digital Phones and Fax and shall also have support for interconnection with PA system, SCADA and other control relay sys-tem.
The system shall be of 100 % non-blocking type and all the port cards shall have equal access to any free available time slot and shall have equal access to TDM Bus. System shall be based on universal port architecture and shall not impose any restriction whatsoever in terms of slots usage for a particular functional benefit.
The upgradation shall be in building block architecture by adding on additional stacks/cabinets. However, such expansion shall neither involve any processor up-gradation nor any of the other common control cards and cabinet. The EPABX system central processor shall be controlled with non-volatile or stored programs. The software pro-gram stored in a volatile memory and subject to commercial power interruption shall be either a) protected from loss by a short term

memory retention battery, or b) permitted to be lost but reloaded from some memory storage device after the normal condition is restored.
The system shall be capable of working as transit switch, local switch, data circuit switch, and packet switch in both digital and analog environment.
System shall support following signaling protocols:
a) ISDN BRI and PRI
b) E&M (2W/4W)
c) Dual Tone Multi Frequency (DTMF)
d) Interface cards suitable for PA system Interface and any other protocols needed for the specified functions.
In case of emergency failures, the modules in hot standby mode shall take over without dropping/interrupting any of the existing calls in progress. EPABX offered shall be capable of providing hot standby configuration, if required in future, using CPU and common control cards. Presently the bidder shall offer the EPABX system without hot-standby configuration. But feature demonstration will be tested during Factory and Acceptance Testing of the EPABX system. The bidder shall arrange for the test bench / setup for the same on his own. The redundant system configuration shall ensure high reliability and maximum MTBF (Mean Time Between Failures) and minimum MTTR (Mean Time To Repair).

7.27.4. GENERAL SYSTEM FEATURES

Each subscriber shall be programmable for various COs say as
Class C1 Incoming and outgoing local calls.
Class C2 Local plus STD calls with software programmable barring facility.
Class C3 Local plus STD and ISD calls with software programmable barring facility.
The EPABX shall have the following features:
a) Automatic distribution of incoming calls at reception desks
b) Auto attendant feature in case of all reception desks being busy
c) Direct Inward Dialing
Digital attendant console shall be with the following facilities:
a) All incoming PSTN calls shall land on operator‘s desk and operator shall divert the same to desired destination. Auto attendant facility also shall be provided.
b) Automatic and manually selected trunks access
c) Operator controlled trunk-to-trunk connections
d) Adjustable time operator recall to advice caller that called station is busy
e) Automatic call return to attendant when called station fails to answer within preset time period
f) Emergency intrusion and, if necessary, disconnection of call in progress by attendant
g) Call intrusion tone, which will announce to the engaged lines that an intrusion is taking place
h) Abbreviated dialing of up to 64 pre-entered numbers for authorized stations
i) Howler tone on stations dialing incorrectly or left off hook
j) Touch tone dialing, with pulse converters wherever required by local public telephone company
k) Verify the status of a voice terminal that appears to be out of order and quickly identify a faulty trunk
l) Alphanumeric display

m) Hands free operation shall be possible with the console provided.

The System should support following features:

Abbreviated Dialing, Last Number Redial, Call Forwarding, Call Pickup, Camp on, Leave Word Calling, Conference, Emergency Transfer Facility, Speed Dialing, Direct Outward Dialing (DOD), Group Hunting, Barge in facility, Direct Inward Dialing (DID), Call Forwarding, Different ring for internal, external and feature activated calls (e.g. call back), Password protected trunk access, Direct in line facility for pre-defined senior executives, Operator/Attendant consoles

System shall support operator console for call handling application. Console features include the following:

a) Music on hold
b) Automatic and manual call waiting tone to busy line
c) Visual indication of camped call holding beyond prescribed time limit
d) Busy lamp field or traffic status feature
e) Incoming trunk identification
f) Outgoing trunk identification
g) Constant or pulsed trunk status display
h) Calling station number display
i) Display confirmation on dialed extension.
j) Display confirmation of attendant dialed outside number
k) Calling extension readout
l) Extension number display
m) Add on conference calls
n) Ring again on busy C.O. and internal extensions
o) Automatic last number radial

7.27.5. EPABX SOFTWARE REQUIREMENT FOR VOICE MAIL FACILITY

EPABX shall support Voice mail facility. Every extension shall be allotted a mailbox. Incoming calls shall be routed to extension through operator. After predetermined number of rings, if call is not responded, EPABX with voice guidance shall route caller to called ex-tension‘s mailbox.

TELEPHONE SETS

Analog telephones shall have the following features.

a) Instruments shall be desk types.
b) 80 cm coiled cord on handset.
c) Message waiting light.
d) Last number re-dialing.
e) Volume control on ringer. Key pad lock
f) Redial
g) Flash (300 ms)
h) Pause (2 sec)
i) Mute
j) Tone/Pulse selection by switch
k) Ringer volume control
l) Visual indication of ring by LED
m) Pulse/Tone dynamic change over

7.27.6. POWER SUPPLY

The EPABX shall use 230volts power supply and make provision for 2 hr battery back up with suitable un-interruptible power supply (UPS) of sufficient capacity Contractor shall pro-vide un-interruptible power to the EPABX system during normal availability of commercial power and during commercial power transients and failure. The UPS shall be non-redundant and consist of a battery rectifier/charger, a "SMF" type battery pack, an inverter, and an UPS failure bypass transfer switch. The battery discharge time shall be no less than 120 minutes and the battery recharge rate shall be 8- 15 times the discharge time. The equipment shall be sized for the line/station capacity of the configuration. The inverter can be omitted if the total system requires only DC power. The bidder shall

Specify the equipment to be provided. The Contractor shall indicate the maximum load requirement for the proposed capacity. Wire, cable, and hardware shall be provided to interconnect the system, connect the system to the wall service outlet power receptacle. The system shall include a power line transient voltage suppressor (TVSS), central office telephone service TVSS devices, and inter- building cable TVSS devices to protect user personnel and pre-vent equipment damage or total loss resulting from voltage and current surges superimposed upon the commercial power line and all telephone line circuits by lightning strikes, commercial power faults, and power line to telephone line faults.
It shall be the Contractor's responsibility to provide any wiring for system components such as rectifier and inverter required on the system side of the electrical receptacle. The EPABX cabinet shall be grounded with a No. 6 AWG or larger solid copper insulated ground wire to a single point ground. The ground wire shall be tagged and identified at the service equipment enclosure and panel board.
The Contractor shall provide main Distribution Frame (MDF) and Internal Distribution Box/Board panel (IDB) along with suitable cables from MDF to EPABX and EPABX to IDBs to individual extension. Capacity of IDB and Cables shall be suitable for distributing the EPABX capacity extensions.

7.27.7. TELEPHONE CABLES

Telephone cables going out of the building shall be jelly filled steel armoured, fire retardant, outdoor type. All indoor as well as outdoor cables shall have approval of DoT and other telecommunication and standard organizations. Wire, cable, and hardware shall be pro-vided to interconnect the system, connect the system to the wall service outlet power receptacle, and to connect the system to the PSTN network demarcation or Employers Engineer provided PABX interface point. The telecommunication wiring should be in accordance with the requirements specified in ANSI/EIA/TIA- 568.

8. Specifications for Leak detectors

This section covers the specifications of Leak detectors which the contractor has to provide for detection of leakages in the water supply network in the ABD area. The equipment used for leak detection should be capable to detect leaks in all types of pipes not confined to only metallic pipes. The equipment to be used should be cordless, highly accurate and be able to pinpoint

leakages without any error. The equipment should be designed for outdoor use and of robust construction so as to resist water, dust, impact etc.

Since the equipment is to be used by personnel it is preferable to have a device of compact size and at the same time being light weight so that it could be easy to carry.

a. Leak Noise Co-relator

The technical Specifications for Leak Noise Co-Relator are as follows-

Sno.	Parameter	Description
1	Pipe material	All common pipe materials; mixed material mode
2	Sound velocity	Sound velocity table and on-site velocity check
3	Correlation resolution	16,000 points
4	Correlation accuracy	1 cm for 100 m (1" for 1,000 ft)
5	Display	High resolution LCD display with background illumination
6	Filter	Automatically selected, manually infinitely adjustable
7	Frequency analysis	FFT, coherence and ASA (advanced spectrum analysis) simultaneous multi-correlation
8	Notch filter	User selectable
9	Frequency response	1-5000 Hz
10	Peak suppression	Unlimited, user selectable
11	Memory capacity	Up to 60 correlations with all measurements data to enable post-processing of correlation with changed parameters
12	Multimedia card	MMC for additional data storage and leak noise analysis within PC software
13	Sensors	Ultra-compact high sensitivity piezo-ceramic sensors with built-in radio transmitter and magnetic fixing
14	Output	Bluetooth for headphone and data transfer to PC. Multi-purpose socket for battery charger, hydrophones, ground microphone and hand-probe
15	Power	Correlator and sensors: rechargeable Lithium polymer battery
16	Battery charging	Vehicle or indoor
17	Battery charge life	Correlator: up to 12 hours; Sensors: Up to 8 hours

b. Leak detection Ground Phones

The technical Specifications for Leak detection Ground Phones are as follows-

Sno.	Parameter	Description
1	Display mode:	Simultaneously showing real time signal and minimum noise profile
2	Frequency response:	From 1 to over 5000 Hz (Pocket ground mic: from 100 to over 5000 Hz)
3	Filters:	All band and infinitely adjustable with a narrow band-width
4	Memory:	Last 8 measurements
5	Display:	LCD with backlight
6	Power:	standard 1.5 V alkaline batteries
7	Battery life:	Typically 60 operating hours
8	Operating temperature:	-10ºC to +55ºC (14ºF to 131ºF)

PART G – BUILDINGS/CIVIL

All the works shall follow Andhra Pradesh Detailed Standard Specifications and Central Public Works Department (CPWD) Specifications.