Bihar Urban Infrastructure Development Corporation Ltd.

Bihar Urban Development Investment Program – BUDIP

BID DOCUMENT

IMPROVEMENT OF THE WATER SUPPLY SYSTEM – PHASE II
for
BHAGALPUR MUNICIPAL CORPORATION

TECHNICAL SPECIFICATION
Volume II

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DSC CONSULTANTS

Shah Technical Consultants Pvt. Ltd.

in association with:

IPE Global Pvt. Limited

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SUB-SECTION 6.1

TECNHICAL SPECIFICATIONS OF CIVIL & ELECTRO-MECHANICAL WORKS

1. This section describes the conceptual scheme, scope of supply and construction of plant and services and tender drawings.

1. Technical Specification

2. Technical specifications (civil) of the work components under the contract package are given below:

3. The general arrangement of the intake works envisaged at bid stage is indicated in the drawings enclosed with the bid document. These drawings are for guidance purpose only and the Contractor is expected to prepare his own layout and design. The Contractors design shall however incorporate minimum requirements as stated below.

Construction of Intake structure consists of:

- Approach channel in river
- Constructed channel in banks
- Intake wells
- Connecting pipes
- Jack well and pump house
- Allied works

i) Apprach chanel in river bed

4. Intake wells are located on banks and thus for smooth flow of river water approach channel is excavated in river bed. The LWL of river is 24.00 and the design criteria for approach channel are as below.

Table 1: Design criteria for Approach Channel in River

Component	Units	Values
Bed level of channel in river (start)	m MSL	18.00
Bed level of channel at bank at RL 24 m	m MSL	17.50
Length upto 24 m MSL	m	40.00
Bottom width at 18 m MSL	m	10.00
Side slopes	-	1:5 (approximately)

ii) Constructed channel in river bank

The approach channel terminates at 24 m RL of river bank. The constructed channel is excavated from river bank at 24.00 m RL upto 30.00 m RL. The bed level is kept at 17.50 m MSL. The design criteria for constructed channel is as below.

Table 2: Design criteria for Constructed Channel

Component	Units	Details
Bed level	m MSL	17.50
Bottom width at 17.50 m RL	m	10.00

Natural ground elevation at start	m MSL	24.00
Natural elevation ground elevation at Intake well	m MSL	30.00
Length:	M	15.00
Side slopes	m	1:2:5
Side slope protection		Stone revetment supported by piling. Side slopes shall also be provided as steps of 30 cm (W) to 15 cm (H)

Technical Specification for forming approach channel by dredging

5. To draw the water from the Ganga River near Vikram Sheela Bridge a channel has to be excavated for a length of about 40 m in the river position from the end of embankment of the river at 24 m RL size **the channel to be dredged are given below**

Dredging in River portion

From the bed level of river at 18 m RL to the farthest end at 24 m RL : approximate Length of dredge channel	40 m
Bottom width of channel:	10 m
Side gradient	1 vertical to 5 Horizontal

Embankment portion with protection of Banks

From the embankment at 30 m RL to 24 m RL of the river bank: Length	20 m
Bottom Width:	10 m at 17.50 m RL
Side gradient	1 vertical to 2.5 Horizontal

6. To achieve the targeted depth in the channel and as mentioned above, the contractor shall deployadequate Number of cutter suction dredging unit in Bhagalpur –near at proposed intake site near Vikram sheela Bridge area at Bhagalpur Town . The contractor shall ensure that dredge channel section shall be available, as specified above, at the time of commissioning of the scheme.

DREDGING

7. Dredging is an excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location. Dredging is the term given to digging, gathering, or pulling out material to deepen water ways, create harbours, channels, locks, docks and berths, desilt lakes and keep river entrances and approaches to boat ramps clear. The material removed during dredging can vary greatly and can be combination of rocks,clats, silts or sands.

8. In all situations the operation is undertaken by special floating plant , known as dredger.

Dredging procedure

1. Pretreatment
2. Extraction

3. Disposal

Pre-treatment
Not required in this case.

Extraction
9. The extraction process involves the movement of the spoil from its natural pretreated position into vertical transportation and its delivery to the transport system.
10. Extraction processes are often a combination of at least two operations: the primary operation which disintegrates or dislodges the soil and the secondary operation which moves it.
The first of the operations is performed either mechanically or hydraulically.

Disposal
11. Disposal facilities are consists of bottom discharge, grab, scarpers, pipelines, land based unit, natural processes.

Hydraulic Dredging:
12. Hydraulic pipeline dredging incolves use of a hydraulic (suction) dredge, most commonly for either beach nourishment of suitable sands, or deposit into an upland containment area (for dewatering or direct disposal)
13. Hydraulic dredging provides the cleanest and least obstrusive method for sediment removal without damafing the sensitive environment.
14. Typically the dredge uses a cutter head on the end of the suction arm to loosen the material while the dredge pump suctions the loosened material through the arm to the pump in a slury of about 75 to 90 transfer area.
15. A hydraulic dredge floats on the water and excavates and pumps the material through a temporary pipeline to an offsite location, often several thousand feet away. This dredges acts like a floating vacuum cleaner that can remove sediment very precisely.

Suction cutter dredger
16. It is similar to the suction dredger, except that it has a rotary cutter head which carves clay, breaks off chunks of softer rocks such as coral and shale, and stirs up gravel and sand so that pipe carries material to its capacity.
17. This dredger is being suitable for channel work, cut offs, new construction, harbour excavation and making fills.
18. A cutter suction Dredgers(CSD) suction tube has a cutting mechanism at the suction inlet.
The cutting mechanisam loosens the bed material and transports it to the suction mouth.
19. The dredged material is usally sucked up by a water resistant centrifugal pump and discharged either through a pipe line or to a barge.
20. Cutter suction dredgers are most oftern used in Geological areas consisting of hard surface materials (for example gravel deposits or surface bed rock) where a standard suction dredger would be ineffective.
21. In recent years, dredgers with more powerful cutters have been built inorder to excavate harder rock without the need for blasting.

22. Assessment of dredging Quantity in Ganga River

The assessed quantity of dredging & open excavation during construction of the Channel is tentatively given as below: However this may vary depending upon the suspended solids present in the river water

In the River portion : 7280 cub.m (Tentative)

In the Bank Bund portion : 10640 cub.m (Tentattive)

23. To maintain the required Depth as mentioned above a total quantity of dredging shall be assessed .

24. The Depth of the water at intake well shall be minimum 7 m from the bed level of the dredged channel..
The assessment of river section required to be dredged in the stretches is given for the purpose of indication only.

Technical Specification of CSD units:

25. The Cutter Suction Dredging unit comprises of the following:

a) One cutter suction dredger
b) One Tug
c) One Accommodation Boat
d) One Anchor Pontoon and associated dredge pipelines

26. The technical specification of the cutter suction dredgers, workboat and accommodation boat are briefly mentioned for the purpose of indication only

27. Principal dimensions and main particulars of cutter suction dredging units each comprising of one no. Cutter suction dredger, one workboat/ tug, one accommodation boat and one dumb anchor pontoon

A) Capacity of cutter suction dredgers to be enaged for dredging:

Dimension

Draft	1.20 m
Mean draft (30 T of stores)	1.14 m
Mean Draft (Fully Loaded)	1.38 m
Fuel capacity	80m3

Main Engine for Dredge Pump

Make	Cummins
Model	KTA 38 m2
No. of Cylinder	12
Total max output	895 KW (1200 HP)
RPM	1800

Dredge Pump

Make	Damen dredging Equipments (Netherlands)
Model	BP 5045 HD

Gland Pump

Make	Burhani Engineers & Contractors
Model	BEC 80/36
Type	Slef- Priming
Capacity	65 cum/hr. at 8 bar

Auxiliary Engine

Make	Cummins
Model	KTA 19- D(MI)
HP	550 BHP
No. of Cylinder	6
Power for Alternator	65 KVA

Emergency Gen Set

Engine Make	Kirloskar oil engine
Model	4R 1040 T
Power (HP)	82
RPM	1500
Alternator make	Crompton Greaves
Model	GIR 200 SC
Capacity	50 KVA

General Service Pump (Driven by Emergency Gen Set)

Make	B E Pumps
Model	A-5 120- kk
Type	Self- Priming
Capacity	15 cum/hr @ 3.5 bar

F.W. Cooling system Pump

Make	B E Pump
Model	SH 65 – 160 MN -2- 316
Capacity	30 cum/hr @ 3 bar

Plate Heat Exchanger

Make	SONDEX A/S Denmark
Model	S 19 A–IG-10-86- TMTL73
Capacity	344.2 kw

Sewage Discharge Pump

Make	Allweiler As
Model	AEBIE200 – IE
Capacity	7 cum/hr. @3 bar

General Service Pump (Bilge GS/Deck Wash)

Make	Johnson Pumps
Model	CH-40-200, G2M2 TL
Type	Hoz. Self- priming
Capacity	25 cum/hr @ 4bar

Air Compressor (2 Nos.)

Make	Atlas Copco
Model	LT- 7-30 KE
Capacity	20m3 /hr. @ 30 bar
Speed	1500 rpm

Hydraulic Pump- No.1 (Aux. Engine Driven)

Make	HY- COM B.V.
Model	PV 140
Capacity	P= 96 Kw, Q= 320 L pm
Speed	2500 rpm

Hydraulic Pump – No. 2 (Aux. Engine Driven)

Make	HY-COM B.V.
Capacity	P= 144 kw, Q= 480 L pm
Speed	1800 rpm

Emergency Hydraulic Pump

Make	HY-COM B.V.
Model	ALP 2 – D- 16
Capacity	17.25 L pm
Speed	1450 rpm
Pressure	100 bar

Ladder Hoisting Winch

Make	Damen Dredging equipments / Brevini Power Transmission
Model	BW I/140/2
Capacity	13 Tons
Pressure	130 bar

Cutter Unit Assembly

Make	Damen Dredging equipments/POCLAIN
Model	TS CO 45 bladed
Capacity	110 Kw
Pressure	160 bar

Side Winches (2 nos.)

Make	Damen Dredging equipments/ BreviniPower Transmission
Type	BWI/140/2
Capacity	13 Tons
Pressure	130 bar

Spud Tilting Winch

Make	Damen Dredging equipments/ Brevini Power Transmission
Model	E 90290 LS
Capacity	2.5 Tons
Pressure	195 bar

Carriage Cylinder

Make	HYCOM B.V.
Pressure	300 bar

Spud Clamp Cylinder

Make	HYCOM B.V.
Pressure	330 bar

Spud Hoisting Cylinder

Make	HYCOM B.V.
Pressure	250 bar
WORKBOAT/	TUGS: Tug S.C. Bose
Multipurpose Tug Sukhdev	
Length (overall)	28.00 m
Breadth (Mld)	7.20 m
Depth	2.60 m
Draft	1.2 m
Fuel Capacity	20 t
Bollard Pull	6 T
Propulsion	Twin Screw
Make	Cummins
Model	NT- 855 M
BHP	270 BHP at 1800 RPM
Type	Rudder Propeller
Make	HRP 2000
HRP	2000
Model	2111 WM
HP	200/ KW
Model	A 7110 KKTE – 1 B – WCF
Make	KOEL (25 KVA)
Model	3R 1040
Alternator	Crompton
Make	KOEL (50 KVA)
Model	4R 1040 T
Alternator	Crompton
Crane	
Make	Crompton Greaves Ltd.
Model	GIR 160 SC
Details	25 KVA, 415 V, Class H

BILGE/ G.S./ FIRE PUMPS

Make	B.E. Pumps Pvt. Ltd.
Model	SH-160 N

28. Assessment of Number of days engagement of dredgers: The deployment of CSD unit in Bhagalpur- Vikram shella Bridge stretch, the capacity of the Channel to be dredged has been assessed as (10640+7280) 17920 cub.m).. Adequate allowance for non-operational days due to repair and maintenance, shoal to shoal movement and other factors have been taken into account while assessing the capacity of the dredging units.

29. The contractor shall provide sufficient numbers of pingers (noise emitting devices to keep the Dolphins away from the dredging area. The contractor shall employ one Environmental Expert as a nodal person for protection of Environment health and safety of aquatic life as well as workers engaged. He shall monitor and mitigation measures as per IEE Report and EMP and any corrective and preventive actions shall be set up to safe guard the monitoring plan

30. The contractor shall start the dredging activities only after getting the prior approval from the inland water ways authorities. The Inland waterways authorities shall be informed the time of dredging. The dredging work shall be carried out only in the presence of the officers of Inland water ways authorities. The dredged quantity shall not be disposed in the river and shall be disposed for off away from the river. The contractor shall comply all applicable National, provincial and local environmental laws and regulations.

Dredging operation during O&M period of 10 Yrs.

31. The scope work of this work is for undertaking the dredging operations for construction of channel and suitable maintenance of channel during the maintenance period. Using the Cutter Suction Dredger unit. The contractor shall estimate the dredging quantity based oon the suspended solids present in the river water during dry period. As per the primary calculation, the dredging interval may be around once in 40 days. However the contractor shall makes his own estimation what dredging interval and period of dredging. During the mansoon period when the water level of the river is sufficiently high i.e more than 27.5 m RL and thus dredging shall not be required.

DURATION OF WORK:

32. The dredging units Cutter Suction Dredger is to be engaged by the contractor after the signing of agreement. The period of deployment of these cutter suction dredging units is for minimum period of 10 days in a year especially during non-mansoon period.

Details of Dredging

Dredging Interval	40 Days
No. of Dredging in a year	10 days
Dredging quantity	
River Portion	1200m3/ dredging
Bank Portion	785m3/dredging

iii) Intake Wells

33. The intake wells will be located on the Ganga River on the right bank. Intake well has been proposed to accommodate the required numbers of gates as per design so as to draw 95 MLD during Intermediate stage and additional pumps for withdrawing 46 MLD during ultimate stage as mentioned in subsequent section. The intake shall be so designed so as to have the entry velocity of 8 m /min in the intake. The design criteria for the Intake well (twin D type) intake structure is given in table below.

Table 3: Design Criteria for Intake Wells

Component	Units	Value
Design Flow	MLD	141
Design Year	year	2047 (Ultimate stage)
Operation	hrs/d	23
Maximum discharge of River Water	m^3/sec	48000
Width of river at intake location (approximate)	m	2800
Ground level at intake	m	+30.00
Bed level of constructed channel	m msl	+17.50
Low Water Level (LWL)	m msl	+ 24.00
Normal Water Level	m msl	+27.50
Approximate Maximum Scour Level	m msl	+7.5
Hard rock level (below 7.5 m)	m	As per bore hole data
Entry velocity (maximum) in the intake	m/min	8.00
Nominal Well Inside Diameter (twin D	m	5.00

Component	Units	Value
shape)		
Approximate Bottom Elevation of Well	m msl	+ 17.50
Top of Well Elevation (Deck slab level)	m msl	+ 30.00 flush at ground level
No. of wells (twin wells)	No	1
Inside well dia.(minimum)	m	5 (twin D shaped)
Gate Openings		
Velocity through port	m/min	8
Intake port locations	No.	2
Gates at each Level	No.	2
Gate Dimensions (w x h), each	m	2200 mm x 2200 mm
Approximate Invert EL of Lower Gates	m msl	20.00
Approximate Invert EL of Upper Gates	m msl	25.00
Coarse Screens		
S.S. Flat strips	mm	12x12
Bar Spacing c/c	mm	80

34. The Intake wells shall be twin D-shaped RCC structure and will most likely to be constructed in segment and allowed to settle under its own weight as sediment is excavated from inside. The top elevation shall be flush with ground level of 30.00 m.

35. A tremie concrete plug shall be poured into the bottom of the well after it reached its lower level in the rock layer below. Reinforcement shall be extended out of the side walls to make the tremie concrete integral with the well, or an equivalent means of attachment must be provided. Holes shall be drilled through the concrete bottom plug and into the rock and dowels grouted into the rock and concrete plug to anchor the well to the rock. It should be stable even at 1.5 times of breaking wave impact.

36. After the concrete plug has been grouted the void space in the well shall be filled up with cement concrete M 20 or sand. A RCC (M 35) cap shall be placed upon the filled up compacted sand or concrete.

37. A series of sluice gates shall be installed at the two (2) intake levels for river water. These sluice gates shall be mounted on the outside or inside of the well so as to operate under a seating head condition. The general arrangement of the gate openings is indicated on the Drawings. Sluice Gates shall be of CIass as per IS 13349 and guiding channel of SS.

38. Bar screen shall be provided at the openings, to the outside wall of the well. Inside of the bar screens, gate openings shall be mounted and attached to the inside or outside wall of the well, at Contractor's option. The bars comprising the screens shall be minimum 12 mm wide SS square bars. Stiffener may be provided as per requirement of structural design. Bars shall be spaced at 80 mm on-center (c/c) maximum.

39. Raw water inlet velocity through gate opening and screen in the well shall be as per CPHEEO manual.

40. Anti-vortex measures to be adopted by Contractor.

i. Well Sinking

41. This work shall include construction of well sinking up to the rock level and it down through all kinds of sub-strata, plugging the bottom, in accordance with the details shown as per the Contractor's design, approved drawings as per standard specifications and as per

the directions of the Employers representativeand as per IRC-78 and IRC-6-2000 or latest publication.

42. Twin D-shaped well shall be proposed to accommodate the sluice gates at two levels.

43. The process of taking down the well to the foundation level is known as well sinking. After reaching the foundation level, the hollow inside the well, “dredge hole” is plugged at the bottom by concrete “bottom plug”.

44. To facilitate sinking of well, steel cutting edge is fabricated and connected to a concrete well curb of required shape. On top of the well curb, adequate height of well steining is cast in stages as sinking progresses and the process of sinking is carried out. After a portion of the well has been sunk, another height of well steining is casted on top of the previous section and further sinking carried out. This process is continued till the bottom level of the well reaches rock level / foundation level shall be as per approved drawings.

45. At the top of the well steining, floor slab shall be constructed as per approved design and drawing of the Contractor.

46. Before the work is commenced, at least one borehole must be drilled by the Contractor & respective data must be available in accordance with these specifications at well location, prior to commencement of work. The depth of boreholes should extend up to a depth equal to one and a half times the outer diameter / least dimension of the well below the anticipated founding level. In case the well foundation is to rest on a rocky strata, it may be necessary to undertake additional borings / probing prior to commencement of work to ascertain the actual profile and the quality of the rocky strata, at the level at which the well has to be seated plugged.

47. Controlled blasting if required and if permitted may have to be resorted to in order to facilitate sinking through difficult strata, such as boulders and rocks etc. The Contractor shall obtain all necessary permission and abide by all rules and regulations thereto. The Contractor shall be liable for all consequences arising out of blasting.

48. The grade of concrete for curb and of steining shall not be leaner than M 35.

49. In case the borehole data shows the presence of steeply dipping rock, chiseling may have to be resorted so as to obtain proper seating of the foundation. For this purpose, the well may require to be dewatered completely under high air pressure inside the well. This process is known as pneumatic sinking. Pneumatic sinking may also have to be resorted to in cases where obstacles such as tree trunks, large sized boulders or hard strata etc. cannot be removed by open dredging. The necessity of adopting pneumatic sinking shall be decided by the Employers representative based on site conditions. It will not be allowed in Eco sensitive zone near sanctuary area.

50. The curb and steining have to be specifically designed for special loadings when pneumatic sinking is adopted.

51. Necessary reference points shall be fixed, away from the zone or blow-ups or possible settlements resulting from well sinking operations. Such reference points shall be connected to the permanent theodolite stations with the base line on the banks. The center of the individual wells shall be marked with reference to these stations. The distance, wherever practicable, shall be checked with the help of accurate tapes and precision distomat.

52. Reference points shall also be fixed to mark X-X axis (usually traffic direction) and Y-Y axis (normal to X-X axis) accurately.

53. A temporary benchmark shall also be established near the well foundation, away from the zones of blow-ups or possible settlement. The benchmark shall be checked regularly with respect to the permanent benchmark.

54. All necessary machinery and equipment shall be deployed for construction of well sinking as required and as directed by the Employers representative. Generally, the following equipment may be required for the work.

a. Crane with grab buckets – capacity 0.5 to 2.0 cu.m.
b. Submersible pumps
c. Air compressors, air locks and other accessories where pneumatic sinking of well is anticipated
d. Chisels of appropriate sizes
e. Aqua-header for cutting rocky strata
f. Diving helmets and accessories
g. Equipment for concrete production, transportation and compaction

55. All the works shall be executed in accordance with best engineering practices.

56. The mild steel cutting edge shall be fabricated from structural steel sections based on the approved drawings and shall be strong enough to facilitate sinking of the well through the type of strata expected to be encountered. The weight of the cutting edge shall not be less than 40 kg per meter length and be properly anchored into the well curb, as per Contractor approved drawings. In V shaped cutting edge, the inclined plate should meet the vertical plate in such a way that full strength connection by welding is achieved.

57. To start with the parts of cutting edge shall be erected on level firm ground. Temporary supports shall be provided to facilitate erection and maintaining the assembly in true shape and level as per approved design and drawing.

58. The fabrication may be carried out in the shop or at site. Steel sections shall not be heated and forced into shape. However, 'V' cuts may be made in the horizontal portion, uniformly throughout the length, to facilitate cold bending. After erection, 'V' cuts should be closed by welding. Joints in the lengths of structural sections, unless otherwise specified shall be fillet welded using single cover plate to ensure the requisite strength of the original section.

59. Initially the cutting edge shall be placed about 300 mm above ground level.

60. The well shall be sunk true to vertical through all types of strata.

61. Sinking or loading of the well with kentle edge shall be commenced only after the steining has been cured for at least 48 hours or as specified in the Contractor's approved drawings.

62. No well shall be permitted to be placed in a pre-dredged hole.

63. The well shall be sunk by excavating material uniformly from inside the well hole.

64. Use of water jetting, explosives and divers may be adopted for sinking of wells through difficult strata with prior approval of the Employers representative.

65. Normally dewatering of well should not be permitted as a means for sinking the well.

66. It shall never be resorted to if there is any danger of sand blowing under the well.

67. Dewatering shall however be done when well is to be founded into rock. Pneumatic sinking may have to be resorted to where obstacles such as tree trunks, large size boulders, etc. are met at the bottom or when there is a hard stratum which cannot be removed by open dredging. The necessity for pneumatic sinking shall be decided by the Employers representative.

68. Sinking history or log book of well sinking shall be maintained in the required format.

ii. Sand Blows in Wells

69. Dewatering shall be avoided, if sand blows are seen. Any equipment or men working inside the well shall be brought outside the well as soon as there are any indications of sand blow. Sand blow often can be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy kentle edge.

iii. Use of Kentledge as Sinking Load

70. Kentledge shall be placed in an orderly and safe uniform manner on the loading platform and in such a way that it does not interfere with the excavation of the material from inside the dredge hole and also does not in any way damage the steining of the well and will cause well to uniformly sink.

71. Where tilts are present or there is a danger of well developing a tilt, the position of the load shall be regulated in such a manner as to provide greater sinking effort on the higher side of the well.

iv. Use of Water Jetting

72. Water jetting and jack down method be employed for well sinking as per requirement.

v. Use of Explosives

73. Mild explosive charges may be used if required as an aid for sinking of the well only with prior permission of the Employers representative. Blasting of any sort shall only be done in the presence of the Employers representative and not before the concrete in the steining has hardened sufficiently and is more than 7 days old. When likelihood of blasting is predicted in advance, protection of the bottom portion of the well shall be done as per these specifications. After blasting operations are completed, the well curb and steining shall be examined for any cracks and remedial measures taken.

74. If blasting has been used after the well has reached the design foundation level, normally 24 hours shall be allowed to lapse before the bottom plug is laid. The charges shall be exploded well below the cutting edge by making a sump so as to avoid chances of any damage to the curb or to the steining of the well. A minimum sump of 1 m depth should be made before resorting to blasting. Use of large charges, 0.7 kg or above, may not be allowed except under expert direction and with the permissions from the Employers representative. Suitable pattern of charges may be arranged with delay detonators to reduce the number of charges fired at a time. The burden of the charge may be limited to 1 m and the spacing of holes may normally be kept as 0.5 to 0.6 m. All prevalent laws concerning handling, storing and using of explosives shall be strictly followed.

75. All safety precautions shall be taken as per IS:4081 “Safety Code for Basting and related Drilling Operations”, to the extent applicable, whenever blasting is resorted to. There

should be no equipment inside the well nor any worker in the closed vicinity of the well at the time of exploding the charges.

76. If rock blasting is to be done for seating of the well, the damage caused by flying debris should be minimized by covering blasting holes by rubber mats before blasting.

vi. Use of Divers

77. Use of divers may be made both for the sinking purpose like removal of obstructions, rock blasting and for inspection. All safety precautions shall be taken as per acceptable safety code for sinking with divers or any statutory regulations in force.

78. Only persons trained in the diving operation shall be employed and shall be certified to be fit for diving by an approved doctor.

79. They shall work under expert supervision. The dividing kit and other equipment shall be of acceptable standard and certified to this effect by an approved independent agency. It shall be well maintained for safe use.

80. Arrangement for ample supply of low pressure clean cool air shall be ensured through an armoured flexible hose pipe. Standby compressor plant shall be provided in case of breakdown.

81. Separate high pressure connection for use of pneumatic tools shall be made. Electric lights where provided shall be at 50 Volts (maximum). The raising of the diver from the bottom of wells shall be controlled so that decompression rate conforms to the rate as laid down in appropriate regulations.

vii. Use of Pneumatic Sinking

82. The Employers representative shall familiarize himself with particular reference to caisson diseases and working of the medical air-lock. A doctor competent to deal with cases of “Caisson Diseases” or other complications arising as a result of working under high pressure, shall be stationed at the construction site when pneumatic sinking is under progress. The Contractor shall provide complete facilities including the issuing of orders to ensure strict enforcement of the requirements outlined in these Specifications. Safelya provision as contained in IS: 4138 and in these Specifications shall be strictly followed. Pneumatic sinking shall be restricted to a depth of 30.0 m.

viii. Additional Safety Provisions

83. The weight of the pneumatic platform and that of steining and Kentledge, if any, shall be sufficient to resist the uplift from air inside, skin friction being neglected in this case, if, at any section the total weight acting downwards is less than the uplift pressure of air inside, additional kentledge shall be placed on the well.

84. If it is not possible to make the well heavy enough during excavation, “blowing down” may be used. The men should be withdrawn and air pressure reduced. The well should then begin to move with small reduction in air pressure. “Blowing down” should be only be used when the ground is such that it will not heave up inside the chamber when the pressure is reduced. When the well does not move with the reduction in air pressure, kentledge should be added. “Blowing down” should be in short stages and the drop should not exceed, 0.5 m at any stage. To control sinking during blowing down use of packing are recommended.

85. The pneumatic sinking plant and other allied machinery shall only be of proper design and make, and also should be operated by competent and well trained personnel. Every part of the machinery and its fixtures shall be minutely examined before installation and operation. Availability of appropriate spares, standbys, safety of personnel as recommended in IS: 4138 for working in compressed air must be ensured at site. Codes for safety and for working in compressed air and other labour laws and practices prevalent in the country, as specified to provide safe, efficient and expeditious sinking shall be followed.

86. Where blasting is resorted to, it shall be carefully controlled and all necessary precautions regarding blasting shall be observed. Workers shall be allowed inside after blasting only when a competent and qualified person has examined the chamber and steining thoroughly, and found the same to be safe. Any mishap arising out of all such works shall be Contractor's liability.

ix. Precautions during Sinking

a. During sinking of dumb-bell or double D-shaped wells, the excavation in both the dredge holes should be carried out simultaneously and equally.

b. Bore chart shall be referred to constantly, during sinking for taking adequate care while piercing different types of strata. The type of soil as obtained during the well sinking should be compared with bore chart so as to take prompt decisions.

c. Before seasonal floods, all wells on which sinking is in progress shall be sunk to sufficient depths below the designed scour level. Further, they shall be temporarily filled and plugged so that they do not suffer any tilt or shift during the floods.

d. All necessary precautions shall be taken against any possible damage to the foundations of existing structures in the vicinity of the wells, prior to commencement of dredging from inside the well.

e. The dredged / excavated material shall not be allowed to accumulate over the well. It shall be dumped and spread, as far away as possible, and then continuously and simultaneously removed, as directed by the Employers representative. In case the river stream flows along one edge of the wellbeing sunk, the dredged material shall not be dumped on the dry side of the bank but on the side on which the river current flows.

f. Very deep sump shall not be made below the well curb, as it entails risk of jumping (sudden sinking) of the well. The depth of sump shall be generally limited to one-sixth of the outer diameter / least lateral dimension of the well in plan. Normally the depth of sump shall not exceed 3.0 m below the level of the cutting edge unless otherwise specially permitted by the Employers representative.

g. In case a well sinks suddenly with a jerk, the steining of the well shall be examined to the satisfaction to the Employers representative to see that no damage has occurred

h. In pneumatic sinking, the well shall not, at any time, be dropped to a depth greater than 500 mm by the method of “blowing down”.

i. Dewatering shall be avoided if sand blows are expected. Any equipment and men working inside the well shall be immediately vacated out of the well as soon as there are any indications of a sand blow.

j. Sand blowing in wells can often be minimized by keeping the level of water inside the well higher than the water table and also by adding heavy knowledge.

k. In soft strata prone to settlement / creep, the construction of the abutment wells shall be taken up only after the approach embankment for a sufficient distance near the abutment has been completed.

x. Tilts and Shifts

87. The inclination of the well from the vertical is known as tilt and the horizontal displacement of the center of the well at the founding level from its theoretical position is known as shift.

88. Unless otherwise specified, the tilt of any well shall not exceed 1 (horizontal) in 80 (vertical), and the shift at the well base shall not be more than 150 mm in any resultant direction.

89. Tilts and shifts shall be carefully checked and recorded in the format regularly during sinking operations. For the purpose of measuring the tilts along the two axes of the bridge, reduced level of the marks painted on the surface of the steining of the well shall be taken.

For determination of shift, locations of the ends of the two diameters shall be precisely measured along the two axes, with reference to fixed reference points. Whenever any tilt is noticed, adequate preventive measures like placing eccentric kentledge, pulling, strutting, anchoring or dredging unevenly and depositing dredge material unequally, putting obstacles below cutting edge. Water jetting etc. shall be adopted before any further sinking. After correction, the dredged material shall be spread out uniformly.

90. A pair of wells close to each other has a tendency to come closer while sinking. Timber struts may be introduced in between the steining of these wells to prevent tilting.

91. Tilts occurring in a well during sinking in dipping rocky strata can be safeguarded by suitably supporting the curb.

92. In the event of a well developing tilt or shift beyond the specified permissible values, the contactor shall have to carry out, at his own cost, suitable remedial measures to the satisfaction to the Employers representative, to bring the tilt and shift within permissible values. If the resultant tilt and / or shift of any well exceeds the specified permissible values, generally it should not exceed 1 in 50 and 300 mm respectively. The well so sunk shall be regarded as not conforming to specifications and a sub-standard work. The Employers representative in his sole discretion may consider accepting such a well, provided:

i) Calculations for foundation pressures and steining stresses, accounting for the actual tilt and shift furnished by the Contractor show that the well is safe. Remedial measures required to bring the stresses within permissible values (such as increase in the dimension of the well cap, provision of dummy weights on the well cap etc.) shall be carried out by the Contractor at his own cost.

ii) The contract shall be subjected to reduction in rates as a penalty in accordance with Clause elsewhere mentioned.

93. In case the Employers representative, in his discretion, rejects the well, the Contractor shall dismantle the rejected well to the extent directed by the Employers representative and remove the debris. Further the Contractor shall, at his own risk and cost complete the construction of well with arrangement acceptable to the Employers representative.

xi. Seating of Wells

94. The well shall be uniformly seated at the foundation strata. It shall be ensured by test borings that the properties of the soil encountered at the foundation strata and upto a depth of one and a half times the well diameter is identical to that adopted in the design. As an additional measure of safety, the well shall be anchored to the rocky strata by anchor bars provided in the steining of the well, as shown on the Contractors approved drawing irrespective of the fact that tension develops or not at the base of the well under design loads. After the well has been evenly seated on good hard rock, arrangements shall be made to facilitate proper inspection in dry and visible conditions before the bottom plug is laid.

xii. Bottom Plug & Intermediate Plug

95. The bottom plug shall be provided in wells. Before concreting the bottom pluge, it shall be ensured that it's inside faces have been cleaned thoroughly.

96. The concrete mix used in bottom plug shall have a minimum cement content of 330 kg per cum with a slump about 150 mm to permit easy flow of concrete through tremie to fill up all cavities. For under water concrete, the concrete shall be placed by tremie under still water condition and the cement content of the mix be increased by 10 percent.

97. Admixtures, if required may be added to the concrete to achieve the required characteristics.

98. In case of grouted concrete, the grout mix shall be leaner than 1:2. It shall be ensured that the grout fills up all interstices upto the top of the bottom plug by suitable means such as controlling the rate of pumping etc.

99. Any dewatering required, shall be done 14 days after concreting of bottom plug.

100. The concrete production equipment and placement equipment should be sufficient to enable under water concreting within stipulated time. Necessary standby equipment should be available for emergency situation.

101. Before commencing plugging, all loose material from the bottom of the well shall be removed.

102. Concreting shall be done in one continuous operation till the dredge hole is filled upto the required height and thereafter sounding shall be taken upto ensure that the concrete has been laid to the required height.

103. Concrete shall not be disturbed in any way for at least 14 days.

104. Intermediate plug shall be provided to counter balance the uplift pressure.

(i) Tolerances

105. For the well steining the permission tolerances shall be as follows:

a)	Variation in dimension	:+50 mm, -10 mm
b)	Misplacement from specified position in plan	:15 mm
c)	Surface irregularities measured within 3 m straight edge	:5 mm
d)	Variation of level at the top	:+0.25 m

(ii) Tests and Standards of Acceptance

106. All the materials of construction shall be tested in accordance of IS Standards. The material shall be tested in accordance with these specifications and shall meet the prescribed criteria.

107. The work shall conform to these specifications and shall meet the prescribed standards of acceptance.

108. If any well with tilt and / or shift exceeding the permissible values is accepted by the Employers representative, the Contractor shall be subjected to a reduction in the rates as follows:

Table 4: Amount of tilt and / or shift percent deduction in the rate (s) for sinking of whole well

1.	Tilt exceeding the specified permissible value but equal to or	5%

	within 1 in 60	
2.	Tilt exceeding 1 in 60but equal to or within 1 in 50	10%
3.	Tilt exceeding 1 in 50	20%
4.	Shift exceeding the specified permissible valuebut equal to or within 200 mm	2%
5.	Shift exceeding 200 mm but equal to or within 300 mm	5%
6.	Shift exceeding 300 mm 10 percent	10%

109. Excessive tilt and shift shall not be allowed as overhead pump house is to be constructed on the wells.

xiii. Horizontal Forces due to Water Current

110. Suitability of the well shall be checked for horizontal forces due to water current as per IRC-6-2000.

xiv. Pile Foundation

111. Pile foundation design shall be as per IRC-78-2000 latest edition.

xv. Well Curb

112. The well curb shall be such that it shall offer minimum resistance while sinking, but shall be strong enough to be able to transmit superimposed loads from the steining to the bottom plug. The shape and the outline dimension of the curb as given in drawing may be referred for guidance. The internal angle of the curb shall be 30° to 37° depending upon geotechnical data.

113. The well curb may be precast or cast-in-situ. The well curb shall be reinforced concrete of mix not leaner than M 35 with minimum reinforcement of 72 Kg/cu.m excluding bond rod. The reinforcement shall be HYSD bars with epoxy coating.

114. The steel shall be suitably arranged to prevent spreading and splitting of curb during sinking.

115. Steel formwork for well curb shall be fabricated strictly in conformity with the drawing. The outer face of the curb shall be vertical. The bottom ends of vertical bond rods of steining shall be fixed securely to the cutting edge with check nuts or by welds.

116. The formwork on outer face of curb may be removed within 24 hours after concreting. The formwork on inner face shall be removed after 72 hours. All concreting in the well curb shall be done in one continuous operation.

117. In case blasting is anticipated, the inner faces of the well curb shall be protected with the steel plates of thickness not less than 10 mm up to the top of the well curb. If it is desired to increase the steel lining above the well curb then the thickness in the extended portion can be reduced to 6 mm. This extra height of the steel shall not be exceed 3 m, unless specific requirement exists, as decided by the Employers representative. The curb in cases involving blasting, shall be provided with additional hoop reinforcement consisting of 10 mm dia deformed bars at 150 mm spacing which shall also extend upto a higher of liner.

xvi. Well Steining

118. External surface of curb and steining shall coincide and shall be smooth to facilitate sinking.

119. The dimensions, shape, concrete strength and reinforcements of the well shall strictly conform as per the Contractor's approved drawing. The formwork shall preferably be of MS sheets shaped and stiffened suitably. In case timber forms are used, they shall be lined with plywood or MS sheets.

120. Well steining built in the first lift above the well curb shall not be more than 2 m and in subsequent lifts it shall not exceed the diameter of the well or the depth of well sunk below the adjoining bed level at any time. For stability, the first lift of steining shall be cast only after sinking the curb at least partially. Concreting of steining may be carried out in subsequent lifts of about 2 to 2.5 m. Attempts should be made to minimize the number of construction joints. The concreting layers shall be limited to 450 mm restricting the free fall of concrete to not more than 1.5 m. Laitance formed at the top surface of a lift shall be removed to expose coarse aggregates before setting of concrete at the proposed construction joint. As far as possible, construction joints shall not be kept at the location of laps in the vertical steining bars.

121. The steining of the well shall be built in one straight line from bottom to top such that if the well is titled, the next lift of steining will be aligned in the direction of the tilt. The work will be checked carefully with the aid of straight edges of lengths approved by the Employers representative. Plumb bob or spirit level shall not be used for alignment.

122. After sinking of a stage is complete, damaged portions if any, of steining at top of the previous stage shall be properly repaired before constructing the next stage. Concrete mix shall not be leaner than M30.

123. The level indicator shall be painted on outer surface. The height of steining shall be painted by making at least 4 gauges (preferably in water current direction and in a direction normal to water current direction) distributed equally on the outer periphery of the well each in the form of a 100 mm wide strip painted on the well, with every meter mark shown in black paint. The gauges shall start with zero at the bottom of the cutting edge. Marking of the gauges shall be made carefully with a steel tape.

124. After reaching the foundation level, the well steining shall be inspected to check for any damage or cracks / tilts. The Employers representative will direct and the Contractor shall execute the remedial measures before acceptance of the well steining. In case the well cannot be accepted even with any remedial measure, then the well shall stand rejected.

125. Reinforcement in steining shall confirm to IRC-78-2000.

Connecting Pipe:

126. To convey the raw water from Intake well to jack well, connecting pipe of 12 mm thick, MS pipe 1600 mm dia is proposed to be laid. The velocity of flow through the connecting pipe shall not exceed 0.9 m/sec at designed flow. This shall be laid by trenchless technology at invent levels shown in the drawing. The design criteria for connecting pipe is given below.

Table 5: Design criteria for Connecting Pipe

S. No.	Component	Unit	Details
i)	Designed flow	MLD	141
ii)	Hours of pumping	Hr	23
iii)	Velocity of flow	m/sec	0.9
iv)	Diameter (OD)	mm	1632 say 1600
v)	Length	m	50

vi)	Type		MS
vii)	Plate thickness (min)	mm	14
viii)	Method of laying	-	Trenchless
ix)	Invert of Intake well	m MSL	18.00
x)	Invert at Jack well	m MSL	17.50

Note: Instead of MS pipe, RCC NP4 class pipe will also be accepted for connecting pipe.

Jackwell and Pump House:

127. Jack well is located 50 m away from Intake well Twin D shaped having 9 m dia. Jackwell with overhead pump house has been proposed to accommodate the required number of vertical turbine pumps as per design so as to pump 95 MLD during Intermediate stage and 141 MLD in Ultimate stage. The contractor shall accordingly design, supply and install the pumping machinery. Supply and installation of pumping machinery for Ultimate stage requirement is not included in present contract however adequate space has to be provided by the contractor. The jackwell shall be designed so as to operate the pumping machinery smoothly without cavitation and turbulence of flow. The design criteria for jack well (caisson type) structure is given in table below.

Table 6: Design Criteria of Jackwell – Pump House

Component	Unit	Details
Designed flow	MLD	141
Design year	Year	2047 (Ultimate stage)
Operation	Hrs / day	23
Ground level	m MSL	33.00
Approximate maximum scour level	m MSL	4.5
Entry velocity of peak flow	m/sec	0.9
Nominal inside diameter of well (twin D shaped)	m	9.00
Approximate bottom elevation of well at top of plugging	m	14.50
Top of well elevation (Deck slab level)	m MSL	36.00
No. of wells	No.	1 (twin D shape)
Inside diameter (minimum)	m	9
Corbel level of pump house	m	42.00
Top slab of pump house	m	44.50

128. The jackwell shall be caisson tyhpe structure. The floor level shall be at least 1 m above the flood level of river Ganga of 100 years return period. Bottom level shall be penetrated 2.5 m in the hard rock. Well sinking, well curb, well stening etc. shall be similar to Intake well.

xvii. Raw Water Pumping Station

129. R.C.C Raw water pumping station shall have to be constructed on top of the floor slab to serve as the floor of the raw water pump station. This slab shall be integral with the walls of Jack well. A pump house shall be constructed on this slab to house the raw water pumping station. The floor level of the raw water pumping station shall be at least 1.00 meter above the HFL considering 100 years return period of the river.

130. The requirement of raw water pump house at the intake structure shall include but not be limited to:

i. The well structure shall be designed to accommodate the weight of the pump house, and to support the raw water pumps and other equipment housed inside also.

ii. The raw water pumps shall be contained within a pump house constructed on top of the well. The pump house design shall include:

- The pump house building shall be designed in accordance with relevant subsection.
- An electric overhead traveling (EOT) crane of adequate capacity to lift out the raw water pumps shall be installed. The crane and pump house floor area shall be designed with adequate space for the EOT crane to be able to lower equipment onto a truck/Trolly.
- Local disconnector for motors is to be installed in intake. The electrical equipment shall be 150 mm (minimum) elevated from the floor level.
- Provide permanent access platforms to service the pump motors. Platforms shall be constructed of steel beams and columns with a GI checker plate walking surface.
- Double floor system shall be adopted. Pumps motors will be housed at bottom floor and Electrical gadgets at top floor. The top floor may will be of structural sections, with removable arrangements.
- Valves shall be accessible from the pump house floor level.
- The platforms and walkways shall have a 2 rail system of 1.0 m in height made of galvanized steel tubes of 32 mm diameter (pillars and upper railing) and 25 mm diameter (lower railing). The walkways shall be accessible from the upper floor of the control building and by means of 800 mm wide stairs.
- A separate control room for the instrument control panel (ICP) and SCADA interface. The room shall be air conditioned. The room shall be furnished in accordance with relevant subsection.
- on. It may be combined with WTP control room.
- A separate storeroom. The door shall be lockable. The storeroom floor shall have acid resistant tiles installed in a dedicated 2 m2 area for battery and acid storage. This area shall be curbed in for containment.
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.
- Windows shall be installed on the exterior walls of the pump house.
- Thrust blocking shall be provided at pump discharges and the deadhead end of the pumping header.

- A 250 mm diameter drain line shall be installed at the invert of the pumping header. The drain line shall contain a sluice valve at the connection to the header. The pumping header shall be sloped at least 1% in each direction to the low point at the drain connection.

- A first aid kit shall be supplied and mounted in the pump room area.

- A potable water supply service line of at least 50 mm diameter shall be provided near substation. The potable water service shall supply drinking water with toilet facilities.Bearing lubrication, if required for the vertical turbine pumps shall be provided.

- A high pressure pump shall be installed to provide sluicing water for the de-silting maintenance operation. Complete de-siltation period of well shall be restricted within 2 hours. Pumped raw water shall be used as the diluting medium. The discharge service piping shall be designed accordingly (hose bibs) installed at various locations to be able to reach the entire volume of the Intake well structure with a hose.

xviii. Raw Water Pumps

131. The raw water pump station shall be configured to accommodate three (3) vertical turbine type raw water pumps; two working and one standby in each section of well for Intermediate stage in the general arrangement as shown on the approved Drawings. Each pump shall have a rubber arch coupling or metal bellows on the pump discharge, followed by a check valve, motorized butterfly valve and isolating sluice valve prior to teeing into the pump header. The line should also contain air valve, dismantling joint. Each pump shall have a pressure gauge and high and low pressure switches mounted in the discharge piping prior to the isolation sluice valve.

132. The pump house shall be designed so the pumps can be removed (pulled) from their bases and transported to an off-site maintenance facility. It will be acceptable for the motor to be removed and loaded separately from the pump.

133. The pumping machinery to be supplied and installed under this contract will be suitable for pumping water up to Intermediate stage requirement. Provision for Phase II requirement shall be made in the pump house.

134. Two working and one standby in each section of well for Intermediate stage.

xix. Desilting Pump

135. The raw water pump station shall also be configured to allow space for a (1W +1S) submersible centrifugal vortex type desilting pump to be stored and lowered into each well upto the bottom of the well. This pump shall be equipped with a hose on the discharge side which will be connected to a permanent discharge line above the floor level in the pump house. The pump discharge line shall run back to discharge into the river, outside of the area of influence of the intake structure.

136. A sluicing system shall be installed, consisting of piping and valves to accommodate minimum 100 mm diameter hose. A wash down pipe shall be installed from 2 individual pumping header to the bottom of each well. The wash down pipe shall be metal pipe with detachable segments each of length not more than 3 m. suitable mechanical arrangement for insertion and extraction of the pipe, shall be provided. The hose shall supply water from

the discharge of the raw water pumps, when required, and agitate the accumulated silt. A sufficient number of access hatches or openings shall be provided to allow hosing and pumping of the silt from all bottom areas of the well during this maintenance operation.

137. The detailed specifications for the submersible centrifugal vortex type desilting pump are given in relevant section elsewhere in the document, and conform to that of acceptable make.

xx. Raw Water Pump Header

138. The raw water pumps shall discharge into a common pumping header. This header shall run outside of the pump house and connect to the raw water transmission main on shore. The header shall have flanged or welded joints and shall incorporate two (2) stainless steel bellows specials, one (1) at each end of the bridge. These bellows shall have flanged end connections.

xxi. Raw Water Pump Layout

139. The design and layout prepared on the basis of relevant standard .Raw water pumps shall be installed as per approved drawings.

140. The pump installation shall be designed so that Ultimate stage Pumps (2w+1s) can be installed easily in each section of well.

141. Bell mouth velocity of each pump shall not exceed 1.5 m/sec. The discharge piping of each pump shall be designed for a maximum velocity not to exceed 2.5 m/s. The piping and valves shall be designed so that the system will be stable should a valve be closed and a pump operating at shutoff head.

142. Pump layout and intake parameters shall conform to Hydraulic Institute guidelines and Pump Manual.

xxii. Gates, Valves and Couplings

143. The sluice gates and valves on the pump discharge lines and for other services shall be as described in elsewhere in Bid Documents.

144. The sluice gates shall need to be specially designed to match the curvature of the circumference of the intake well structure. The Contractor shall make sure that the gate manufacturer understands this and submittals of design details for these gates need to be detailed in order to warrant approval by the Employer's Representative. Or alternatively, straight gate shall be erected on the projection part of the wall. Wall projection shall be especially designed from structure point of view.

145. Each of the inlet sluice gates shall be equipped with a double shafted operator arrangement, having two (2) geared operator pedestals connected by a shaft.

146. Contractor shall provide cleaning arrangement of accumulated garbage on the bar screen.

147. The pump discharge and other piping shall be designed in accordance with the details given elsewhere in bid documents.

xxiii. Raw Water Pumping Station Control System

148. An Instrument Control Panel (ICP-H) housing PLC-H, serving the Raw Water (RW) Pumps and the Intake Well, shall be located in the control room of the Intake Structure. Alarm annunciation and status indicators for the RW Pumps and Transmission system including flow meter, level indicators and valves with position indicators shall also be mounted on ICP-H. ICP-H shall have a NEMA 4X, or IP 64 enclosure.

149. The function of the PLC system shall be remote monitoring and control of the following operations:

- Automatic sequencing of the RW pump start-up and shutdown operations
- Monitoring of the pressure in the RW and annunciate alarms and initiate pump shutdown procedures
- Monitoring of the intake well water level
- Monitoring of the RW transmission main flow meter

150. The instrumentation and control cable shall be installed with casing pipe at the time of installation of the Raw Water Transmission Main.

xxiv. Instrumentation Schedule

151. A listing of the basic instruments to be installed in the intake structure / raw water pump station is given in Table below. The intake structure shall have a main instrument control panel (ICP) with a programmable logic controller (PLC) mounted on the face of the panel. The PLC shall have a human machine interface (HMI) screen with a Colour touch screen sized at least 175 mm in diagonal measurement.

Table 7: List of Instruments for the Raw Water Pumping Station

Service	No.	Type of Instrument	Instrument Function
Flow Measurement			
Flow in Pump Station Discharge Header	1	Full bore electromagnetic type flow meter on discharge header	Indication and recording of flow rates and totalization of pumped flows
Flow Switches to determine if flow is passing through a pump	1 per pump	Flow Switch	Indication of pump operation
Level Measurement			
Water Level in Raw Water Intake	1	Radar type level measuring system	Monitoring of river level. Measurement at set intervals and trending of data.
	2	Staff Gauges on exterior of well (180^{o} apart)	Manual determination of river level
	1	Conductivity type level switches for high and low level detection	Tripping of pumps at low water level and generating an alarm.
Pressure Measurement			
Pressure in the discharge line of each pump	1 per pump	Pressure Gauges	Local Indication

Service	No.	Type of Instrument	Instrument Function
Pump Station discharge pressure	1	Pressure measuring system consisting of a Pressure Transmitter and panel mounted indicator system	Pressure monitoring and generating an alarm
Pressure Switch to detect high pressure in Transmission Mains	1	Pressure Switch	To detect closure of valve or blockage on pumping mains when the pumps are in operation.
Pressure Switch to detect low pressure in Transmission Mains	1	Pressure Switch	To detect pipe break or leakage condition on pumping mains when the pumps are in operation.
Temperature Measurement			
Motor winding and bearing temperatures and pump bearing temperatures for pumps	1 per pump	12-channel temperature scanner (1 per pump-motor set) for large capacity pumps / larger kW motors	- Temperature monitoring - Alarm for high bearing temperature. - Alarm for high winding temperature
	1per pump	Temperature Switches for small capacity pumps /small kW motors	- Tripping of pumps at very high winding and bearing temperatures
			- Tripping of pumps at very high winding and bearing temperatures
Pump/Motor Temperature	1	Portable temperature meter	Monitoring of Pump / Motor temperatures
Sound Measurement			
Sound Levels in the RWPSs and CWPSs	1	Portable sound level meter	Monitoring of sound (noise) levels
Vibration Measurement			
Pump and Motor vibrations	1	Vibration switch for large pump and motor set	**-** Alarm for high vibration of pump motor set -Tripping of pump at very high vibration
Pump and Motor Vibrations for RW and CW Pumps	1	Portable vibration meter	Monitoring of vibrations of pumps and motors
Valve / Gate Position Indication			
Position of control valves on the discharge line from each pump	3	Limit switches for open and closed and transmitter for intermediate valve positions	Open, closed and intermediate position indications for monitoring and control. Must open to a set position when pumps are energized
Position of inlet gates	4	Limit switches for open and closed and transmitter for intermediate gate positions	Open, closed and intermediate position indications for monitoring and control. Must open to a set position when pumps on that main are energized
Control System			
Control System for the RWPS	1	PLC based Instrument Control Panel (ICP).	Monitoring, alarming and semi-automatic control of the pump start-up and shutdown functions. ('Auto' operation to be initiated manually).

Service	No.	Type of Instrument	Instrument Function
	--	A local SCADA System serving the WTP, Intake and Reservoir	The ICP shall facilitate connection to the SCADA

xxv. Electrical Substation

152. A high voltage (33 kV) dedicated feeder, as determined by the Bihar State Electricity Board (the local utility), Substation and switch yard will be provided at the Raw Water Pump House and Water Treatment Plant (WTP) site. A description of these is given in elsewhere in bid documents.

153. The 440 v feeder shall be installed in conduit ran overhead by a means acceptable to the Employer's Representative to get to the intake structure (Jack well).

154. Switchgear (circuit breakers, motor starters, disconnects and meters) in a motor control center (MCC) for the pumps and ancillary equipment shall be installed in the Substation Area. Separate disconnect switches shall be installed at each pump also, in addition to those in the MCC.

155. Piping and Specials: A separate lighting panel shall be provided with circuit breakers, motor starters (if required) and disconnects for the lighting system and low voltage appliances.

xxvi. Boundary Wall and Fencing

156. Intake site shall be encircled by a boundary wall of at least 2,200 mm in height. A layer of coiled barbed wire 400 mm in height shall be attached to the top of the boundary wall. A vertical picket type wrought iron gate (double doors with a center closure) shall be installed. The boundary wall shall be made with brick masonry and RCC pillars (with 3m spacing) with suitable foundation as per specification given elsewhere and the Standard Specifications. The bricks shall be set in cement mortar 1:4 (cement to sand) and shall be pointed in cement mortar 1:4. The top of the wall shall be provided with 75 mm thick RCC coping. The boundary wall shall conform to the requirements of relevant subsection. The barbed wire shall be galvanized iron and shall confirm to IS;278-1978.

xxvii. Approach road to Intake & WTP Pathways and Hard-Standings

157. Bituminous Concrete approach road of 3.50 m width from the existing road to Intake site & to WTP shall be provided to permit vehicular access. The approach road shall be constructed as per the drawings showing alignment& cross section.

158. Ministry of Road Transport and Highways (MORTH), Government of India Specifications for Roads and bridge works and relevant IRC specification should be followed.

159. Hard standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Employer's Representative.

xxviii. Raw Water Pumping Main and Transmission System

160. The scope of work regarding the raw water pumping main includes supplying and laying mild steel pipe line of length approx. 2550 m of outer diameter 1321 mm and associated civil works.

(i) Manufacture and Supply of Mild Steel Pipes

161. **General.** All materials supplied and works carried out shall be in accordance with provisions of relevant IS codes. A minimum 1200mm cover is required for all pipes designed to carry water.

(ii) Applicable Standards/Codes

162. Following standards shall be referred for manufacture of mild steel pipes. In all cases, latest revision of the standards / codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards / codes, this specification shall govern.

Table 8: Standards for Manufacture of Mild Steel Pipes

IS: 2062 IS: 3589	Grade of steel Seamless / electrically welded steel pipes for water, gas, sewage – specification.
IS: 4853	Recommended practice for Radiographic inspection of fusion welded butt joints in steel pipes.
IS: 4260	Recommended practice for ultrasonic butt weld in ferric steel.
IS: 3600 (Part – 1)	Methods of testing fusion welded joints and weld mains in steel: part 1 cruciform fillet weld tensile test
IS: 4711	Sampling of pipe for various tests and criteria for conformity.
IS: 1894	Methods of tensile testing of steel tubes.

(iii) Grade of Steel

163. The steel plates used for manufacture of the pipes shall be of grade Fe 410 conforming to IS: 2062.The quality of steel, chemical composition and tensile strength of the steel plates shall be as specified in IS: 3589 for steel of grade Fe 410. Positive tolerance as per IS: 3589 shall be allowed for plate thickness, but no negative tolerance shall be allowed. All manufactured pipes delivered at site need to have the following markings:

- Manufacturer's name/stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot-end.
- Each Pipe /fitting shall be marked with the standard Marks

(iv) Electrodes

164. The electrodes used for welding of steel plates shall conform to IS: 814.

(v) Ultrasonic and Chemical Composition Test for Steel Plates

165. All plates shall be tested by ultrasonic equipment to check for manufacturing defects such as voids layers etc. The Contractor shall supply test certificate to this effect from the manufacturer. The Contractor shall also supply certificate for chemical composition of the plates used, from the manufacturer.

(vi) Standard Length of Pipes

166. The pipes shall be manufactured in lengths of 10 to 13m with beveled ends. Length of each pipe shall be measured at diametrically opposite at four places and average of the four measured lengths shall be considered for measurements of pipe length. In steep gradient, pipes measuring 4 to 6 m length with beveled ends shall be allowed.

(vii) Welding Process

167. The pipes shall be manufactured from steel plates, butt welded spirally / longitudinally by automatic submerged arc welding process using at least two runs, one of which shall be on the inner side of the pipes. Welding shall be so done that there will be through fusion and complete penetration and shall be free from cracks, oxides, and slag inclusion and gas pockets.

(viii) Deviation in Length

168. Finished pipe length shall not deviate from straightness by more than 0.2 percent of the total length.

(ix) Radiographic / Ultrasonic Test

169. Three percent of all seams of pipes, welded in the fabrication shop, shall be radio graphed (as per IS: 4853) to render visible inspection of any internal defects such as blow holes, slag, inclusion of cracks. If any defects are detected, the metal at the location shall be chipped out and re-welded. In addition to the radiography of the joints, 100 percent testing by ultrasonic equipment (as per IS: 4260) shall also be done for welding tests. Any defects found out shall be rectified free of cost. Welds found deficient in quality shall be removed by chipping or melting and remade as per specifications. Chipping or cutting the weld shall not extend to the base metal.

(x) Hydraulic Test at Works

170. Each pipe shall be hydraulically tested at manufacturer's works before applying any coating / lining In accordance with Clause 10 of IS: 3589.

(xi) Allowable Tolerance

- Allowable tolerance for out- side diameter shall be (+,-) 0.75% of the specified diameter.
- Allowable tolerance for ovality shall not be more than 1% of the specified dia.
- Negative tolerance for plate thickness shall not be allowed.

(xii) Sampling and Testing

171. Sampling and conformity criteria for various tests shall be as given in IS: 4711. The test samples shall be cut from pipes in the final condition of supply. Tests for tensile strength, percentage elongation, guided bend test, shall be carried out and the test values shall be in conformity with those specified in IS: 4711.

(xiii) Third Party Inspection

172. The pipes ready in the manufacturer's work yard shall be inspected and tested before dispatch, by the inspecting agency appointed by the employer. All the tests including hydraulic test shall be carried out on the specified quantity of samples from each lot as specified in IS: 4711, in presence of the inspecting agency. The internal epoxy lining shall be applied to the pipes only after the inspecting agency is satisfied regarding the test results, which shall be in conformity with the limits specified in IS: 4711. The Contractor shall produce the test certificate issued by the inspecting agency. The supplied pipes will be considered for measurements and payment only after receipt of the satisfactory test certificate from the inspecting agency. The inspection charges of the inspecting agency shall be paid by employer and latter on deducted from contractor bill..

(xiv) Application of Red oxide

173. The pipes cleared by the inspecting agency shall be provided with specified external coating or one shop coat of red oxide as per relevant IS, externally, as the case may be, prior to dispatch.

xxix. Manufacture and Supply of MS Specials

(i) Fabrication of Specials and Appurtenances

174. Specials such as bends, tapers, and tees shall conform to IS: 7322. Specials shall be fabricated by cutting plates of required thickness to the required shape, obtained by developing the form of specials on ground. Abutting profiles shall be obtained using templates, which guide the cutting torches as to obtain a uniform cut. No hand cutting shall be permitted. Specifications for using and testing of the plates, electrodes, welding process, etc shall be the same as for the MS pipes. Plain ends shall have bevelled edges. Specials shall be manufactured as per construction drawings. Stiffeners shall be provided wherever necessary.

(ii) Requirement

175. Specials as specified below shall be required. Slight variation may be possible as per the site conditions.

- Horizontal and vertical bends
- Air valve tees
- Washout valve tees
- Access manhole tees with blank flange
- Eccentric reducers (tapers)
- Dismantling joints
- Steel strap ring and bearing plates at chairs proposed for the above ground pipeline.
- Stiffener rings for pipes and specials as required and as directed by the Employers representative.
- Blank flanges etc.

(iii) Bends, tees and tapers

176. The testing of these specials is not envisaged at the fabrication stage. These shall be subjected to test when the completed pipeline is tested hydraulically. In view of this, the

Contractor shall fabricate these specials with due care so that there is no failure of any welded joint during testing of the completed pipeline, which will invite dewatering the main, repairing and retesting.

(iv) Eccentric tapers (reducers)

177. The tapers shall be fabricated in one or more pieces as may be necessary according to their lengths and plate sizes available. Stiffener rings shall be provided as necessary and as directed by the Employers representative. The tapers shall be eccentric with bottom portion straight and top reducing.

(v) Stiffener Rings

178. Stiffener rings shall be provided for the pipes on each side of air valves, washout valves, on line valves and access manholes to strengthen the pipe at provided openings.

(vi) Bearing Plates and Steel Strap Rings

179. Bearing plates, equal in width of chairs and thickness equal o pipe thickness shall be provided on the chair / pedestal supports below roller bearings. Steel straps of size and thickness as required shall be provided and fixed for pipe anchorage with the chair supports. The straps shall be welded to MS angle on either end and anchored with the chair concrete by providing MS bolt

(vii) Measurement and Payment

180. The item covers cost of all material and fabrication of specials, application of internal lining and coating as per pipeline specifications, loading, transportation to the work site, unloading, stacking on work site including all taxes and duties, cost of nut bolts, rubber gaskets etc complete.

(viii) Specifications for Gas cutting

181. Cutting of the pipe for providing tees for air valves, washout valves, preparation of manhole openings, etc becomes necessary. The edges of the specials are required to be cut to match with the pipe edge for proper jointing and welding. Plate cutting operations at such places are performed with the use of gas cutting. Payment for gas cutting of the pipe surfaces at required locations and edges of the specials shall be deemed to be covered under the quoted price of the bid.

(ix) Manufacture and supply of MS dismantling joint

182. Dismantling joint shall be provided for each online sluice / butterfly valve, bulk flow meter, pressure reducing valve and washout valve etc to facilitate removal of the valve / meter for repairs whenever required. The joints shall be fabricated as shown in the standard drawing for valve chambers enclosed with the bid document. The item covers cost of plates, fabrication cost including all taxes and duties and cost of epoxy lining and coating, packing, transportation, cost of jointing including required material such as flanges, nut bolts, rubber packing, labour cost etc. complete with hydraulic testing to required pressure.

xxx. Specifications for internal epoxy lining

- Internal lining shall be provided using following method
- Internal epoxy lining to ms pipes and specials

(i) General

183. All the Epoxy lining and coatings shall be conforming to IS: 3589 and AWWA C-210.

184. All the buried MS pipes and specials shall have internal Epoxy lining in three coats including primer coat with a total Dry Film Thickness (DFT) of minimum 430 micron.

185. Exposed pipes and specials or pipes and specials installed in steep hilly terrain shall also have Epoxy coating on external surface in 3 or more coats including the primer coat. Total DFT of all the layers of external coating shall be minimum 600 microns including the primer coat and applied in the same manner as that of lining.

(ii) Materials

186. Internal Epoxy lining shall be with one primer coat of 2-part Chemically cured spray applied liquid Epoxy minimum 30 micron thick followed by 2-part Chemically cured spray applied liquid Epoxy 2 top coats. Total Dry Film thickness of the two top coats shall be minimum 400 micron.

187. All Epoxy lining and coatings shall be Factory spray applied and repaired as required during field installation. Welded field joints shall be field coated to the same total DFT and as specified above.

(iii) Steel surface preparation

Cleaning

188. Prior to abrasive blast cleaning, the internal and external surface shall be inspected and, if required, cleaned to remove oil, grease or other foreign matter. Only approved solvents that do not have a residue shall be used. Preheating to remove oil, grease, mill scale, water and ice may be used, provided full pipe is preheated in a uniform manner to avoid distorting the pipe.

Abrasive blast cleaning

189. The pipe surfaces shall be abrasive blast cleaned to achieve a white metal surface. Prior to blast cleaning any sharp protuberances, surface laminations, weld spatter, etc shall be removed by thorough cleaning and grinding. The abrasive used should be capable of producing a minimum profile of 50-75 microns corresponding to "medium" in accordance with BS 7079 Part C4. Throughout the blast cleaning process the humidity should be less than 85%. The pipe surface should be at least 3^0 C above due point prior to abrasive blasting.

190. Immediately after blast cleaning, all dust, residues and debris left on the surface must be removed. Dry, oil free compressed air shall be used to remove the loose foreign matter in a manner that does not adversely affect the cleaned surface. Alternatively, vacuum cleaning or other methods may be used in place of compressed air.

Pipe ends for welded field joints

191. After blast cleaning, ends of pipes which will subsequently be welded should mask off for 150 mm back from end of pipe.

(iv) Application of Epoxy

General

192. Prepared surface must be completely clean of dust, dirt and grease and thoroughly dry.

No lining or coatings shall be applied in the following atmospheric conditions:

i. Relative humidity exceeding 85%
ii. When the surface to be coated is less than 3^0 C above the dew point
iii. When the surface temperature is less than 7^0 C or greater than 50^0 C

193. Linings and or Coatings shall be curtailed 150 mm from both ends of the pipe to permit site welding of joints.

Successive coats

194. If more than one coat is applied, or application of the coat after primer coat application, the second coat shall be applied within the time limits, surface conditions, and temperature recommended by the manufacturer. If the period between coats is exceeded, then a repair procedure shall be obtained from the coating manufacturer, and its recommendations shall be followed.

Coating thickness

195. Final thickness of internal lining shall not be less than 430 microns and that of external coating shall not be less than 600 micron.

Application temperature

196. The temperature of mixed coating material and of the pipe at the time of application shall not be less than 10^0 C. Preheating of the coating material, the use of inline heaters to heat the coating material; or heating of the pipe, fittings or specials, may be used to facilitate the application. Heating shall confirm to the recommendations of the coating manufacturer.

Plural feed hot airless spraying

197. The base component and Activator shall be heated separately by either or a combination of the following:

i. Individual drum heaters for Base and Activator, each heater fitted with a variable thermostatic control,
ii. In-line heaters, fitted in to the Base and Activator lines at the pump. 110 volt heaters for site work fitted with variable thermostats.

198. The Base and Activator shall be pumped individually to an airless proportioning pump and re-circulated either through the Base and Activator lines back into the heated tanks or via the in-line heaters, through the lines, back into the Base and Activator containers or back into the heated tanks.

199. The heated Base and Activator shall be kept separate throughout the system until they meet at the mixer head at the end of each individual coating feed line. To minimize temperature losses, the paint feed lines shall be insulated and the spray gun attached by a

single airless paint line to the mixer head. The length of this line shall be kept to a minimum. Subject to the results of the trial application, the "whip end" line shall also be insulated, and long lengths shall be heated if necessary.

200. During start up and when spraying stops, the Base and Activator shall be re-circulated down the Base and Activator return lines and left on re-circulation to ensure that the coating in the lines is maintained at constant temperature. When any spraying stops for lunch, moving scaffold etc, the solvent flush line shall be activated, to flush out and clean the mixer head and whip end line.

Touch up and repair procedures

201. The finished coating shall be inspected for damage or reduced thickness. Any such areas shall be repaired by thoroughly degreasing the surface and abrading using 180 grade abrasive papers, the abraded area should extend from edge of the damage for 50-75 mm onto surrounding sound coating. The repaired surface can then be re-coated.

202. The coating shall be hard dry before the surface is abraded. No surface shall be abraded within the times given in the following table.

Table 9: Abration of Coating

Temperature degrees C	7	10	15	20	25	30
Time to elapse between application and abrasion for repairs (hours)	36	32	24	16	12	8

Final cure time

203. The lined pipes shall be stored for curing in accordance with the durations given in the following table.

Table 10: Duration of Lined Pipes for Curing

Ambient Temperature (degree C)	45	40	35	30	25	20	15	10	7*
Minimum number of days storage	1	1	2	4	5	7	11	17	22

* Minimum possible cure temperature

Electrical inspection for continuity

204. After curing, but prior to installation, the coating system applied to the pipe shall be tested for holidays according to the procedures and using the voltage settings. Any holidays indicated by the detector shall be marked with chalk or left-tip marker to identify the area to be repaired.

Care during transportation and handling

205. The Contractor should take extreme care and precautions during handling (loading, unloading, shipping, transportation, storage to avoid damaging to the factory applied coatings. Any damages to the factory applied lining or coatings shall be repaired by brush cleaning and re-coating prior to applying the field coatings. Shop coatings and field touchups shall be electrically inspected by the use of holiday detector.

Coating of joints after welding

206. All weld areas shall be thoroughly cleaned to remove welding spatter and debris, including damaged coating, using angle grinders, needle guns or rotary grinders ensuring that a coarse profile is achieved on metal surfaces and surfaces are not polished.

207. The abraded area should extend from the edge of the weld area for 50-75 mm onto surrounding sound epoxy coating ensuring the surface of the coating is thoroughly flatted off to remove all gloss and is then uniformly profiled. The requirement is absolutely essential to ensure a sound finish and shall be strictly followed at all times.

208. All loose dust and abrasive residue shall be removed from surface by brush or airline. Surfaces shall be degreased with detergent solution to ensure no oil or grease resulting from the abrading process is present.

209. The two-part epoxy coating shall be mixed in accordance with the manufacturer's product data sheet and then applied to the prepared area to achieve the same thickness as the pre-coated pipe.

210. Electrical inspection shall be carried out as explained earlier for holidays if any for the coatings on welded joints.

(v) Tests and inspection

211. The Contractor shall carry out the following tests:

Surface preparation stage

i. Comparison with appropriate standards for surface preparation
ii. Comparison with appropriate standards for blast profile
iii. Cleanliness of surface prior to coating
iv. Humidity, dew point and surface temperature during blast cleaning

Application stage

i. Wet film thickness
ii. Visual assessment
iii. Humidity, dew point and surface temperature

Minimum 24 hours after application

i. Dry coating thickness

After 48 hours curing

i. Test for porosity using holiday detector

(vi) Trial application

212. Once the Contractor has established his equipments and working method, he shall do a trial lining of a coated section of pipe. The length of the initial sample pipe shall be not less than 2 m. If, in the opinion of the Employers representative, the finished lining does not comply with the specifications, then the Contractor shall modify the equipment or method so as to achieve a satisfactory result. The trial shall be repeated until a satisfactory finish is achieved. Once the trial lining has been approved on the sample length, the Contractor shall line and cure a section of pipe of normal length to the satisfaction of the Employers representative. If, after curing, the coating demonstrates any residual surface tack then the

Contractor shall wet the surface of lining to demonstrate whether or not this causes it to disappear. If the surface remains tacky then the Contractor shall consult the manufacturer. Residual surface tack may be due to the temperature and humidity at the location of application and if it disappears under the application of water is not a cause for concern.

xxxi. Specification for External Coating to MS pipes and Specials

213. External coating shall be provided using following method:

a. External Coating with Pre-fabricated Polyolefin Tape to MS pipes and Specials or 3 LPE external coated pipe preferably factory made (conforming to DIN-30670,1991 and DIN-30678, 1992).

(i) General

214. All buried pipeline shall be coated externally with pre-fabricated polyolefin tape coating as per AWWA C-214-07 with cathodic protection or 3 LPE external coated pipe preferably factory made (conforming to DIN-30670,1991 and DIN-30678, 1992) with cathodic protection. The Contractor shall perform all the work in accordance with these specifications and the latest pipeline coating practices, and shall complete the work in all respects to the full satisfaction of the owner / owner's representative. The entire coating application starting from cleaning and surface preparation till coating shall be performed under the supervision of skilled personnel who are well conversant with the work. Pipes which have been cleaned and primed or cleaned, primed and coated, without having been inspected and approved shall be rejected.

215. This specification shall not intended to be all inclusive and the use of guide lines set fourth here does not relieve the Contractor of his responsibility for the quality and performance of the applied coating system, and to supply coating material capable of performing its intended service.

216. All steel special sections, connections and fittings to be used for underground pipeline shall be coated with cold applied tape consisting of liquid adhesive and prefabricated tape as described in 3 LPE external coated pipe preferably factory made (conforming to DIN-30670,1991 and DIN-30678, 1992) or AWWA C-209-07.

(ii) Tape coating system

217. The buried steel pipeline shall be protected with cold applied tape protective coating conforming to 3 LPE external coated pipe preferably factory made (conforming to DIN-30670,1991) or, AWWA C-214-07. Protective coating shall consist of primer, inner tape wrap, and outer wrap.

(iii) Coating system

218. The prefabricated polyolefin tape coating system shall consist of the following layers to provide an applied coating system thickness of 80 mills (2.032 mm) on the exterior of the steel pipes for corrosion protection.

1. A liquid adhesive layer, thickness 50 to 75 microns
2. An inner layer tape for corrosion protection, minimum thickness 20 mills (0.51 mm)
3. An intermediate layer for mechanical protection, minimum thickness 30 mills (0.76 mm)

4. An outer layer tape for mechanical and ultra violet protection, minimum thickness 30 mills (0.76 mm

(iv) Liquid adhesive layer

219. The liquid adhesive layer shall consist of a mixture of suitable rubber and synthetic compounds and solvent. The liquid adhesive layer shall be spray applied to the abrasive blasted prepared pipe surface before application of the inner-layer tape. The function of the liquid adhesive is to provide a bonding medium between the pipe surface and the inner-layer tape.The properties of liquid adhesive shall be as follows:

Table 11: Physical properties of the Liquid Adhesive

Colour	Base	Weight		Flash Point
Black	Rubber and Synthetic Resins	Flammable	0.72 – 0.96 kg / l	-17^0 C or greater
		Non flammable	1.20 – 1.44 kg / l	None

220. The Liquid Adhesive shall be supplied by the manufacturer that supplies the inner-layer tape. The liquid adhesive shall not settle in the container forming a cake or sludge that cannot be easily mixed by hand or mechanical agitation and it shall have good machine application properties.

221. The function of the liquid adhesive is to provide a bonding medium between the pipe surface and the inner-layer tape.

(v) Inner-layer tape

222. The inner-layer tape shall be a two-layer tape consisting of a Polyolefin backing layer with a laminated butyl-based adhesive layer. The inner tape shall be compatible with the liquid adhesive. The manufacturer shall certify that the backing material shall be Polyolefin only, containing not less than 3.0 percent or more than 7.0 percent by weight of non-polyolefin material consisting of Carbon black and antioxidants. The inner-layer tape shall be applied after the liquid adhesive and before the outer layer tape. The backing and adhesive shall be made from materials that provide high electrical resistivity, resistance to corrosive environments, low moisture absorption and permeability, and shall provide an effective bond to a primed steel surface. The inner-layer tape shall be of material that will resist excessive mechanical damage during normal application operations and shall be sufficiently pliable for the intended use. The inner-layer tape shall withstand, without tearing, the tensile force necessary to obtain a tightly wrapped inner coating free of voids. The inner-layer tape shall be supplied in roll form wound on hollow cores with a minimum inside diameter of 75mm.To ensure a proper smooth coating, the inner-layer tape shall be provided in standard widths as per manufacturer recommendations consistent with the pipe diameter.

Table 12: Physical properties of inner layer tape

Property	Requirements		Test method (Ref: AWWA C-214-07)
	Minimum	Maximum	
Width deviation	-5% -6 mm whichever is smaller	+5%	Sec. 5.3.1
Nominal thickness 20mil (508 pm)	19 mil (483 pm)	22 mil (559 pm)	Sec. 5,3.2

Property	Requirements		Test method (Ref: AWWA C-214-07)
	Minimum	Maximum	
Ratio of adhesive to total inner-layer tape thickness, t	40% of total t	60% of total t	Sec, 5.3.2
Adhesion to prepared steel	2,190 N/m width		Sec. 5.0.433
Water absorption (24 h)		0.2% by wt	Sec. 5.3.4
Watervapor transmission		0,2 perms[1.15 x10^{11} kg(Pa.s.m^2)]	Sec. 5.3.5
Dielectric strength	6,000 V/single thickness		Sec. 5.3.6
Insulation resistance	500,000 meg-ohms		Sec. 5.3.7
Tensile strength	3,500 N/m width		Sec. 5.3.8
Elongation	100%		Sec. 5.3.9
Nonpolyolefinic Material Percent by weight	3,0	7.0%	Sec. 5.3.12

(vi) Outer-layer tape

223. The outer-layer tape shall be a two-layer tape consisting of a polyolefin backing layer with a laminated butyl adhesive layer. The manufacturer shall certify that the backing material shall be polyolefin only containing not less than 3.0 percent or more than 7.0 percent, by weight, of non-polyolefinic material consisting of pigments, antioxidants and stabilizers. The outer layer shall be compatible with the inner-layer tape. The primary function of the outer layer tape is to provide mechanical protection to the inner-layer tape. The outer-layer tape colour shall be white or grey.

224. Materials used in outer-layer tape shall have high electrical resistivity, low moisture absorption and permeability. The outer-layer tape shall be supplied in roll form wound on hollow cores with a minimum inside diameter of 75mm.

225. Dimensions: The outer-layer tape shall be provided in standard widths and lengths. The width of the outer-layer tape shall be at least equal to that of the inner-layer tape.

Table 13: Physical properties of outer-layer tape

Property	Requirements		Test method (Ref: AWWA C-214-07)
	Minimum	Maximum	
Width deviation	-5% or -1/4 in. (-6 mm)whichever is smaller	+5%	Sec. 5.3.1
Nominal thickness 30mil (762 pm)	27 mil (686 pm)	33 mil (838 pm)	Sec. 5,3.2
Adhesion to Inner layer	20 oz /in width (200 N / m width)		Sec. 5.0.433
Tensile strength	40 lb/in (7.0 Tensile strength 00 N / m width)		Sec. 5.3.8
Elongation	100%		Sec, 5.3.9
Nonpolyolefinic Material Percent by weight		3.5%	Sec. 5,3.12

226. The properties of the complete coating system shall conform to the following requirements.

Table 14: Physical properties of total coating system

Property	Requirements		Test method (Ref: AWWA C-214-07)
	Minimum	Maximum	
Thickness 80 mill, nominal	73 mill (1,854 pm)	88 mill (2.235 pm)	Sec. 5.3.2
Dielectric strength	12000V		Sec. 5,3.6
Impact resistance	25 lb • in.		Sec. 5.3.10
Penetration / deformation resistance	25% with no holiday at72 °F (22°C)		Sec. 5.3.11

xxxii. Coating application

(i) General

227. The coating application shall be a continuous operation starting with properly abrasive blasted pipe surface. Longitudinal & spiral welds of the pipe shall not exceed a height of 3/32 inch (2.4mm) above the pipe surface and shall be ground flush a full 18 inch (450mm) along the length of the pipe from both ends prior to the coating process.

228. Four steps, which shall be performed consecutively in a plant, shall consist of (1) liquid adhesive application; (2) application of the inner-layer tape directly onto the prepared pipe surface; and (3) application of the intermediate-layer tape directly on top of the inner-layer tape and (4) application of outer-layer tape directly on top of the intermediate-layer tape.

(ii) Pipe preparation

a. Metal surface condition

229. Bare pipe shall be free from mud, mill scale, mill lacquer, wax, coal tar, asphalt, oil, grease, or any other foreign material. Before blast cleaning, surfaces shall be inspected and pre-cleaned according to SSPC-SP 1 to remove oil, grease, and loosely adhering deposits. Visible oil and grease spots shall be removed using a solvent. Only solvents that do not leave a residue shall be used. Preheating to remove oil, grease, and mill scale may be used provided that the entire pipe is preheated in a uniform manner to avoid distortion.

230. After drying and removing all loosely adhering foreign materials, the pipe surface shall be cleaned by blasting with grit or steel shots to achieve a surface preparation at least equal to that specified in SSPC-SP 6 / NACE3. The blast anchor pattern or profile depth shall be 1 mil to 3 mils (25 pm to 75 pm) measured in accordance with ASTM D4417.

231. For consistent surface finish, a stabilized working mix shall be maintained in abrasive recycling blasting machines by frequent small additions of new grit, shot infrequent large editions shall be avoided. The abrasive working mix, abrasive recycling blasting machines shall be maintained clean of contaminants by continuous effective operation of blasting machine scalping and air-wash separators.

232. The cleaned exterior pipe surface shall be inspected for adequate surface preparation. Surface imperfections, such as slivers, scabs, burrs, weld spatter, and gouges, shall be removed by hand filing or grinding if necessary to prevent holidays.

233. Blast-cleaned pipe surfaces shall be protected from conditions of high humidity, rainfall, or surface moisture. No pipe shall be allowed to flash rust before coating. To ensure a dry pipe surface at the time of liquid adhesive application, the minimum steel substrate temperature shall be 30°C and at least 3°C above the dew point.

b. Liquid adhesive application

234. The liquid adhesive shall be applied in a uniform thin film at the coverage rate recommended by the manufacturer. The liquid adhesive shall be thoroughly and continuously mixed and agitated during application to prevent settling. The liquid adhesive shall be applied to the entire exterior surface of the pipe by spray to cover the entire exterior surface of the pipe.

235. The liquid adhesive coat shall be uniform and free from floods, runs, sags, drips, or bare spots. The liquid adhesive coated pipe surface shall be free of any foreign substances, such as sand, grease, oil, grit, rust particles, or dirt.

236. Before applying the inner-layer tape, the liquid adhesive layer shall be allowed to touch dry in accordance with the manufacturer's recommendation.

c. Application of inner-layer tape

237. The inner-layer tape shall be applied directly onto the prepared pipe surface using mechanical constant-tension coating equipment. The inner layer tape shall be spirally applied with neck down tension as recommended by manufacturer. When applied to spirally welded pipe, the direction of the tape spiral shall be generally parallel to the weld spiral. The minimum overlap shall not be less than 25 mm. When a new roll of tape is started, the ends shall be overlapped at least 150 mm measured circumferentially.

d. Application of Intermediate and Outer-layer tape

238. The intermediate and outer - layer tape shall be applied over the inner-layer tape and intermediate layer tape respectively using the same type of mechanical equipment used to apply the inner-layer tape. The intermediate and outer- layer tape shall be spirally applied with neck down tension as recommended by manufacturer. The overlap of the intermediate-layer tape shall not coincide with the overlap of the inner-layer tape. The minimum overlap shall not be less than 25 mm. When a new roll of tape is started, the ends shall be overlapped at least 150 mm measured circumferentially. The intermediate and outer-layer tape shall be applied at a minimum roll body temperature of 21°C or as recommended by the tape manufacturer.

e. Tape Coating cutback

239. Coating cutbacks shall be 150 mm +/- 25 mm

(iii) Tape Coated-Pipe Application Acceptance Tests (Dielectric Coating)

a. Thickness

240. The thickness of the coating system shall be checked in accordance with SSPC-PA 2. The thickness shall be in accordance with the values given in the Table III and shall be checked at a frequency specified by the Owner / Owner's representative.

b. Holiday Testing

241. Each coated pipe section shall be electrically tested for flaws in the coating using a suitable holiday detector approved by the Owner / Owner's representative. The detector shall impress a minimum of 6,000 V. Reference should be made to NACE RP-02-74. The electrical inspection shall take place on the inner-layer tape before the intermediate -layer tape is applied. If a holiday is detected, it shall be repaired as per specifications.

c. Peel strength

242. The peel strength of the inner-layer tape to steel shall be checked in accordance with ASTM D-1000. The average value below the limits stated in the Table I shall constitute a failure of the system to meet the adhesion requirement. The peel test shall be conducted at a frequency specified by the Owner / Owner's representative.

d. Coating Repair

243. All damaged or flawed areas, holidays, and mislays shall be repaired by using Type 1 and Type 11 coatings (as specified under *Coating of Field Welded Joints).* Alternatively, cold-applied tape coatings conforming to AVVWA 0209 or polyethylene patch sticks or patch materials as recommended by the manufacturer and approved by Employer's Representative may also be used. The damaged area shall be covered with a minimum of 50 mm overlap around the damaged area by using either a precut patch or wraparound coating. The repaired area shall be tested with a holiday detector after the repair is completed.

e. Shipping, handling and storage

244. Coated pipe shall be handled, stored and shipped in a manner that will prevent damages to the coatings. Coated Pipe also shall be handled and stored in a manner to prevent damage to pipe walls and ends.

245. Trench-side Storage: Pipe stored along the trench side shall be suitably supported off the ground to avoid damage to the coating.

f. Coating of Field Welded Joints

246. This section provides the requirements for heat-shrinkable type coating, including material application, inspection, testing, marking and packaging requirements. Heat-shrinkable type coating shall be used to coat all field welded joints.

247. All materials provided by the Contractor shall be of the specified quality. The entire operation of applying the heat shrinkable coating shall be performed by workers trained in the application of heat-shrinkable coating system. The materials provided shall meet the provisions of AVVVVA 0216. Work or material that fails to conform to this standard may be rejected at any time before final acceptance.

248. Heat-shrinkable coatings consist of material fabricated from cross-linked polyolefin sheet or tubing pre-coated with an adhesive. After they are installed, the coating shall conform to all surface contours of the pipe. Heat shrinkable polyolefin material shall conform to the following requirements:

(iv) Material

249. The Heat Shrinkable polyolefin coating shall be a laminate that consists of a cross linked polyolefin backing and a homogeneous adhesive layer. The adhesive may be either a tack, pressure-sensitive amorphous adhesive (mastic) or a non-tacky, semi crystalline adhesive (hot melt). The prefabricated heat-shrinkable polyolefin coating shall be one of the following types:

Type I, Tubular-type Coatings: These are installed before joining the pipe ends by sliding the coating from a free end of the pipe onto the area to be coated.

250. Type II, Wraparound-type Coatings: These are wrapped circumferentially around the pipe area to be coated. Each wraparound coating is provided with either a separate or a built-in closure, as supplied by the manufacturer that secures the overlap during the shrinking process.1.8.9.2 Application of inner-layer tape.

251. The physical properties shall meet the technical requirements as below.

Table 15: Physical properties of Heat-shrinkable Coatings

Property	Minimum	Maximum	Test Method (Ref AWWA C 216)
Width Deviation	± 10% width or 6 mm, whichever is smaller	-	Sec 5.3.1
Thickness (as supplied)	Type I: 1.5 mm Type II: 1.5 mm	- -	Sec 5.3.2 Sec 5.3.2
Water-vapour Transmission	-	0.05 g/h/m^2	Sec 5.0.433
Dielectric Strength	15 volts/p	-	Sec 5.3.4
Volume Resistivity	10^{14} ohm cm	-	Sec 5.3.5
Adhesion to Steel	1.43 kg/cm	-	Sec 5.3.6
Heat Shock (test forcross linking of backing)	Novisual Cracking, flowing, or dipping	-	Sec 5.3.7
Tensile Strength	15.2 MPa	-	Sec 5.3.8
Elongation	400%	-	Sec 5.3.9
Impact Resistance	282 cm-N	-	Sec 5.3.11

252. Type I coatings are provided in sleeves of predetermined diameters to fit the steel pipe. Type II coatings may be supplied in individually precut sizes or in roll form. A roll form product is wound on hollow cores with a minimum inside diameter of 75 mm.

(v) Dimensions

253. The manufacturer shall provide pre-cut coatings in standard widths as specified by Employer's Representative but not less than 450 mm. They shall be adequate to provide the stipulated overlaps on the pipe/fittings coating.

(vi) External Coating of Exposed Pipes, and Pipes installed in Hilly Terrain

254. Exposed pipes or pipes installed in steep, hilly terrain shall consist of one coat of a two part chemically cured epoxy primer and two or more coats of a chemically cured solid based epoxy. The minimum thickness of the coating is 600 microns. The coating shall be factory applied. The Contractor shall take extreme care and precautions during handling (loading/unloading, shipping and storage) to avoid damaging the factory applied coatings. Any damages to the factory applied coating or lining shall be repaired by brush cleaning and recoating prior to applying the field coating.

255. **Clear Water Transmission System:** The scope of work of clear water transmission system includes supply and laying of DI K-9 pipes of length approximately 28.65 km and diameter varies from 150 mm to 1000 mm. All materials supplied and works commencement shall be in accordance with relevant IS codes. The water is pumped from clear ater transmission system to th various storage reservoirs. There are two transmission system: A. Southern Transmission System and B. Western Transmission System. The details of both the water transmission systems are as below.

Table no 16: Details of Southern and Western Transmission System

Details	Western Transmission System	Southern Transmission System
Discharge (intermediate stage)	56 MLD	44 MLD
Design Discharge (Ultimate stage)	74.30 MLD	58.10 MLD
Pumping Hours	23 hours	23 hours
Average water level in clear water sump	46.00 m	46.00 m
Lowest water level in clear water sump	44.00 m	44.00 m
Full supply level in clear water sump	47.50 m	47.50 m
Diameter of clear water main	150-900 mm	150-800 mm
Length of clear water main	16.35 km	12.30 km
Note: The details are for guidance purpose and the contractor shall design the system as per the design criteria given in CPHEEO manual.		

xxxiii. Supply of Ductile Iron Pipes

Table 17: Suppy of Ductile Iron Pipes

Factor	Experience Criteria					
		Bidder				
			Joint Venture or Association			
Sub Factor	Requirement	Single Entity	All partners combined	Each partner	Lead partner	Documentation Required
2.4.1 General Production Experience	(a) Should demonstrate to have a licence issued by Bureau of Indian Standards (BIS) or equivalent International Standard operating for a minimum 5 years to manufacture/product D.I Pipes of diameter 100 mm to 1000 mm class K9 as per IS 8329:2000 or equivalent International Standards. (b) Should demonstrate the authority to put standard marks of Bureau of Indian Standards on pipes by obtaining a certification marks licence, as per IS 8329:2000 by Bureau of Indian Standards, as per gazette notification no S.O. 2749(E) dated 30th Oct'09 issued by Ministry of Commerce & Industry. The certification marks license should be submitted along with the bids. (c) Should demonstrate experience in manufacturing and production of D.I pipes of Diameter 100mm to 1000mm class K9 as per IS 8329:2000 at least 5 years from date of issue of such license.	Must meet requirement	N/A	Must meet requirement	N/A	Form EXP- 1
2.4.2 Performance Experience	(a) Should demonstrate to have proven track record of good performance of D.I Pipes for last 3 (Three) years as per IS 8329:2000. It should be supported by the clients.	Must meet requirement	N/A	Must meet requirement	N/A	(a) Certificates of Clients (b) Test certificates from Govt.

Factor	Experience Criteria					
		Bidder				
			Joint Venture or Association			
Sub Factor	Requirement	Single Entity	All partners combined	Each partner	Lead partner	Documentation Required
	(b) Joint leak tightness Test as per Clause 6.3 of IS 8329:2000, bidders should ensure that the joint is designed to provide adequate joint performance to the highest possible pressure, i.e max. allowable site test pressure (STP) as per Table-1 of Annexure E of IS: 8329:2000. So efficacy of joint design has to be proved by suitable type tests(proof of design test which is once done) and test results, certified by a Govt. recognized institution/ inspection agency are to be submitted with the Technical bid. (c) Cement lining smoothness Type Test to ensure desired smoothness of Cement Mortar Lining, the bidder should submit "C" Value test certificate (Proof of Design Test, which is once done) showing the minimum Hazen William's "C" value of 140, corroborating the guidance of CPHEEO's manual water supply and Treatment (Table 6.1, page 108). The "C" value type test result certified by a Govt. recognized institution/ inspection agency to be submitted with technical bid. The test sample diameters shall be chosen as per clause 9.2 of IS :8329:2000 (d) Portability Test-Bidders shall ensure that the inside lining materials, cement mortar lining and rubber gasket which come in contact with the potable water, will not have any detrimental effect on the quality of water and should not impart any bad taste					recognized institution/inspection agency (c) Test certificates from Govt. recognized institution/inspection agency (d) Test certificates from Govt. recognized institution/ inspection agency

Factor	Experience Criteria					
		Bidder				
			Joint Venture or Association			
Sub Factor	Requirement	Single Entity	All partners combined	Each partner	Lead partner	Documentation Required
	or foul odour as per Clause no. 8.5 and 14 of IS: 8329:2000. Necessary test certificate from a Govt. recognized institution/internationally recognized agency is to be submitted with the Technical Bid.					

(i) Standards

256. Following standards shall be referred for manufacture of Ductile Iron pipes. In all cases, latest revision of the standards / codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards / codes, this specification shall govern. All the DI pipes shall be k-9 class pipes.

Table 18: Standard for the Manufacture of Ductile Iron Pipes

IS: 8329	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage
IS: 5382	Rubber sealing rings for gas mains, water mains and sewers
IS: 638	Sheet rubber jointing and rubber insertion jointing
IS: 1608	Mechanical testing of metals – tensile testing
IS: 12288	Code of practice for use and laying of ductile iron pipes
ISO: 2531	Ductile Iron Pipes, Fittings and accessories and their joints for Water or Gas application, issued by the International Organization of Standardization (ISO)

(ii) Casting

257. The pipes shall be centrifugally cast (spun) Ductile Iron pipes for Water, conforming to the IS 8329. The pipes used will be with push on joints (Rubber Gasket Joints).

258. Surface coating and internal lining: The pipes shall be coated at the manufacturer with Epoxy coating, 75 micron thick including primer and finishing coat and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of the IS 8329.

(iii) Standard length

259. The pipes shall be supplied in standard lengths of 5.50 and 6.00 meters with chamfered ends suitable for push-on jointing. Each pipe of the push on joint variety shall also be supplied with a rubber EPDM gasket, conforming to the IS: 5382. Short length pipes to the extent of allowable limit as per IS shall also be acceptable. Any change in the stipulated lengths will be approved by the Employers representative – in charge.

(iv) Manufacture of Gaskets

260. The gaskets shall also be supplied by the manufacturer of the pipes. They shall preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the contractor to see that the manufacturer of the pipes get them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub contractor's premises as per the relevant IS provisions. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

261. Flanged joints: The flanged joints will conform to **Clause 6.2** of IS 8329. The pipe supply will also include one rubber gaskets for each flange.

262. Hydraulic test at works: Each and every pipe shall be tested hydraulically by the manufacturer as specified under clause 11 for the pressures specified in table 1 of IS: 8329. The test shall be carried out before application of surface coating and lining except Zinc coating which may be applied before the hydrostatic test.

263. Test for Gaskets: The test reports for the rubber gaskets shall be as per acceptance tests of the IS 5832 and will be in accordance to Clause 3.8 and contractor shall submit the test certificate issued by the manufacturer with the pipe supply.

(v) Third party inspection

264. The inspection and testing of the pipes shall be carried out by the inspecting agency appointed by the employer, in the manufacture's workshop. The pipes will be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329 for length, internal and external diameter, wall thickness, deviation from straight length and ovality.
- Mechanical Tests as per Clause 10 of IS 8329 for tensile strength and Brinell hardness test.
- Hydrostatic Test as per Clause 11 of IS: 8329.

265. The sampling for the above tests shall be as per the provisions under clause 9 of the IS: 8329. All the tests shall be conducted in presence of the inspecting agency. The pipes shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory test results as required. The inspection charges with other relevant expenses for third party inspection shall be the
paid by employer and latter on deducted from contractor bill..

266. Re-test: If a test piece representing a batch fails in the tensile or Brinell hardness test in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same batch. If both the test results satisfy the specified requirements, the batch shall be accepted. Should either of these additional test pieces fail in the test, the batch shall be deemed as not complying the required standards and shall be rejected.

267. Marking: All pipes will be marked as per Clause 18 of IS 8329 and shall show markings as below:

- Manufacturer name/ stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end

268. Packing and transport: The pipes shall preferably be transported by road from the factory and stored as per the manufacturer specifications to protect damages. Any damages either by road transport or by any other means shall be the contractor's risk and cost.

xxxiv. Supply of Ductile Iron Fittings (Specials)

(i) Standards

269. Following standards shall be referred for manufacture of Ductile Ironspecials. In all cases, latest revision of the standards / codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards / codes, this specification shall govern. All the DI specials and fittings shall be suitable for DI k-9 class pipes for Tyton or Flanged joints as the case may be.

Table 19: Standard for the Manufacture of Ductile Ironspecials

IS: 9523	Specification for DI fittings for pressure pipes for water, gas, and sewage
BS: 4772	Specification for DI fittings

(ii) Types of specials

270. The following types of DI fittings shall be manufactured and tested in accordance with IS: 9523 or BS: 4772.

- flanged socket
- flanged spigot
- double socket bends (90^0, 45^0, 22 1/2 ^{0}, 11 1/4 ^{0})
- double socket branch flanged tee
- all socket tee
- double socket taper
- all flanged tee
- double flanged Taper
- double flanged bends

(iii) Supply

271. All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring (EPDM) shall conform to IS: 12820 and IS: 5382. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

272. **Manufacture of Fittings/Specials:** The fittings should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the contractor to see that the manufacturer of the pipes get them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub-contractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

(iv) Hydrostatic test pressure at works

273. The specials shall be tested at works for hydrostatic test pressure as specified under table-2 of IS: 9523.

(v) Lubricant for ductile iron pipes and specials

a. General

274. The lubricant used for Tyton push-in rubber ring joint for the assembly of Ductile Iron pipes and specials shall conform to the specifications as given below:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings
- to be applied in hot and cold weather; ambient temperature 0 - 50 °C, temperature of exposed pipes up to 70 °C
- must be non-toxic
- must be water soluble

- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf live not less than 2 years

275. **Acceptance tests.**They shall be conducted in line with the provisions of the IS 9523.

276. **Packing for DI Specials and Rubber Gaskets.** All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags and nuts, bolts etc. shall be supplied in separate jute bags.

xxxv. Earthwork–Excavation for pipeline trenches and Foundations

277. Earthwork will be for digging of pipeline trenches, construction of valve chambers, thrust blocks, saddle supports and any other earth work required in the contract package. Earth work will include all types of soils including soft rock, hard rock etc. The earth work shall include:

i. Removal of all surface obstructions including shrub, jungle, etc.;
ii. Scraping of black top of road surface wherever applicable
iii. Excavation of WBM / WMM
iv. Carrying out all necessary excavations for all lifts;
v. Providing and installing at place all sheathing, shoring and bracing to the trenches as necessary for the work and removal thereof after the work;
vi. Pumping and bailing out water for progressive excavation and to keep trenches dry during pipe laying and jointing process till the joints mature;
vii. Arrangement for diversion of flows from storm drains, valleys or other sources;
viii. Protecting all pipes, conduits, culverts, roads, railway tracks, utility poles, fences, buildings, public and private properties etc. (other than pre-identified utilities as agreed by Employers representative for “shifting of utilities under provisional sum”) and restoring the same without any additional payment;
ix. Separate payment shall be made from the “Provisional Sum” for the pre-identified Utility -shifting and restoring the same.
x. Backfilling with excavated material ;
xi. Removal and disposal of surplus soil from excavation after back filling to location as directed by Employers representative.
xii. Leveling and dressing of surplus soil from excavation or part of it in soil banks along with the trench as directed by Employers representative;
xiii. Restoring all structures and properties injured or disturbed by the construction activities to as near its original shape, as possible.
xiv. Restoring the surface of all roads, streets, valleys, walks, drives, easements, working spaces, and right of way to condition as good as prior to excavation (for metal, concrete, brick surfacing and bituminous road, it should be considered up to GSB level) including safety measures for carrying out the work in all respect.
xv. For existing metal/bituminous roads, separate items for GSB, WMM and bituminous are taken for road restoration work.

(i) Site Clearance

278. The pipe line alignment shall be cleared of all bushes, shrubs, roots, grass, weeds and if required trees, coming in the alignment of pipe line in the trench width portion. The rates for excavation shall cover all such site clearance work and no extra payment will be allowed on this account.

(ii) Alignment Marking

279. After the work site is cleared as above, pipe line alignment with required trench width shall be marked on the ground with apex points, curves etc, as shown on the drawings or as directed by the Employers representative for the stretch where the work is to be started. The Contractor shall provide all labour, survey instruments, and materials such as strings, pegs, nails, bamboos, stones, mortar, concrete etc. required for setting out and establishment of bench marks. The Contractor shall be responsible for the maintenance of bench marks and other marks and stakes as long as they are required for the work in the opinion of the Employers representative. The gradient and alignment shall be such that minimum horizontal and vertical bends shall be required.

(iii) Working Survey

280. Working survey of the pipeline alignment shall be carried out by the Contractor before start of the excavation work. The Contractor shall provide all the instruments such as leveling instruments, steel tape, ranging rods, strings, pegs etc for carrying out the survey. Based on the working survey, the alignments, L-section (depth of laying), grade, and location of specials, valves and chambers shall be finalized and got approved from the Project manager.

(iv) Use of Machinery

281. All excavations shall be carried out by mechanical equipment / machinery unless, in the opinion of the Employers representative, the work involved and time schedule permit manual excavation.

(v) Trench Width and Depth

282. There shall be a minimum clearance of 200 mm on either side of the pipe as specified under IS:5822.Accordingly, trench width as specified below shall be allowed for excavation of various pipe sizes.

a.	100 mm to 150 mm diameter DI / pipes	:	0.50 m
b.	200 mm to 300 mm diameter DI pipes	:	0.70 m
c.	400 mm to 600 mm diameter DI pipes	:	1.00 m
d.	700 mm to 800 mm diameter DI pipes	:	1.20 m
e.	900 mm to 1000 mm diameter DI pipes	:	1.40 m
f.	1321 mm outer diameter MS pipes	:	1.90 m

283. The Contractor may, for the facility of work or similar other reasons, excavate and also backfill later, if so approved by the Employers representatives, at his own cost, outside the allowable trench width specified above. Should any excavation be taken below the specified trench bottom, Contractor shall fill it up to required level, at his own cost, with the same material available at the trench bottom including watering and compaction.

284. The excavation shall be taken down to such depths as shown in the working drawings prepared by the contractor after alignment fixing and working survey. The grade and alignment shall be so finalized that there shall be minimum cover of fill material over top of pipes for a depth of 1.20 m for pipes of 300 mm and above diameters and 1.0 m for pipes

of 250 mm and below, except at local depressions, nala / drain crossings etc. Pipes shall be encased in M-200 concrete with minimum 200 mm thickness all around where the cover is less than 450 mm. Pipes crossing major roads of the Bhagalpur Municipal Corporation shall also be encased with concrete for the road formation width between side drains. Excavation for extra depth equal to the thickness of proposed pipe bedding shall bed one below pipe soffit level for providing bedding below pipe line. The trench bottom shall be excavated to proper grade. The Contractor shall provide site rails and leveling instruments required for checking the grade during excavation, bottom bedding and pipe laying. Projections in rock excavation shall be removed by chipping.

285. The Contractor shall carryout extra excavation at the pipeline joints to be welded, as required (minimum 0.6 m deep and 0.9 m lengthwise, all around the pipe), for facilitating proper welding of the bottom joint from outside. The work of trench excavation should be commensurate with laying and jointing of the pipe line. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise permitted by the Employers representative.

(vi) Barricading and Guarding

286. To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of work, till filling of the trenches after pipes are laid. The lighting, barricading, guarding of the trenches and the maintenance of watchman shall be done by the Contractor at his cost.

287. All precautions shall be taken during excavation and laying operation to guard against possible damage to any existing structures, underground utilities such as cables, pipe lines of water, gas, sewage etc. Any damage done to such properties will have to be repaired / rectified by the Contractor at his cost. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process
- hindrances to the public have to be minimized
- the trench must not be eroded before the pipes are laid
- the trench must not be filled with water when the pipes are laid
- the trench must not be refilled before laying of the pipes
- In the water logged areas, refilling of the trenches up to original ground level including compaction should be done immediately after laying and jointing is completed so as to avoid lifting of pipes due to buoyancy

288. The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

(vii) Reuse of surface material

289. All surface materials, which in the opinion of the Employers representative, are suitable for reuse in restoring the surface shall be kept separate from the general excavation material, as directed by the Employers representative.

(viii) Stacking of excavated material

290. All excavated materials shall be stacked in such a manner that it does not endanger the work and avoids obstructing foot paths and roads. Hydrants under pressure, surface boxes, fire and other utility controls shall be left unobstructed and accessible until the work is

completed. Gutters shall be kept clean or other necessary provisions made for street drainage and natural water courses shall not be obstructed. All the excavated material shall be the property of the Employer and shall be stacked or disposed off as directed by the Employers representative.

(ix) Maintenance of traffic

291. The work of excavation and pipe laying shall be carried in such a manner that it causes the least interruption to traffic and the road / street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridging arrangement shall be provided. When the street is closed for traffic, suitable signs indicating that street is closed shall be placed and necessary detour signs for proper maintenance of traffic shall be provided.

(x) Structure protection

292. Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of work shall be furnished under the direction of the Employers representative. The structures which have been disturbed shall be restored upon completion of work.

(xi) Protection of property

293. Trees, shrubbery fences, poles and all other property shall be protected unless their removal is allowed by the Employers representative. When it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the Employers representative.

(xii) Avoidance of existing services

294. As far as possible, the pipeline shall be laid below existing services, such as water and gas pipes, cables, cable ducts and drains but not below sewers. Excavation of the trenches shall be carried out to the required depth accordingly. If it is unavoidable, the pipeline shall be suitably protected and lesser trench depth in such cases can be allowed. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. When thrust or auger boring is proposed for laying pipeline across roads, railway or other utilities, larger clearance as required shall be provided. Adequate arrangements shall be made to protect and support the other services during excavation and pipe laying operations. The work shall be so carried out as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements made to support the utilities in consultation with them.

(xiii) Bailing out Water

295. During the excavation if subsoil water is met with, Contractor shall provide necessary equipment and labour for dewatering the trenches. If pumping out subsoil water is found necessary, Contractor shall provide sufficient number of pumps for the same. The tendered cost shall cover all costs for bailing out of water including hire charges of pumps, cost of diesel and labour etc. and hence, no extra payment shall be allowed on this account.

(xiv) Disposal of Loose Boulders, etc.

296. All loose boulders, semidetached rocks, (along with earthy stuff which might move therewith), not directly in the excavation but close to the area to be excavated, as to be liable, in the opinion of the Employers representative, to fall or otherwise endanger the workmen, equipments, or the work etc., shall be stripped off and removed away from the area of excavation and disposed to locations specified by the Employers representative. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe. The tendered cost is supposed to cover this job and no extra payment will be allowed on this account.

(xv) Coarse Sand Bedding Below Pipe Line

297. Wherever rock is met with at the bottom of the pipeline trenches and wherever directed, before lowering of the pipes in trenches, a layer of coarse sand of 150 mm thickness shall be provided below the pipe line to act as cushion. All sand shall pass through a screen of 3/16" mesh. All fine aggregate shall confirm to IS: 383 and test for conformity shall be carried out as per IS: 2386 (Part I to VIII).The bedding shall be compacted properly including required watering and the thickness of well compacted layer shall not be less than 150 mm. The bedding shall be provided for full trench width with proper grade or as directed by the Employers representative. Sand to be used for bedding needs to be free from silt, dirt, and foreign materials. No crushed sand or combination of natural sand & crushed sand shall be allowed to be used.

(xvi) Refilling the Trenches

a. Use of selected excavated material

298. Filling of excavated material in trenches shall be commenced as soon as the joints of pipes and specials have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care so that no damage is caused to the pipes and the outer coating. Selected surplus spoils from excavated material shall be used as backfill. Fill material shall be free from clods, salts, sulphate, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of sand or earth to fill up the voids and the mixture used for filling.

b. Filling Zones

299. For the purpose of back-filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

Table 20: Filling Zones

Zone A: From the bottom of the trench to the level of the Centre line of the pipe	Back-filling by hand with selected approved material available from excavation, placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width on each side of the pipe, specials and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone B: From the level of the centre line of the pipe to a level 300 mm above the top of the pipe	Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm; special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.

Zone C: From a level 300 mm above the top of the pipe to the top of the trench.	Back-filling shall be done by approved mechanical methods in 15 cm layers after compacting and carried to the level necessary to allow for the temporary restoration of road and path surfaces, and also for hard-core (if and where ordered) on roads or to such level as will leave the requisite space for the top soil, road surface etc. to be reinstated as directed by the Employers representative. In case of agricultural or waste land and after approval by the Employers representative, back-filling may be made in thicker layers up to 200 - 300 mm above the initial ground level.

300. All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Employers representative, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Employers representative, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

301. The back filled layers shall be wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

302. The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the Retention Period.

303. On completion of pressure and leakage tests, exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal as refuse or unsuitable soil.

c. Fillings of Trench Excavated in Rock

304. In case of excavation of trenches in rock, the filling up to a level of 30 cm above the top of the pipe shall be done with fine materials, such as soft soil, murum,sand etc. The filling up to the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 15 cm, whereas the filing above the centre line of the pipe shall be done by hand compaction or mechanical means in layers not exceeding 15 cm. The filling from a level of 30 cm above the top of the pipe to the top of the trench shall be done by mechanical methods with broken rock filing of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

d. Consolidation

305. The consolidation of the filled material shall be done to attain 90 % proctor density. The density of the filled and compacted material shall be tested regularly and record maintained accordingly.

306. The item covers all leads and lifts required for collecting selected material available along the trenches and filling the same as per specifications. Balance excavated material remained after filling the trenches shall be disposed off without any extra cost.

(xvii) Lowering, laying and jointing of MS pipeline

a. Tools and Equipment

307. The Contractor has to provide all the tools and equipment required for the timely, efficient and professional implementation of the work as specified in the various sections of the contract and as specified by the instructions of manufacturers of the pipes and other material to be handled under this contract. On demand he shall provide to the Employers representative a detailed list of tools and equipment available. If in the opinion of the Employers representative the progress or the quality of the work cannot be guaranteed by the available quantity and type of tools and equipment, the Contractor has to provide additional ones to the satisfaction of the Employers representative. The Contractor will always have a leveling instrument on site.

b. Handling,Transportation of Pipes and Specials

308. The Contractor has to transport the pipes and other materials from manufacturer or site store yard to the site of laying as indicated by the Employers representative. Pipes should be handled with care to avoid damage to the surface and the socket and spigot ends, deformation or bending. Pipes shall not be dragged along the ground or the loading bed of a vehicle. Pipes shall be transported on flat bed vehicles/trailers. The bed shall be smooth and free from any sharp objects. The pipes shall rest uniformly on the vehicle bed in their entire length during transportation. Pipes shall be loaded and un-loaded by suitable mechanical means without causing any damage to the stacked pipes.

309. The transportation and handling of pipes shall be made as per IS 12288. Handling instructions of the manufacturers of the pipes shall be followed. All precautions set out shall be taken to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes.

310. Whatever method and means of transportation is used, it is essential that the pipes are carefully placed and firmly secured against uncontrolled movement during transportation to the satisfaction of Employers representative.

311. Cranes shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. Where using crane hooks at sockets and spigot ends, hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining / coating. Damage to lining / coating must be repaired before pipe laying according to the specifications mentioned elsewhere and as per instructions of the Employers representative. Pipes shall not be thrown directly on the ground.

312. When using mechanical handling equipment, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement shall be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

313. Rolling or dragging pipes along the ground or over other pipes already stacked shall be avoided.

314. Stringing of Pipes along the alignment: The pipes shall be laid out properly along the proposed alignment in a manner that they do not create any significant hindrance to the public and that they are not damaged.

315. Stringing of the pipes end to end along the working width should be done in such a manner that the least interference is caused in the land crossed. Gaps should be left at intervals to permit the passing of equipment across the working area. Pipes shall be so laid out that they remain safe where placed and that no damage can occur to the pipes and the coating until incorporated in the pipeline. If necessary, pipes shall be wedged to prevent accidental movement. Precautions shall be taken to prevent excessive soil, mud etc. entering the pipe.

316. Generally, the pipes shall be laid within four weeks from the date of their dispatch from the manufacturer / store or from out coating yard.

c. Laying of Pipes below Ground

317. After the trench is made ready with bedding, and after the jointing pits are excavated at the joint position, the coated and lined pipes shall be lowered in the trenches.

318. The MS pipe ends shall be cleaned with special care to ensure that they are free from dirt and unwarranted projections. The whole of the pipes shall be placed in position singly and shall be laid true to profile and direction of slope indicated on longitudinal sections. The pipes shall be laid without deflection in a straight alignment between bends and between high and low points. The alignment and levels shall be checked by the Contractor with theodolite.

319. Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes.

320. Pipes and the related specials shall be laid according to the instructions of the manufacturers and using the tools recommended by them.

321. Cutting of pipes shall be reduced to a minimum required to conform to the drawings. Cutting has to be made with suitable tools and according to the recommendations of the manufacturer without damage to the external coating and internal lining. The spigot end has to be beveled again at the same angle as the original beveled end. While assembling the pipes the ends shall be brought close enough to leave a uniform gap not exceeding 3 mm. Marginal cutting shall be done if found necessary, for which no extra payment shall be admissible. There shall be no lateral displacement between pipe faces to be jointed. After the pipes are properly assembled and checked for the correct line and level, tack welding for the pipe joint shall be done. Final welding of the joint from inside and outside shall be done thereafter.

d. Straps

322. Whenever the pipe laying work proceeds from two ends and if gap remained between two faces is less than 30 cm, such gap shall be bridged by providing a strap. Strap shall also be provided during fixing of expansion joint for above ground pipeline. Such strap shall be fabricated on site by cutting a piece from the pipe. This piece shall be split longitudinally and stepped over the gap. A minimum overlap of 8 cm shall be provided on both the pipe ends to be connected. The strap shall be welded with pipe ends with required number of fillet welds from inside and outside. The gap between ends of the strap shall be butt welded longitudinally. of supply of specials Laying and jointing of the pipeline shall cover all types of welding such as tack welding, lap welding for straps or butt welding for joints, specials externally as well as internally.

e. Distance Piece

323. Distance piece shall be provided when the gap between pipe faces to be jointed is more than 30 cm. Distance pieces shall be cut from pipe pieces for required length either on site or in factory. Payment shall be as per the laying and jointing of pipeline item.

324. All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronization with the pipes. The Contractor has to ensure that the specials and accessories are ready in time to be installed together with the pipes. The payment for laying and jointing of the specials shall be deemed to be covered under the item of pipeline laying and jointing including tack welding and final welding.

325. At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt or other foreign matter by means of approved plugs or end caps.

326. When pipe laying is not in progress, the open ends of installed pipe shall be closed by approved means to prevent entrance of trench water and dirt into the line. No pipe shall be laid in wet trench conditions that preclude proper bedding, or when, in the opinion of the Employers representative, the trench conditions or the weather are unsuitable for proper installation.

327. The pipe line laid should be absolutely straight unless planned otherwise. The accuracy of alignment should be tested before starting refilling with the help of stretching a string between two ends of the straight stretch of pipes to rectify possible small kinks in laying.

xxxvi. Welding of Joints

(i) General

328. Before aligning, assembling and welding, the pipe faces shall be cleaned by scrapping with wire brushes or by any other approved method.

329. Welding of pipes in field shall confirm to IS: 816 (code of practice for use of metal arc welding for general construction in mild steel). Electrodes used for welding shall comply with IS: 814. In case of variation, specifications hereunder shall have precedence.

330. Welders shall be qualified and well experienced and shall be approved by the Employers representative. Contractor shall remove such of the welders from the job whose work is not satisfactory.

331. The Contractor shall keep record of the welding for each circumferential joint. It shall contain the name of the welder, date of completion of the welding runs internal as well as external.

(ii) Gauging and Chipping

332. MS pipes to be jointed are large in diameter and hence the joints shall be welded with two numbers of runs from inside and a sealing run from outside. External sealing run shall be done only after internal welding is completed. Before starting the external welding, the weld material in the joint shall be cleaned by chipping out loose scales. Gauging shall be done before rectification of any defective welding wherever necessary and as directed by Employers representative.

333. Gauging and chipping shall not be paid separately and the rate for welding shall be deemed to include the cost of gauging and chipping.

(iii) Electrodes

334. Welding electrodes shall conform to IS: 814. The selection of electrodes shall be depending on thickness of the plates to be welded and the type of joint. The Contractor shall use standard current and AC voltage required for the machine as per manufacturer's directions.

(iv) Type of Joints

335. The circumferential joints of the pipes shall have butt welded with required number of runs externally and internally.

336. All the fillet welds / lap welds shall have throat thickness not less than 0.7 times the thickness of the pipe to be welded.

337. **Testing of Welded Joints:** Welded joints shall be tested in accordance with the procedure laid down in IS: 3600, Method of testing fusion welded joints and weld metals in steel.

338. At least one test specimen shall be taken out for testing for every 50 field joints. Test pieces shall be taken out from the places pointed out by the Employers representative. These shall be machined and tested as early as possible. The shape of the test pieces removed for testing shall be such that it shall give the specimen of the required dimensions with the weld in the middle of the specimen. It must ensure good butt weld.

(v) Tensile test

339. The test specimen taken perpendicularly across the weld shall be shaped in accordance with IS: 3600 (part 3). The tension test specimen shall be machined. The protruding welded portion from inside as well as outside shall be removed by machining before the specimen is tested. The specimen shall be tested in tension in accordance with IS: 1608.

340. If the specimen shows defective machining or develops flaws not associated with welding, it shall be discarded and another specimen substituted. The welded joint shall show strength not less than the minimum tensile strength for the plate in accordance with IS: 226.

(vi) Bend Test

341. Bend test specimen shall also be prepared in the same fashion as the tensile test specimen. The specimen shall be bent cold 180^0 around a pin that has a diameter equal to 4 ½ time the plate thickness, without developing cracks. For this test, face representing inside of the pipe shall be placed next to the pin.

(vii) Tree-panned plugs

342. Tree-panned plugs shall be taken out from any welded portion as pointed out by the Employers representative. These plugs shall not show any defects in welding such as inclusion of slag, blow holes, cavities, etc. The plug shall be 12 mm in diameter and shall be taken out by means of suitable electrically operated machine. Such holes in the pipe shall either be filled back by inserting a steel stud and welding around or threading the hole and

providing suitable GI plug. This test shall be done if considered necessary by the Employers representative.

(viii) Non-destructive tests

343. Non-destructive testing of the completed weld shall be carried out on pipelines by radiographic method as specified under IS: 4853 or ultrasonic method as per IS: 4260.

344. **Procedure on Failure of Test Specimen:** If the test specimen fails in either tensile or bent test or in both, two additional test specimens shall be taken out from the section and shall be tested again for both the tests. If any one of them fails, extensive gouging and repairing shall be carried out for the welded joints in that section to the full satisfaction of the Employers representative However, if both the samples give satisfactory results, the joint from which the original sample was taken and had failed, shall be repaired at Contractor's cost.

345. Welder who has done the welding of the joint that has failed shall be solely held responsible for bad workmanship and failure. Since all other factors like electrodes, current, arc voltage, etc. are already controlled; negligence on the part of the welder only is responsible for such failure. For first such failure, the welder shall be warned and if the failure is repeated, he shall be removed from the job.

xxxvii. Laying and jointing of DI pipes and specials

346. **Use of Tackle:** Pipes should be lowered into the trenches with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes suitable mechanical equipment have to be used.

347. **Cleaning:** All construction debris should be cleared from the inside of the pipe either before or just after a joint is made. This is done by passing a pull-through in the pipe, or by hand, depending on the size of the pipe. All persons should vacate any section of trench into which the pipe is being lowered.

348. **Laying on steep slopes:** On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is back filled over the barrel of the pipe.

349. The assembly of the pipes shall be made as recommended by the pipe manufacturer and using the suitable tools.

350. **Anchoring of the pipeline:** The designed anchoragewith anchor blocks of concrete not less than M-150 mix shall be designed and provided on slopes as specified under clause 5.8 of IS: 12288 as below.

Table 21: Anchorage Specification

Gradient	Spacing of Anchor blocks
1 in 2 and steeper	5.50 m
Below 1 in 2 to 1 in 4	11.00 m
Below 1 in 4 to 1 in 5	16.50 m
Below 1 in 5 to 1 in 6	22.00 m
Flatter than 1 in 6	Not required

351. **Jointing:** The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot shall have to be coated with a suitable lubricant recommended by the manufacturer of the pipes. Oil, petroleum bound oils, grease or other material which may damage the rubber gasket shall not be used as lubricant. The rubber gasket shall be inserted into the cleaned groove of the socket. It has to be checked for correct positioning.

352. The two pipes shall be aligned properly in the pipe 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.

353. **Deflection of pipes:** Deflection of the pipes, if any, shall be made only after they have fully been assembled. The deflection shall not exceed 75 % of the values indicated by the pipe manufacturer.

354. **Thrust resistance**: Thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. They shall be constructed as designed by the contractor and approved by theEmployers representative according to the highest pressure during operation or testing of the pipes, the safe bearing pressure of the surrounding soil and the friction coefficient of the soil.

355. **Measurement and payment:** The net length of pipes as laid or fixed shall be measured in running meters correct to a cm. The laid length includes length of specials and valves. The portion of the pipe at the joints (inside the joints) shall not be included in the length of pipe work.

356. 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, but may be provided as leveling course and to maintain proper grade. While laying in rocky areas suitable bed of sand or gravel or selected material from excavation shall be provided. The up to about 300 mm above the pipe should be screened excavated material.

357. 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).

358. 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.

359. The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.

360. 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.

361. 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.

362. 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.

363. 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.

364. Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 90% maximum dry density.

365. **Jointing of pipes:** The pipes shall have a jointing system that shall provide for fluid tightness for the intended service conditions. The pipe shall be cut square and the face of the pipe shall be slightly scrapped prior to welding to remove oxidized layer. Method of jointing between the pipes to pipes and pipes to specials shall be butt fusion welding using automatic or semi-automatic, hydraulicallyoperated superior quality butt fusion welding machines which will ensure good quality butt fusion welding of HDPE pipes. Skilled staff shall be employed for the jointing of pipes specifically that provided by the pipe manufacturer, so that the jointing would be sound and the joint strength would be equal to the pipe strength.

366. **Test of 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:

- Smell of the extract
- Clarity of the colour of the extract
- Acidity and Alkality
- Global migration UV absorbing material Heavy metals
- Unreacted monomers (styrens) and Biological tests.

367. **Measurement:** The net length of pipes as laid or fixed shall be measured in running meters correct to a cm.Specials shall be covered under measurement. The portion of the pipe at the joints (inside the joints) shall not be included in the length of pipe work.

368. **Anchoring of pipeline:** Concrete thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. The contractor shall design the thrust blocks for all piping system covered under raw water pumping main and distribution system for the maximum pressure during field hydraulic testing of the pipeline stretches, The thrust design shall be safe to transfer the thrust on the vertical bearing surface behind the bend, tee etc.The safe bearing pressure of the surrounding soil and the friction coefficient of the soil shall be ascertained for the design of bearing area required.The internal design pressure for thrust block design as well as field hydraulic testing of the stretch under test shall be maximum of the-

a. Pumping system

1. 1.5 times maximum working pressure with respect to the hydraulic grade line
2. Maximum static pressure with respect to highest level to which water is pumped (Lip of aeration fountain in case of raw water pumping main) plus water hammer pressure

xxxviii. Hydraulic testing of pipeline

(i) Sectional Tests

369. After laying and jointing the pipeline shall be tested for water tightness of barrels and joints, and stability of thrust blocks in sections approved by the Employers representative. The length of the sections depends on the topographical conditions. Preferably, the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, and other chamber). At the beginning, the Contractor shall test stretches not exceeding 1 km. After successful organization and execution of tests the length may be extended to more than 1 km after approval of the Employers representative. The testing in a section of 1 km shall have to be completed within 6 weeks of laying and jointing.

370. The water required for testing shall be arranged by the Contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, such as water tankers, pumps, pressure gauges, valves etc. required for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test / saturation test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol:

- Complete setting of the thrust blocks
- partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- opening of all intermediate valves (if any)
- fixing the end pieces for tests and after temporarily anchoring them against the soil (not against the preceding pipe stretch)
  1. At the lower end with a precision pressure gauge and the connection to the pump for establishing the test pressure
  2. At the higher end with a valve for air outlet
- If the pressure gauge cannot be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly
- Slowly filling the pipe from the lowest point(s).
- the water for this purpose shall be reasonably clear and free of solids and suspended matter
- Complete removal of air through air valves along the line.
- Closing all air valves and scour valves.
- Slowly raising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring.
- Keeping the pipeline under pressure for the duration of the pre-test / saturation of the lining by adding make-up water to maintain the pressure at the desired test level. Make up water to be arranged by the Contractor himself at his own cost.
- Start the test by maintaining the test pressure at the desired level by adding more make up water. Record the water added carefully and the pressure at intervals of 15 minutes at the beginning and 30 minutes at the end of the test

period. The hydro-testing shall be carried out for the period of 4 (four) hours. The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipe work shall be accepted by the Employers representative until all requirements of the test have been satisfied.

371. On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

372. **Field Test Pressure:** The Contractor shall give the field test of the raw water pumping main for hydraulic pressure of 13 Kg/cm^2 (130 m water head).

373. Section wise test pressure requirements for the MS, DI pipelines in the transmission main shall be equal to 1.5 times the maximum static pressure on the stretch under test, **Test requirements for MS pipes**

374. The quantity of water added in order to re-establish the test pressure shall not exceed 0.1 litre per mm of pipe diameter, per km of pipeline length under test, per day, for each 30 m head of pressure applied.

(ii) Test requirements for DI pipes

375. Pre-test and saturation period with addition of make-up water in case of DI pipes with Cement Mortar lining is 24 hrs.

376. The duration of pressure testwith addition of make-up water Pressure shall be 3 hours.The quantity of water added in this period shall not exceed 1 litre per 10 mm of pipe diameter, per km length, per 30 m head of pressure applied, per 24 hours.

377. **Failure to pass field test:** If the test fails, all the expenses required for re-testing of the pipeline including emptying the line, removing the leakages, re-filling the line with water and re-testing up to the required standard will be at the cost of Contractor.

378. **Flushing and disinfecting of pipelines:** After testing and before pre-commissioning, the Contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Employers representative. Disinfection of drinking water pipelines shall be made by the Contractor after flushing.

xxxix. Plain and reinforced cement concrete works

(i) General

379. Reinforced concrete chambers shall be constructed for air valves, washout valves and on line butterfly valves.

380. Raw water pumping main chambers: These shall be constructed as per the standard chamber approved drawings provided by Contractor.

381. Transmission Network Chambers: These shall be constructed as per the standard approved drawings provided by the contractor.

382. The concrete used shall confirm to the specifications given below.

(ii) Construction Material

a. Source of Material

383. The Contractor shall notify the Employers representative of his proposed source of materials prior to delivery. If it is found after testing & trial that sources of supply previously approved do not produce uniform & satisfactory product of desired quality or if product from any other source proves unacceptable at any time, Contractor shall furnish acceptable material from other sources as directed & approved by the Employer.

b. Sand/Fine Aggregate

384. For plain and reinforced cement concrete works fine aggregate shall consist of clear, hard strong, durable uncoated & well graded particles of natural sand. The source of sand shall be as approved by the Employers representative. The sand shall not contain dust, lumps soft or flaky materials mixed or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the embedded steel. Fine aggregate having positive alkali-silica reaction shall not be used. All sand shall pass through a screen of 3/16" mesh. All fine aggregate shall confirm to IS: 383 and test for conformity shall be carried out as per IS: 2386 (Part I to VIII). The fineness modules of fine aggregate shall neither be less than 2.0 nor greater than 3.5.

385. No crushed sand or combination of natural sand & crushed sand shall be allowed to be used. Fine aggregate shall be stacked on brick platform on dry ground free form any possibility of seepage of water into the stock yard. The stock of fine aggregate shall be covered by HDPE sheet and it shall be separated from course aggregate stock with a wall separator to avoid mixing of aggregates.

c. Metal or Course Aggregate

386. For plain or reinforced cement concrete works, course aggregate of required size shall consist of clean, hard strong, dense, non-porous& durable pieces of crushed black basalt metal. They shall not consist of 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 aggregate shall confirm to IS: 383 & test for conformity shall be carried out as per IS: 2386 (Part I to VIII). The course aggregate shall be stored on brick platform in open hard and dry ground free from admixture of foreign materials such as clay, grass, etc. It shall be as per IS: 4082. The stock of course aggregate shall be covered by HDPE sheet and it shall be separated from fine aggregate stock with a wall separator to avoid mixing of aggregates.

d. Cement

387. Cement to be used in the works shall be any of the following types with the prior approval of the Employers representative:

1. Ordinary Portland cement, 43 Grade, conforming to IS: 8112.
2. Ordinary Portland cement, 53 Grade, conforming to IS: 12269.
3. Rapid hardening Portland cements conforming to IS: 8041.

388. Cement brand confirming to IS shall only be used. As far as possible only one brand of cement as approved by Employers representative shall be used during entire construction. Frequent change in brand will not be allowed.

389. Only fresh and tested cement shall be used during construction. Factory test certificate for cement shall be submitted with supply of each lot on site. Cement bags shall be stacked in well-guarded and closed store on raised platform. Care shall be taken that the bags do not catch any moisture or dampness. Heaters shall be provided in the store to eliminate the possibility of moisture and dampness.

390. Cement conforming to IS: 8112 and IS: 12269 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.

391. Cement conforming to IS: 8041 shall be used only for precast concrete products after specific approval of the Employers representative.

392. Total chloride content in cement shall in no case exceed 0.05 percent by mass of cement, also; total sulphur content calculated as sulphuric anhydride (SO_3) shall in no case exceed 2.5 percent and 3.0 percent when tri-calcium aluminate percent by mass is up to 5 or greater than 5 respectively.

393. The tests shall be carried out in approved testing laboratory. Irrespective of manufacturer's test certificate, if the sample fails during testing the entire lot of cement form which the representative sample has been taken, shall be rejected &Contractor has to replace it with fresh lot, confirming to all tests as stipulated and as directed by the Employers representative.

e. Water

394. 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:

1. 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.
2. To neutralize 200 ml sample of water, using methyl orange as an indicator, it shouldnot require more than 10 ml of 0.1 normal HCl.
3. The permissible limits for solids shall be as follows when tested in accordance with IS: 3025:

Table 22: Maximum Permissible Values

1.	Organic	200 mg/lit
2.	Inorganic	3000 mg/lit
3.	Sulphates (SO_4)	500 mg/lit
4.	Chlorides (Cl)	500 mg/lit *
5.	Suspended matter	2000 mg/lit

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

395. All samples of water (including potable water) shall be tested and suitable measures may be taken where necessary to ensure conformity of the water to the requirements stated herein.The pH value shall be in the range of 6.5 to 8.

f. Steel Reinforcement

396. For reinforced cement concrete works, the reinforcement steel shall consist of following grades of reinforcing bars.

Table 23: Grades for Reinforcing Bars

Grade Designation	Bar type confirming to governing I. S. specification	Characteristic strength fy MPa	Elastic Modulus
Fe 415	I. S. 1786 High yield strength deformed bars	415	200

397. All steels shall be procured from original manufacturers. No re-rolled steel shall be incorporated in the work. HYSD / TMT of Fe 415 grade steel shall only be used. Only new steel shall be delivered to site with manufacturer's test certificate. After receipt at site, sample for each dia of bar shall be taken and sent for testing to approved testing laboratory as directed by the Employers representative. Desired characteristic of test shall be got confirmed and only after satisfactory test results the steel shall be allowed to be used. Every bar shall be inspected before assembling on the work and defective, brittle or brunt bar shall be discarded. Cracked ends of bar shall be discarded. Binding wire shall be provided for use by Contractor at his cost. Bar bending & cutting work shall be carried out in separate work yard near the work site. Steel shall be stacked on wooden blocks so as not to have contact with soil.

g. Tests & Standard of Acceptance

398. 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 and steel for every consignment shall be done by the Contractor in the laboratory approved by the Employers representative before use. Any cement & steel 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.

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

xl. Form Work

400. The entire form work either of steel, ply wood or wooden planks of 38 mm to be used should be in perfect line & length without any buckling or dent. The entire form work shall be very strongly propped and braced with sufficiently strong vertical & horizontal members and the entire supporting structure shall be sufficiently strong to take up load of concrete and all stresses it may be subjected to without any deflection. The form work shall be smooth and entirely free from any dust particles; dirt and its inner surface shall be oiled with shuttering oil for easy removal of form work and shall be water tight. The centering or form work to be used shall be got approved from Employers representative. It will be obligatory on the part of Contractor to submit & get approved the design for centering work if asked for at any stage & level of construction by the Employers representative. The Contractor shall be wholly & fully responsible for any defects in the entire form work & its supporting structure.

xli. Concrete

401. All concrete in the works shall be controlled concrete as defined in IS: 456 unless it is a nominal mix concrete. Whether reinforced or otherwise, all controlled concrete work to be carried out as per standard specifications. While concreting, sample test specimens (cubes) shall be taken as per the criteria specified under IS: 456.2000.Minimum compressive strength of 15 cm. Cubes at 7 and 28 days after mixing, conducted in accordance with IS: 516 shall be as given below.

Table 24: Minimum Compressive Strength

Class	Preliminary test Kg/cm^2		Work test Kg/cm^2		Max. size of Aggregate
	At 7 days	At 28 days	At 7 days	At 28 days	
M300	264	384	204	300	40 or 20
M250	220	320	170	250	40 or 20
M200	175	260	135	200	40 or 20
M150	135	200	100	150	40 or 20
M350				350	40 or 20
M400				400	40 or 20

402. It shall be very clearly understood that whenever the class of concrete such as M 200 is specified it shall be Contractor's responsibility to ensure that minimum crushing strength stipulated for the respective class of concrete is obtained at works. The maximum total quantity of aggregate by weight per 50 Kg. of cement shall not exceed 450 Kg., except when otherwise specifically permitted by Engineer.

(i) Admixtures

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

404. "Plasticizers" and "Super - Plasticizers" shall meet the requirements indicated for "Water reducing Admixture".

405. 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 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.

406. The chloride content of the admixture shall not exceed 0.2 per cent when tested in accordance with IS: 6925. In addition, the maximum permissible limit of chloride content of all the constituents as specified shall also be observed.

407. 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.

408. 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 or the value stated by the manufacturer.

- Relative density (for liquid admixtures): to be within 2 percent of the value stated by the manufacturer.

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

410. Admixtures may be used in concrete only with the approval of Employers representative based upon evidence that, with the passage of time, neither the compressive strength nor its durability will reduce. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement, or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water, in an amount not to exceed 1½ percent of the weight of the cement, in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instructions and in the manner and with the control specified by Employers representative. However, the specific requirements as given above shall be adhered to.

(ii) Mix Design

411. This is to investigate the grading of aggregates, water cement ratio, workability and the quantity of cement required to give preliminary and works cubes of the minimum strength specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Mix proportioning shall be based on the principles given in IS: 456-2000 and SP: 23-1982 “Handbook for Design Mix Concrete.”

412. Whenever there is a change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and / or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing mix proportions, over-wet mixes shall always be avoided.

413. While fixing the value for water / cement ratio for preliminary mixes, assistance may be derived from the graph (Appendix A IS: 456) showing the relationship between the 28-day compressive strengths of concrete mixes with different water / cement ratios and the 7 day compressive strength of cement tested in accordance with IS: 269. The cost getting of mix design shall be borne by the Contractor.

(iii) Preliminary tests

414. Tests specimens shall be prepared with at least two different water/cement ratios for each class of concrete, consistent with workability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those, to be actually employed in the works as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength. It will be Contractor’s sole responsibility to carry out statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed:

415. Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water, cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

416. The mix design shall be got approved and certified by the approved Employers representativeing College or approved testing laboratory as directed by Employers representative.

(iv) Cover Blocks

417. For bottom covers of beams, slabs etc. separators or cover blocks of precast cement mortar of suitable size with wire embedded as directed will be used and tied to the reinforcement bars between layers of reinforcement. Separators consisting of pieces of suitable diameters shall also be used. In such case the required cover to the bars will be ensured as per I. S. 456 – 2000. Cover blocks should be of cement product having water cement ratio not more than 0.40. Such blocks can be made using press (Normally used for block making) or using high dose (about 2 %) of super plasticizer. The other alternative is to use manufactured PVC cover blocks. However long term performance of PVC cover blocks may not be as good as proper quality concrete covers blocks. Use of PVC cover blocks of approved quality may be permitted with prior approval from Employers representative.

(v) Concrete Mixing

418. The concrete shall be only machine-mixed. Mixing shall be continued for at least 2 minutes after all materials and water placed in the drum. The drum shall revolve for 14 to 18 revolutions per minute or as specified by the makers. The capacity of the mixer will be such that a whole bag of cement is used in each batch.In no case hand mixing shall be allowed.

(vi) Consistency

419. The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test; care should be taken to ensure that no water or other material is lost. The material used for the slump test may be remixed with the remainder of the concrete for making the specimen test cubes. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

(vii) Placing

420. The forms will be first just moistened before pacing concrete. The concrete shall be placed in position within 20 minutes after adding water to the concrete. It shall be slowly deposited in its place in uniform layers. It should generally comply with clause 12.2 of 456 – 2000.

(viii) Tamping, Ramming and Consolidating

421. The concrete being laid shall be vigorously vibrated during laying and also rodded by bars where vibrator cannot reach so that dense and complete filling is assured. The Contractor shall make his own arrangements for procuring vibrators at his cost.

422. The efficiency of tamping and consolidation shall be judged by absence of any air pockets and absence of honey combing any defective consolidation and tamping shall be entirely on Contractor’s risk and casting will have to be entirely pulled down if so directed and redone properly entirely at the cost of the Contractor.

(ix) Construction Joints & Key

423. Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints, as specified hereinafter. Time lapse between the

pouring of adjoining units shall be as specified on the Drawings or as directed by Employers representative.

424. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made where the work is stopped. Joints shall be either vertical or horizontal, unless shown otherwise on Drawings. In case of an inclined or curved member, the joint shall be at right angles to the axis of the member. Vertical joints shall be formed against a stop board; horizontal joints shall be level and wherever possible, arranged so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to the formwork to ensure a horizontal line and if directed, shall also be used to form a grooved joint. For tank walls and similar works joints shall be formed as per IS: 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering. Horizontal and vertical construction joints and shear keys shall be located and shall conform to the requirements of the plans unless otherwise directed by Employers representative.

(x) Curing

425. All PCC and RCC work will be watered and kept constantly wet for 28 days after initial set for curing by means of wet gunny bags and ponding as directed by the Employers representative. This operation shall start immediately after initial set of the concrete. Should the Contractor fail to water the concrete continuously, it will be done immediately at Contractor's risk and cost.

(xi) Removal of Form

426. It shall be as under, subject to the written approval and modification by the Employers representative.

Table 25: Formwork

S. No.	Type of Formwork	Minimum Period before striking formwork
a.	Vertical formwork to columns, walls, beams	16-24 h
b.	Soffit formwork to slabs (Props to be refixed immediately after removal of formwork)	3 days
c.	Soffit formwork to beams (Props to be refixed immediately after removal of formwork)	7 days

(xii) Inspection

427. The work of each category of operation i.e. completion of form work placing reinforcement, concreting, removal of form etc. must be got inspected by the Employers representative before commencing and succeeding operation. Concreting must be done in presence of Employers representative himself. In case of failure to comply with above specifications, the work is liable to be pulled down if directed, for any work which is done contrary to specification and no payment thereof shall be admissible.

(xiii) Consumption Record

428. The Contractor shall maintain daily consumption record of cement and steel with the quantity of concrete executed, duly signed by the Employers representative's representative. The copy of the record shall be submitted weekly to the office.

(xiv) Finish and Quality of Concrete

429. The PCC and RCC work cast shall be dense mix, homogenous without any honey combing true in size, alignment and shape. Any defective work shall not be entitled for full tendered rates for payment and if the defects are major no measurements and payment are admissible and Contractor shall have to pull down such defective work and redo at this cost. The decision of the Employers representative regarding such defective work and the directions, viz. pulling it down or rectification as may be necessary shall be final and binding on the Contractor.

430. All RCC work shall be finished as directed by the Employers representative. It should be clearly understood that the finishing is not meant to cover the casting defects but only to give a smooth appearance.

431. Cube casting acceptance of concrete will be as specified in IS 456 – 2000 and relevant ISS. Unacceptable quality concrete shall be demolished and redone without any extra cost by the Contractor.The cube test result shall be as under:

Table 26: Cube Test Result

28 Days test	M 15	M 20	M 25	M 30 M35	M40
150 Kg/cm^2	200 Kg/cm^2	250 Kg/cm^2	300 Kg/cm^2	350kg/cm^2	400kg/cm^2

432. Surfaces not in contact with form work and not subject to any plaster shall be finished by a float to present a smooth and uniform appearance. Surfaces which are in contract of form work for which no plastering is provided as per drawing shall also be finished smooth as directed.

433. In case, whether would be specified in the tender item or not the finish shall be such as to match with the rest of the structure to present a harmonious appearance as per requirement at site and as directed by the Employers representative and Contractor shall have to do it at his own cost. Failure to do proper finishing as directed shall attract the rejection of work done by the Contractor. The decision of Employers representative in this respect shall be final and binding on the Contractor.

xlii. Supply and Installation of Valves

(i) Butterfly Valves

a. General

434. The Butterfly valves shall conform to IS: 13095. Double flanged short body butterfly valves of required nominal diameter and pressure rating PN-1 or as specified in the respective works specifications and drawings shall be supplied. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII). All the valves for transmission networks shall be of PN-1 or PN 1.6 pressure rating as per requirement.

435. The material to be supplied shall include, but not be limited to, that as shown in the table given below. All necessary fittings including bolts, nuts, gaskets, jointing material etc. shall be supplied as required.

b. Scope

436. The butterfly valves shall be with disc and shaft and shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The valves shall have no visible leakage past the disc in closed position under test conditions. The shaft may be of one piece design or in two pieces separately attached to the disc. The valves will be used for water supply on line installations in upright positions with manual operation. The valves shall be suitable for continuous use at their pressure rating within the temperature range of -10^0Cto65^0C.

(ii) Material

437. The material for different component parts of butterfly valves shall conform to the requirements given below:

Table 27: Butterfly Valve Requirements

S. No.	Component	Material	Ref. to IS	Grade
1	Body	Cast iron, Spherical graphite iron, Carbon steel	210, 1865, 2004, 1875, 2856	FG 200, Alin SG 400/12 Cl. 2 or Cl. 3 Cl. 2 or Cl. 3 Gr. 1 or Gr. 2
2	Disc	Cast iron, Spherical graphite iron, Carbon steel Stainless steel, Gun metal, Aluminium bronze	210, 1865, 2004, 1875, 2856 - - 305	FG 200, Alin SG 400/12 Cl. 2 or Cl. 3 Cl. 2 or Cl. 3 Gr. 1 or Gr. 2 Gr. 6 or Gr. 7 - - Gr. 2
3	Shaft	Stainless steel, Carbon steel, Aluminium bronze, Nickel Copper alloy	6603 1570(part2) 305	12 Cr 13 15 Cr 16 Ni 2 04 Cr 18 Ni 10 04 Cr 17 Ni 12 M_o 2 40 C 8 Gr 2
4	Seating ring / Seal retaining ring	Stainless steel, Gun metal, Aluminium bronze, Deposited metal suitable for duty or resilient material	6603 3444 318 305	04 Cr 18 Ni 10 04 Cr 17 Ni 12 M_o 2 Gr 2, Gr 6 or Gr 7 Gr LTB, or LTB Gr 2
5	Seat	Elastomers	-	Nitrite, Neoprene, E.P.D.M. rubber
6	Shaft bearing	Manufacturer's		

S. No.	Component	Material	Ref. to IS	Grade
	seals	standards, suitable for duty	-	-
7	Internal fastings	Stainless steel	Manufacturer's standard	Suitable for duty
8	External bolting	Carbon steel; tensile strength 390 Mpa	-	-

(iii) Operation

438. All valves shall be capable of being operated at a differential pressure across the disc as marked on the valves. Leaver, worm gear / traveling nut type or any other suitable type of operator can be used.

439. Manually operated valves shall be closed by turning hand wheel or leaver in a clockwise direction when facing the hand wheel or leaver. The design of leaver when fitted shall be such that the leaver may only be assembled to the valve so that it is parallel to the direction of flow when the valve is open.

440. All traveling nut operators shall be provided with suitable stops to prevent movement of the shaft beyond the limit corresponding to the fully closed position of the disc.

441. All gear / traveling nut operators shall be self-locking type. All leaver operated valves shall be capable of being locked at at-least three intermediate positions. The operating hand wheels shall be marked 'CLOSE' or 'SHUT' to indicate the direction of closure. The operator shall be provided with arrangement to indicate disc position.

(iv) Testing

442. All valves shall be hydraulically tested by the manufacturer before dispatch. The pressure shall be applied without any significant hydraulic shock. Testing shall be carried out before application of paint or other similar treatment.

(v) Body test

443. The body ends shall be blanked. The valve disc shall be in slightly open position and the pressure equivalent to 1.5 times the maximum permissible working pressure shall be applied with water. The duration of test shall be as specified in Table-3 of IS: 13095.

(vi) Seat test

444. Seat test shall be carried in accordance with clause 17.3 of IS: 13095 and test duration shall be as specified in Table-3 of the IS.

(vii) Disc strength test

445. The test shall be conducted with the body flanges in horizontal position. The test pressure shall be 1.5 times the maximum permissible pressure. With disc in closed position, hydrotest pressure shall be applied to the lower face of the disc for duration as per table 3 of the IS: 13095. There shall be no damage to the valve disc or any part of the valve, or disc shall not be permanently deformed.

(viii) Manufacturer's Test certificate

446. The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 13095 and stating the pressures and medium used in the test.

(ix) Third party inspection

447. The inspection and testing of the sample butterfly valves shall be carried out by the inspecting agency / officer appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per the IS: 13095 shall be conducted in presence of the inspecting authority on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting authority for satisfactory performance of the tested valves. All costs towards the inspection charges shall be paid by employer and latter on deducted from contractor bill..

(x) Coating

448. All coatings shall be carried out after satisfactory testing of the valves prior to dispatch. Each valve shall be drained, cleaned, prepared and suitably protected with two coats of red oxide on all exposed and un-machined surfaces and rust preventive coats on machined and flanged surfaces. Ferrous surfaces of the valves, both inside and outside, shall be thoroughly clean, dry and shall be free from rust and grease before painting.

449. Two coats of black Japan confirming to type B of IS: 341 or paint confirming to IS: 9862 or IS: 2932 shall be applied by spray for exterior application in colour.

(xi) Marking

450. Marking shall be cast integral on the body or on a plate securely attached to the body. Marking shall be as specified under clause 21 of IS: 13095.

451. The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

(xii) Acceptable makes for the valves

452. ISI approved or equivalent makes approved by the Employer shall be acceptable. All the valves shall have the same make.

(xiii) Installation

453. The installation of the butterfly valves shall be done at the locations shown on the drawings. The job covers supply of the valves at work site including all type of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valve after installation for the specified test pressure.

xliii. Supply and Installation of Sluice Valves

(i) General

454. The sluice valves shall conform to IS: 14846. Double flanged short body sluice valves with pressure rating as specified in the specifications provided elsewhere. The valves for transmission mains shall be of pressure rating as required.

455. The material to be supplied under this sub-section shall include, but not be limited to, the following: All necessary fittings including bolts, nuts, gaskets, backing rings, counter flanges, jointing material, strainers etc. shall be supplied as required.

(ii) Scope

456. The sluice valves shall be with non-rising stem type. The valves will be used for water supply on line installations in upright positions, with double flange, and cap or hand wheel for manual operation. The valves shall be suitable for continuous use at their PN rating within the temperature range of -10^0 C to 65^0 C.

a. Nominal pressure and dimensions

457. The working pressure on the valves shall be as specified above. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

b. Material

458. The material for different component parts of sluice valve shall conform to the requirements given below:

Table 28: Sluice Valve Requirements

No.	Component	Material	Ref. to IS	Grade / designation
1	Body, bonnet, dome, stool cover, wedge, stuffing box, gland, thrust plate, hand wheel and cap.	Grey cast iron	210	FG 200
2	Stem	Stainless steel	6603	12C_r 13 04C_r 18Ni 10 04C_r 17Ni 12 MO 2
3	Wedge nut, shoe, channel	Leaded tin bronze	318	LTB - 2
4	Body seat ring, wedge facing ring and bushes	Leaded tin bronze	318	LTB - 2
5	Bolt	Carbon steel	1363 (Part 1)	Class 4.6
6	Nut	Carbon steel	1363 (Part 3)	Class 4
7	Gasket	Rubber	638	Type B
8	Gland packing	Jute and hemp	5414	nil
9	Gear	Spheroidal graphite iron	1865	G_r 500 / 7
10	Gear housing	Grey cast iron	210	FG 200
11	Pinion and pinion shaft	Wrought carbon steel	1570 (Part)	C55Mn75

(iii) Marking, testing and inspection

459. The standard marking and packing of the valves shall be done as per Clause 11 and 13 of IS: 14846. The direction of rotation for OPEN, CLOSE position shall be marked on the hand wheel and on the bonnet of the valve.

460. Hydraulic testing of each sluice valve shall be done for close end test in accordance with IS: 14846 Annex B, to the test pressure and test duration as specified in table 5 and 6 of the IS.
All the valves shall be inspected for flaw detection test in accordance with IS: 14846, clause 10.2.

461. The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

(iv) Manufacturer's Test certificate

462. The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 14846 and stating the pressures and medium used in the test.

(v) Coating

463. All coatings shall be carried out after satisfactory testing of the valves prior to dispatch. All the un-machined ferrous surfaces of the valves, both inside and outside, shall be thoroughly clean, dry and shall be free from rust and grease before painting. All exposed machined ferrous surfaces shall be painted with one coat of Aluminium red oxide primer confirming to IS: 5660. Two coats of black Japan confirming to type B of IS: 341 or paint confirming to IS: 9862 or IS: 2932 shall be applied by spray for exterior application in colour.

(vi) Third party inspection

464. The inspection and testing of the sample valves shall be carried out by the inspecting agency / officer appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per the IS: 14846 shall be conducted in presence of the inspecting authority on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting authority for satisfactory performance of the tested valves. All costs towards the inspection charges shall be
paid by employer and latter on deducted from contractor bill..

(vii) Acceptable makes for the valves

465. ISI approved or equivalent makes approved by the Employer shall be acceptable.All the valves shall have the same make.

(viii) Installation

466. The installation of the sluice valves shall be done at the locations shown on drawings as online valves, washout valves and isolating valves for air valves, fire hydrants. The job covers supply of the valves at work site with cost of all the required material and all types of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job also covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

xliv. Supply and Installation of Kinetic Air valves

(i) General

467. Kinetic air valves are required with pressure rating as specified under the specifications elsewhere, confirming to IS: 14845. The air valves for transmission shall be of pressure rating as per requirement.

(ii) Scope and general design features

468. The air valves shall be capable of exhausting air from pipeline automatically when being filled. Air shall be released at sufficiently higher rate so that there shall be no restriction for the inflow rate. Similarly, the valves shall be capable of ventilating pipeline automatically when being emptied. The air inflow rate should be sufficiently high to avoid development of vacuum in the pipeline.

469. The design shall be such that, higher the rate of flow the greater the resultant down thrust, keeping the ball 'glued' to its seat until the last drop of air is expelled from the pipe system.

470. Each air valve shall be provided with an isolating sluice valve with flanged end connection. The possible air velocity (inflow and outflow) must be at least 10 m/s.

a. Construction features

471. The flow of air should be as unobstructed as possible. The low pressure orifice shall be in the same axis as the main discharge / incoming air flow and must have a diameter sufficiently large. The valve body shall be designed in such a way that the turbulent air at the time of filling of pipeline shall not circulate and cause the ball to be caught in the discharging air stream and blowing the valve shut permanently. The cone angle of the low pressure (large orifice) chamber shall be such that even at a critical velocity of air escaping at 344 m / sec the total impact force on the vulcanite covered ball is less than the suction force on the annular area between the ball and cone. The annulus around the low pressure vulcanite covered ball is to be generously proportioned for discharge of air under various differential pressures. Normal range of cone angle is 45^0 to 60^0.

472. The orifice shall be carefully profiled to allow the requisite flow of air under varying differential pressures. It shall be in molded synthetic rubber such that even after extended contact the, vulcanite covered ball does not stick to it, when the line pressure becomes zero.

473. The high pressure chamber having small orifice shall be so designed that the orifice is effectively sealed in working condition. The orifice shall be profiled in such a manner that the rubber covered ball is not damaged even after extended contact. There should be machined guide in the chamber which ensures that the ball travels vertically and makes contact with the nipple and seals off the orifice without fail. The orifice size shall not be less than 2.5 mm and tapering to 10 mm suitable to release accumulated air within the pipeline. High pressure orifice may be fitted from bottom side of the cover.

b. Material

474. The material for different components parts of the air valve shall conform to the requirements given below:

Table 29: Air Valve Requirements

No.	Component	Material	Reference to IS No.	Grade of designation
1	Body, cover, valve disc, stuffing box, valve guide, cowl, gland, cap, joint support ring	Gray cast iron	210	FG 200
2	Stem	High tensile brass	320	HTB 1 or HTB 2
3	Low Pressure seat ring and face ring	Natural rubber	11855	
4	High pressure orifice	Leaded tin bronze	318	LTB-2
5	Stem nut	Leaded tin bronze	318	LTB-2
6	Body seat ring	Leaded tin bronze	318	LTB-2
7	Bolts	Carbon steel	1363	Class 4, 6
8	Nuts	Carbon steel	1363	Class 4
9	Gasket	Rubber	638	Type B
10	Gland packing	Jute / hemp	5414	Type III
11	Float (low pressure orifice)	Timber core with rubber coating	-	-
12	Float (High pressure orifice)	Timber core with rubber coating	-	-
13	Float guide	Leaded tin bronze	318	LTB-2

c. Floats

475. Minimum float diameters for kinetic air valves shall be as indicated in table 3 of IS 14845. The inner core of the floats shall be made from seasoned wood or any other synthetic material having sufficient bearing strength and equivalent specific gravity.

d. Testing

476. Testing of all the air valves shall be carried out in the suppliers work shop as per Is: 14845.Following tests shall be carried for each valve.

- Function and performance test as per clause 12.4.1
- High pressure orifice test as per clause 12.4.2
- Low pressure orifice test as per clause 12.4.3
- Body test as per clause 12.4.4

477. The performance of the valve for the above mentioned tests shall be as specified under clause 12.1, 12.2 and 12.3 of IS 14845.

e. Manufacturer's Test certificate

478. The manufacture shall provide a test certificate confirming that all the air valves have been tested in accordance with the relevant standards and performance of the test results observed.

f. Third party inspection

479. The inspection and testing of the sample air valves shall be carried out by the inspecting agency / officer appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per IS 14845 shall be conducted in presence of the inspecting authority on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall

be dispatched only after issue of the test certificate by the inspecting authority for satisfactory performance of the tested valves. All costs towards the inspection charges shall be paid by employer and latter on deducted from contractor bill..

g. Coating

480. All coatings shall be carried out after satisfactory testing of the air valves prior to dispatch. Each valve shall be cleaned, prepared and suitably protected with two coats of black Japan confirming to type B of IS: 341 or paint confirming to type 2 of IS: 9862 or IS: 2932 shall be applied by sprayand issue of test certificate by the manufacturer as specified above.

h. Marking

481. Each valve shall be permanently marked with a plate securely fixed to the body with the information as specified under clause 15.1 of IS 14845.

482. The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

i. Acceptable makes for the valves

483. Any makes that is as per the specification and ISI standards shall be used . All the valves shall have the same make.

j. Installation

484. The installation of the air valves shall be done at the locations shown on L-sections of the pumping main with isolating sluice valve. The job covers supply of the valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

xlv. Supply and Installation of Pressure Reducing Valves

(i) Scope

485. Diaphragm controlled pressure reducing valves, suitable for automatic reduction of downstream pressure shall be provided and installed with strainer in the distribution networks wherever shown on the network drawings. The downstream pressure shall be constant to the set value, independently of flow and pressure variations on upstream. The pressure rating of the valves shall be minimum PN 1.2 (12 kg / cm2 working pressure) or as per requirements.

a. Material

486. Material for valve manufacture shall be as per the manufacturer’s specifications. The valves shall be suitable to work at the designed pressure between the temperature range of -100 C to + 650 C.

b. Hydraulic test at works

487. Valve seat shall be tested for a pressure of 1.1 x PN rating and Body for 1.5 x PN rating of the valve. The valves shall be tested by the manufacturer for various downstream set pressures with varying upstream pressures and the contractor shall submit the manufacturer's test certificate giving the observed test data. Maximum upstream pressure in the system may be about 90 m head of water.

c. Coating

488. The valve shall be coated internally and externally with electro-statically supplied blue epoxy to WIS4-52-01 class B standards.

d. Packing and forwarding

489. The valves shall be dispatched to the work site with suitable and strong packing to avoid any damage during transport.

e. Installation

490. The valves shall be supplied with accessories needed for proper functioning of the valves as per the recommendation of the manufacturer and installed at the locations shown on the transmission mains drawings. The RCC valve chamber shall be of adequate size so as to accommodate all the valve accessories. The contractor shall be fully responsible for proper functioning of pressure reducing valves. He shall arrange for the visits of the manufacturer at his cost during installation and commissioning and shall give satisfactory test and trial after commissioning. The contractor shall also be responsible for repairs / replacement of the valve during operation and maintenance period of the work for improper functioning of the valves. The manufacturer's visit shall also be arranged by the contractor at his cost, as and when required during the performance guarantee period, if any functioning problem arises.

(i) Power or Telephone Poles and Lines

491. In case pipeline alignment requires relocation of electric / telephone poles / OH lines, or other cables, the Contractor shall inform the Employers representative and the concerned line agency. These works shall be executed by the respective department or according to its instructions, by the Contractor. The expenditure on such works shall be made through provisional sums. Contractor shall be fully liable for damages to existing pipes or structures due to negligence of its staff. All costs for the reinstatement of the original status of the pipes, poles, equipment or structures in case of such damage shall be borne by the Contractor.

xlvi. Commissioning of Pipelines

(i) Flushing and Disinfecting of Pipelines

492. Prior to final testing and commissioning, the Contractor shall first swab clean the pipelines to remove all earth, dirt, trench water etc. The pipelines shall then be flushed with a velocity not less than 1.0 m/s or as approved by the Employers representative till the water coming out (of scour valves) is clear. If specifically desired by the Employers representative, disinfection of the pipeline shall also be done by the Contractor. The disinfection shall be carried out by filling the pipeline with a chlorine solution (using Calcium Hypochlorite Granules dissolved in clear water or any other method approved by the Employers representative) with at least 20mg/l of available (free) chlorine and providing a contact time

of not less than 20 hours to ensure a thorough disinfection. The chlorine solution will be disposed of by neutralizing with the required quantity of lime to ensure pH of effluent not less than 7.

(ii) Final Testing and Commissioning of Pipeline

493. The pipeline shall be tested and commissioned by the Contractor after Physical completion. These tests shall be witnessed by the Employers representative or his designated representative. During testing / commissioning, the Contractor shall supply all material and labour to supervise, adjust, test, repair, and do all things necessary to carry out the testing / commissioning.

494. The Contractor shall test and commission the system for one full day at a stretch. After completing this activity, a taking-over certificate shall be issued by the Employers representative, provided all defects and/or deficiencies noticed are rectified to the satisfaction of the Employers representative.

495. The Contractor shall allow in his costs for commissioning to be conducted at any time during the commissioning period.

496. **Indicators for Successful Commissioning:** The main indicators for the successful commissioning are:

a. No leaks are observed in pipes, joints, specials and valves;
b. All valves, including air valves and scour valves are properly installed and operational;
c. Execution of the entire work including finishing according to the specifications;
d. Submission of as-built drawings.

(iii) Road Restoration Work

497. Road restoration work will be needed due to construction of pipe line trenches on sides of existing roads.

498. All road surfaces damaged due to digging of pipeline trench will have to be restored by the Contractor. For all earthen roads, after laying of pipelines, roads shall have to restored by the Contractor to pre- construction stage for which no extra payment will be made.

499. For existing metallic and bituminous roads, the Contractor will be required to restore up to GSB level by using useful excavated refilling material. Beyond GSB and above, the road will be restored as per relevant clauses of MORTHS Standard drawing for restoration of various types of roads is enclosed with the bid document along with chamber drawings. The restoration of various types of roads shall be done according to this drawing. The restoration of roads shall be done immediately after hydraulic testing of the pipeline stretch so as to avoid inconvenience to the traffic and public due to damaged roads. The cost of road restoration is supposed to be included in the quoted price of the bid.Relevant MOSRT&H Specification:

i. Granular sub-base (GSB) with close graded material (Table 400-1) Clause 401 of MOSRT&H specification

ii. Wet mix macadam (WMM) clause 406 of MOSRT&H specification
iii. Prime coat clause 502 of MOSRT&H specification
iv. Tack coat clause 503 of MOSRT&H specification
v. Open graded pre mix surfacing of 20mm thickness composed of 13.2 mm to 5.6 mm aggregates with anti-stripping agent, using penetration grade bitumen (60/70) etc. as per clause 511 of MOSRT&H specification
vi. Seal coat with anti-stripping agent (as per IS: 14982), clause 513 of MOSRT&H specification.

Note: Resotoration of the road should be done within 45 days after commencement of pipeline laying works, failing which cost of restoration of road as per SOR of Bihar

xlvii. Valve Chambers

(i) Covers of Valve Chambers

500. The cover of valve chambers shall be with pre-cast RCC slabs or combination of partly covered RCC slab and partly with pre-cast slabs. The pre-cast slabs are provided with lifting arrangement for entering in to the chambers for valve repairs etc. The covers are designed to carry the heavy traffic load. In case of chambers in the sub-work of transmission system, the chambers shall be constructed as shown in the standard drawings enclosed and as per the structural designs done by the contractor. There may be variation in the internal size of the chambers to some extents depending upon the dimensions of the valves and specials supplied by the contractor. Similarly height of the chambers may vary depending on the depth of pipeline excavation at the particular chamber location. The roof, walls and foundation shall be designed for traffic load with the consideration of IRC Class-B loading.

(ii) Footrests in Valve Chambers

501. MS footrests shall be provided and fixed at valve chambers of depth more than 1.2m. It shall comprise of steel bar of 16mm dia grade Fe 415 steel bar encapsulated with minimum 3 mm thick plastic all-round as per IS 10910 with the overall minimum length of 263 mm and width 165 mm and anchored in cement concrete and fixed.

(iii) Supplying, Fixing and Fitting MS Flats in Saddle Supports

502. Mild steel flats will be used for use as clamps to hold pipes in all saddle supports. Width and thickness of clamps shall be 50 mm and 10 mm respectively. Suitable nuts and bolts shall be used for fixing the clamps in saddle supports. The specification mild steel flats will be as per the codes given below:

Table 30: Mild Steel Flat Specifications

IS 226	Structural Steel (Standard Quality)
IS: 800	Code of Practice for Use of Structural Steel in General Building Construction
IS: 813	Scheme for Symbols for Welding.
IS: 814	Covered Electrodes for Metal Are Welding of Structural Steel (Part I & II).
IS: 815	Classification and Coding of Covered Electrodes for Metal Are Welding of Structural Steel.
IS: 816	Code of Practice for Use of Metal Are Welding for General Construction in Mild Steel.
IS: 817	Code of Practice for Training and Testing of Metal Are Welders.
IS: 822	Code of Procedures for Inspection of Welds.

IS: 823	Code of Procedure for Manual Metal Are Welding of Mild Steel.
IS: 961	Structural Steel (High Tensile)
IS: 1024	Code of Practice for Use of Welding in Bridges.
IS: 1148	Hot Rolled Steel Rivet Bars (Upto 40 Mm Diameters) for Structural Purposes.
IS: 1387	General Requirements for The Supply of Metallurgical Material.
IS: 1477	Part I, Code of Practice for Painting of Ferrous Metals in Buildings - Pre-treatment.
IS: 1599	Method for Bend Test for Steel Products Other Than Sheets, Strip., Wire and Tube.
IS: 1608	Method for Tensile Testing of Steel Products.
IS: 1731	Dimensions for Steel Flats for Structural and General Engineering Purposes.
IS: 1852	Rolling and Cutting Tolerances for Hot-Rolled Steel Products.
IS: 1915	Code of Practice for Steel Bridges.
IS: 2101	Allowable Deviations for Dimensions Without Specified Tolerances.
IS: 7318	Part I Fusion for Assembly of Structural Joints Using High Tensile Friction Grip Fasteners.
IS: 7318	Part I Fusion Welding of Steel.

503. Other I.S. Codes and I.R.C. codes pertaining to the items of structural steel not specifically listed shall also be deemed to come under the purview of this clause.

504. All steel and iron work shall be measured in kilograms. The weight shall be computed from standard tables unless the actual weight can readily be determined.

xlviii. Crossing by pipe pushing method

(i) Scope of work

505. The scope of work includes jacking and pushing for road and railway crossings as per the standard practices followed.

(ii) Construction of jacking pit

506. Jacking pits of suitable size shall be constructed for jacking and pushing of suitable diameterof pipe. The contractor shall decide the pit dimensions to suit the site condition & requirement of pushing platform length. Continuous 24 hour dewatering arrangement shall be made to lift percolating water in the pit till completion of the work.

507. The jacking pit bottom shall be well compacted. Rubble soling shall be provided at the bottom over which, plain concrete floor shall be constructed for having firm support to the pipe to be jack and pushed. Rails / girders shall be fixed on this floor for smooth movement of the casing pipe while jacking and pushing. Suitable thrust resisting arrangement shall be provided on the other end of the pit for installation of the hydraulic jacks.

(iii) Receiving pit

508. The receiving pit of suitable size shall be constructed on the other end with the same material & method adopted for Jacking pit. The depth shall be as required to suit the depth of pipe being jack and pushed. The receiving pit shall be constructed as directed by the Employers representative.

(iv) Jacking of Pipe

509. The hydraulic jacking can start after completing the Jacking pit. The hydraulic jacking shall be by tunnelling method. A guide frame is fixed on the firm support of the Jacking pit. The main jacking station with hydraulic cylinders shall be fixed on the guide frame abutting to the thrust resisting arrangement constructed at the end of the pit. The casing pipe is lowered on the guide frame and jacked through the ground from the Jacking pit to the Receiving pit

by means of hydraulic jacks. MS cutting edge shall be fixed on the casing pipe at the pushing end. Pushing of the casing pipe shall be done by applying pressure with the help of hydraulic jacks and compressors. Simultaneously, the soil inside the casing pipe is removed by hand mining or by suitable machine excavators under the protection of cutting shoe and moved through the jacked section to the surface. Thus the inside excavation and pushing of the pipe will continue simultaneously till the casing pipe cutting edge reaches the end point. Boulders or other obstacles can be removed with the help of winches without any handicaps. The receiving pit shall be constructed before the casing pipe reaches there. After completion of jacking procedure, cut off the cutting shoe and remove out from receiving pit.

a. Sequence of work

- Inspection of pits including abutment structure and approval.
- Installation of hoist at starting pit.
- Installation of main jacking station and guide frame.
- Fixing of frame to the firm support.
- Installation and adjustment of cutting shoe.
- Transportation of casing pipe from yard to jacking station and fixing of the cutting edge.
- Start of jacking by hydraulic pressure from the main jacking station.
- Excavation of soil by hand mining or machining under the protection of the cutting shoe.
- Continuation of jacking, hand mining and pushing of casing pipe
- Before arriving to the Receiving pit construct the Receiving pit.
- After completion of jacking procedure cut off the cutting shoe and remove out from receiving pit, dismantling of jacking station and guide frame.

(v) Safety measures

510. The receiving pit of suitable size shall be constructed on the other end with the same material & method adopted for Jacking pit. The depth shall be as required to suit the depth of pipe being jack and pushed. The receiving pit shall be constructed as directed by the Employers representative.
In order to ensure safety during jacking procedure for all labour and the public, the following measures will be implemented:

- Signal hats and/or signs have to be erected in order to warn the driver around the concerned area, where pits are opened.
- Pedestrians will not be allowed to enter the area closer than 3 metres to an open pit or the control unit, unless there is sufficient barricading.
- A gas monitor has to be used for every entrance and work into the pits or line. Before access, the monitor shall be moved down to the bottom of the pit minimum 5 minutes by a rope. When poisonous condition is detected, the area will not be entered.
- Accessing people shall use protective clothes, gloves, rubber boots, helmet, head lamp and additional all safety measures including an oxygen bottle with rescue mask has to be available on site all the time.
- A ventilation blower shall be used in the jacking section.
- Pre-arrangements with the next hospital have to be ensured in case somebody is injured.
- A first aid kit must be available on site at every time.
- No stay below hanging goods such as pipes.

- Use fire extinguisher for fire protection

511. The job completes after completion of pushing the casing pipe for required length and dismantling thetapers etc. including construction of the chamber and laying and jointing of the upstream and downstream pumping main pipeline work. Hence these works shall be completed immediately and the pits are refilled to the original ground level.

512. The Contractor shall be responsible for preparation of design and drawing including jacking arrangement, requirement of hydraulic jacks, compressor/s, dewatering sets etc., which shall be got approved from the Employers representative.

513. The job work covers cost of construction of jacking and receiving pits, cost of cutting edge, thrust arrangements and cost / rentals for hydraulic jacks, compressor/s, dewatering sets, rails or girders, jacking frame etc, the item shall include the cost of pipes, valves, chamber etc.

xlix. Power Transformer

514. Two numbers of power transformer suitable for 33 kV/433 Volt, 50 Hz oil immersed copper wound outdoor OLTC type, shall be provided for pumping station and two nos of Auxillary transformers of 0.433/0.433kV , 50Hz oil immersed type OCTC. The power transformer shall conform to IS: 2026 and shall be as per CEA guide lines as amended up to date for losses along with LV enclosure. It shall be equipped with all necessary attachments like Silica Gel breather, of circuit tap changer, HV side bushing and LV side cable end box. Required double pole structure consisting of ISMBs, ISMCs, stays, metering cubicals with CTs and PTs lightening arresters, AB switch with Earth switch, DO fuse, dish and pin insulators, ACSR conductors, Cables, earthling arrangement etc shall be provided with foundation and plinth platform for transformer.

(i) 33 kV HT power line

515. A 33 kV dedicated feeder is proposed to be laid from Sabur of Bhagalpur to Barari HW under Intermediate stage of Bhagalpur Water Supply project. It is proposed to extend the power line from Barari Head Works to proposed substation near Intake Well in a length of 2.5 km to provide continuous power supply of good and dependable quality.

(i) Scop of Work

516. The scope of proposed topographical survey work includes the following:

a. Geo-referenced Topographical Survey of all Roads of transmission system.
b. Establishment of permanent bench marks with respect to GTS bench marks with double levelling using Auto level survey instruments.
c. Fixing of permanent bench mark pillars / baseline stations at selected locations in the form of concrete pillars.

a. Technical Specifications

517. The survey shall be carried out showing all existing topographical features along the road boundary limit - road edge, types/ width of the road, trees having girth more than 100 mm, culverts, bridges, causeways, road side/storm water drains, telephone poles, HT/LT power poles, bus stops, existing garbage dustbins and transfer stations, existing visible water lines (if any) and all man- made features within the survey limit. Survey will be covered from property line to property line. The levels shall be taken at every 25 m for plotting longitudinal sections and

whenever there is a change in gradient and direction.

Specific requirements for the survey:

- Ground levels are to be taken at 25m interval along the roads, at all road junctions and at salient points, one level will be taken at the centre of the road and one level on either side of the road. Type of road (Kutcha /WBM /Asphalt/ Concrete / Brick paved) will be specified on the map.
- Width of all roads and lanes will be marked at 25m interval.
- The survey shall pick up important land mark features along the right of way of the road/lanes and at all road junctions. Land mark locations will have to be accurate.
- The survey will pick up the alignment of road side drains, exact width of existing road side drains at top and bottom, top and invert levels of the drains at 25m interval. Type of drain (Kutcha / Pucca, etc.) will be mentioned. Depth of silt/mud in drain will have to be measured accurately at 25m interval and shown in survey maps.
- Wherever the existing road alignment crosses streams, channels, rivers, rivulets etc. having a width of 2m or more, levels and cross sections on both the banks and at change of section of the stream shall be provided so as to properly identify the stream cross section.
- In case of bridges or large size culverts, high flood levels (HFLs) shall be marked on the map. If HFL is not demarcated on the existing features, surveyor shall enquire from the concerned local authorities and mark the same on the map wherever possible.
- The survey will also pick up property boundaries along the roads and lanes.
- Number of houses on both sides of road shall be counted and marked on the survey sheets.
- The work shall also include leaving TBMs, at least one in each road, which shall be painted on some permanent structure. The TBMs will be also marked on the maps.
- Reduced levels (R.L) shall be taken with respect to GTS bench marks with double levelling using Auto level survey instruments for establishment of permanent bench marks.
- DGPS should be used for recording Northing, Easting, longitude and latitude of all bench marks.
- Permanent Bench marks of RCC pillar of size 15x 15 x 75 cm shall be erected as directed and the RCC pillar shall be embedded 45 cm into the ground strongly secured with cement concrete mixture in order to avoid dislodgement. A flat top nail shall be fixed at the centre of pillar, the R.L. and B.M. no shall be marked on the pillar with red colour.
- Digitized maps of surveyed roads will be submitted in A1 size and in 1:1000 scales. There will be numerous maps to cover the assigned areas of survey.
- A combined digitized base map of Bhagalpur (project area) will be prepared and submitted showing all details of alignment of roads and lanes, road side drains, levels and land marks. Also, contour lines will be generated in the digital map with the help of spot levels along the roads. Contour interval will be 0.5m. Print in suitable size will be submitted.
- The survey sheets of transmission zone of the project area shall be submitted in separate bound volumes.
- The contractor shall submit the surveyed data in following table for each reservoir zone.

Table 31: Survey Data–Transmission main

ll.Sl.No.	Name of road/street/lane	Type of road- BT/metal/ kaccha	Length of road in mtrs					Traffic	
			0 to 3 m wide	3 to 5 m wide	5 to 10 m wide	10 to 15m wide	15m and above	Heavy	Medium
Total									

b. Obligations

1) The survey work has to be carried out using Total Station, Auto Levels and shall be geo-referenced.
2) Leveling work should be carried out using Auto Levels only.
3) All the topographical surveys have to be carried out with respect to the nearest GTS bench mark established by the Survey of India.
4) All the observation /read ups shall be entered in proper field book in good style and in accordance with standard practice followed by SOI. All entries shall be in ink/ball pen. Any wrong entries shall be neatly struck out and rewritten. No overwriting or erasing of any of the entries shall be permitted. All filled books shall be made available for inspection at any stage while the survey work is in progress.
5) The Contractor shall use suitable o-ordinates for the survey.
6) The Contractor shall provide full access to the instruments used as well as to records maintained by it during the execution of the survey works to the authorised representative of the client.
7) All the maps shall be geo-referenced.
8) The maps, drawings and database generated during this assignment are proposed to be integrated in GIS based management system in future. Keeping this in mind, the consultant shall generate all maps, drawings, and database.
9) All the drawings should have very clearly marked and tabulated legends (as per National/ International norms) relevant to the type of work being under taken for the project.
10) The Contractor shall submit all field books to the client after completion of the survey works.
11) All the Survey drawings and site records submitted shall be the exclusive property of the Client.

c. Supervision and Quality Assurance

518. Field engineer in-charge from STC shall issue continuous directions and shall do all necessary activities to ensure the quality of work.

d. Deliverables for the Surveys:

519. Submission of output shall in following manner:

- At the end of the survey, the surveying firm shall produce the following outputs:
- Survey information related to different features should be stored in AutoCAD layers.

- Sample drawings of surveys shall be submitted in standard format to STC to facilitate the decision on scale, formatting and styles to be used in final drawings.
- Three sets of final soft copy of the survey reports shall be submitted after incorporating the suggested modifications along with hardcopies of drawings.
- Three sets of final soft copy of the survey work shall be submitted in Geo-referenced AutoCAD format. All soft copies shall be submitted in CDs and properly documented and labeled. The soft copies of the maps submitted shall have clear layer controls. The number and nomenclature of the layers shall as directed by client.
- All reports and drawings shall be signed by Survey Team Leader.
- Drawings for road and existing drains (natural or manmade) with all necessary details shall be submitted in A1 size.
- All drawings are to be generated using latest AutoCAD version.
- The Longitudinal sections shall be plotted at 1:1000 horizontal and 1:100 vertical scales. The plans shall be plotted in 1:1000 scales. The cross sections shall be plotted at 1:200 horizontal and 1:100 vertical scales. These drawings should be submitted for all drains more than 2m width.
- Base Map of survey area with contours at contour interval of 0.5m. The Base map shall be plotted on a scale of 1:10000.
- Separate layers for each feature with name shall be provided in the drawing.
- List of culverts, bridges and any other utility details with size etc. shall be submitted.
- TBM list and details of level transferred based on Mean Sea Level should be submitted as a separate drawing.

I. Hydraulic Design of Transmission Network

(i) 6.1.3.1.59.1 Obligatory requirement

520. The hydraulic design of the transmission networks shall be done using Water GEMS, hydraulic design software only. The design criteria on which the design is to be based shall be as below.

Table 32: Hydraulic Design Criteria

Sr. No.	Particulars	Requirements
1	Pipe material	1) above 1000 mm - Mild Steel pipes, Conforming to IS: 3589, Fe 410 grade/ DI K-9 conforming to IS 8329.
		2) DI k-9 pipes up to 1000 mm diameter, conforming to IS 8329
2	Design basis	Relevant Indian Standards, CPHEEO Manual and American Water Works Association Manual on Design of MS Pipes – M-11
3	Minimum pipe diameter	150 mm
4	Design Stage	Design demand in the year 2041 (Phase-II)
5	Head loss analysis	Based on Hazen-Williams formula
6	Roughness coefficient	140 – as specified in CPHEEO Manual for internally centrifugally lined pipes
7	Governing level for hydraulic analysis	FSL of the supply Reservoir +0.2 m
8	Selection of Pipe class	Static pressure on pipeline with respect to full supply level of the Reservoir for gravity flow
		Working pressure on pipeline 1.5 times (maximum static + frictional head) in respect of supply by pumps

Sr. No.	Particulars	Requirements
9	Minimum flow velocity	0.60 - 0.9 m / Sec at peak flow
10	Maximum flow velocity	1.2 m / Sec through pipes and 1.5 m / Sec through valves at peak flow
11	Unit head loss	Less than 4 m / km length
12	Pipe laying	All below ground except River, Nala crossings
13	Line valves	Butterfly valves for 400 mm and above sizes, Valve diameter shall be 1 size smaller than the pipe with velocity limitations. Sluice valves for pipe sizes 300 mm and below. Valve diameter same as pipe.
14	Air valves	Kinetic Air valves as required
15	Washout valves	Sluice valves as required for pipe washing and as per topographic requirements
16	Lining and coating to pipes	As per specifications

Table 33: Proposed Clear Water Pumping Main (diameter wise)

S. No	Diameter of Pipe in mm (DI K9)	Length (in km)
A	**Southern Transmission Main**	
1	150	130.4330
2	300	353.47
3	350	3291.40
4	400	1038.37
5	450	1691.22
6	500	361.23
7	700	4029.61
8	800	1409.58
Total Length		**12308.20**
B	**Western Transmission Main**	
1	150	152.37
2	200	957.64
3	300	915.41
4	350	4640.49
5	400	93.74
6	450	924.24
7	600	1991.32
8	700	2401.25
9	800	661.04
10	900	3621.33
Total Length		**16358.83**
Total Length (A + B)		**28667.02**

2. Water Treatment Plant and Clear Water Pumping Station

a. General

521. The work under contract shall be executed by the Contractor on turnkey basis including designs and procurement, where the responsibility of the Contractor will include all preparatory work, topographical and soil surveys, leveling and dressing of site, design, supply, construction, installation, testing, trial run and commissioning of the Water Treatment Plant and facilities. The scope will further include operation and maintenance for five years following successful completion of the trial run period.

522. The general arrangement of the water treatment plant envisaged at bidding stage is indicated in the drawings enclosed with the bid document. These drawings are indicative for guidance of contract and the Contractor shall prepare his own layout and design based on his investigation of site. The Contractors design shall however incorporate minimum requirements as stated in subsequent sections.

b. The capacity of the water treatment plant as proposed is as below

Table 34: Proposed Capacity of Water Treatment Plant

Phase	Target Year	Treated Water (MLD)
Intermediate Requirement	2032	90
Ultimate Requirement	2047	135

523. The overall plant water loss(net) from the system shall be kept to the minimum and not exceeding 5% of input (considering recovery and recycle scheme). The pipes, launders and channels in the WTP shall be hydraulically designed for flow including 20% overload.

524. The WTP premises shall be planned considering the requirement of including all process and allied structures and other ancillary works. The present scope includes the construction for the intermediate requirement work and provision for the Ultimate requirement work. However units such as Pre- Sedimentation Tank, cascade aerator, Parshall flume and channel upto flash mixer and clear water pumping station shall be designed for total flow of Intermediate and ultimate requirement.While units such as flocculator, clarifier, filter and sludge drying facilities shall be constructed for the intermediate stage flow only. The unit planning shall be such that WTP capacity shall be up-gradable to ultimate requirement by just adding necessary additional flash mixer, clarifier, filter units, thickener and sludge drying facilities at later date.

525. The land available for the WTP campus for Bhagalpur WTP is about 2.50 ha. The campus will also accommodate Settled Water Sump and Pump House, Clear Water Reservoir, Clear Water Pump House, H.V. Sub Station, administration building, offices and other ancillary structures, Service Roads, etc. Provision of space for requirements for them shall also be made.

c. Raw Water Quality

526. The treatment plant shall be designed to treat water having the raw water quality of Ganga river. The recorded parameters of raw water have been appended under supplementary information.

527. The Contractor shall carryout independently raw water sample testing/analysis for deciding parameters for adopting in design of treatment plant units.

528. However the plant shall be designed to give desired output in each Stage per day working on 24-hour basis.

529. The quality of raw water may change time to time during rainy season from lower levels in river and the Contractor is to take these changes into consideration while designing the water treatment plant units. The Contractor shall ascertain the raw water quality before bidding.

530. The Contractor shall also carry out analysis of any other parameters required by him, which are not furnished in the raw water analysis supplied by independent supplementary as already stated. The Contractor shall, in addition, carry out the treatability tests (JarTest for ex.), he considers necessary to deliver the desired treated water quality. The turbidity of minimum 300 NTU shall have to adopt for design purpose of WTP.

d. Process Guarantees

531. Treated water quality shall conform to provision in CPHEEO manual. Apart from the quality of the treated water and the indicated water levels at the output and input of the plant the Contractor has to guarantee the following process performances for various flows over the years.

e. Quality of Treated Water Process Guarantees

Table 35: Quality of Treated Water

Turbidity of the effluent of the Clarifier unit	Not more than ≤ 10 NTU
Suspended solids in the effluent of the Clarifier	Not more than 5 mg/l
Minimum filter run period at any time of the year between successive backwashing	24 h
Filter run during 95% time of the year	28h
Maximum water losses in WTP	5 % of the raw water input

f. Treated Water Quality Parameters

Table 36: Treated Water Quality Parameters

Parameters with Units	Required Output Standard
Turbidity (N.T.U.)	< 1
Colour (Units on Platinum Cobalt Scale) TCU	≤ 5
Taste and Odour	Un objectionable
pH	7- 8.5
Faecal coliforms number/100ml	0
Coliform organisms number/100ml	0
Total Iron as Fe, mg/l	≤ 0.1
Residual Aluminium as Al, mg/l,	≤ 0.03
Manganese as Mn, mg/l	≤ 0.05
Chloride as (Cl), mg/l	200
Sulphate as (SO_4) ,mg/l	200
Fluorides as (F), mg/l	1
Nitrates as (NO_3), mg/l	45
Alkalinity, mg/l	200

532. If, at any time during O&M period, any of the quality and process parameters cannot be reached, the Contractor shall at his expenses carry out all necessary modifications to the civil structures, mechanical, hydraulic, electrical and other components of the plant, or modify the operation procedures and alter the chemicals/ Chemical dosing parameters in order to achieve the required performance of the plant.

g. Technical Specifications of Different Components of Water Treatment Plant

i. General Arrangement

533. The Contractor shall collect the data on the water level variations, flood levels near the WTP campus and establish the same on the site. The WTP planning and campus planning shall be done to avoid any damage due to flooding and to avoid any hindrance to proper working of the WTP and allied works due to flooding.

534. The following general guidelines shall be considered while preparing the conceptual design and general arrangement drawings of the proposed water treatment facilities, as specified in this document:

i. The Contractor shall collect the data on the water level variations, flood levels near the WTP campus and establish the same on the site. The WTP planning and campus planning shall be done to avoid any damage due to flooding and to avoid any hindrance to proper working of the WTP and allied works due to flooding.
ii. The architectural layouts of the water treatment plant's buildings shall be functional, be adapted to the regional climatic conditions and shall provide an aesthetic appearance bearing in mind the local environment and culture.
iii. The conceptual and detailed plans, architectural elevations, furnishing details and technical specifications shall be approved by the Employer's Representative.
iv. Sufficient clearances shall be provided between units of the proposed plant to permit safe and convenient access for operation and maintenance.
v. plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements;
vi. Suitable passages, lifting eyes or other means shall be provided to permit the removal of equipment for maintenance or any other purpose that may be required during the course of its normal operational life.
vii. Areas where drainage or wash down activities are likely to occur whether under normal operation or during maintenance shall be provided with covered drainage channels, which shall direct the wastewater either to a suitable plant drain or to a sump from where it can be pumped out to an external drain in the plant area.
viii. Bypass arrangement shall be provided to bypass filter and clariflocculator.
ix. Chemical pipe work shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

535. All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention shall be paid to the layout of

the chemical pipe work, which shall be functional and neat in appearance. Generally, where pipe work is installed in ducts, it shall be supported not less than 150 mm clear of the floor.

536. When selecting materials for pipe work, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight.

ii. Orientation

537. The layout of the proposed plant shall be suitably prepared such that it allows space for future expansion of the treatment plant and fits within the space allotted. Internal roads shall be laid out to be able to access all buildings and process units from at least 3 sides of each. Underground services, requiring to be relocated in order to accommodate the proposed site layout shall be relocated by the Contractor with the approval of the Employer's Representative.

iii. General Design Criteria

538. The following design criteria shall be followed in design of the new and future facilities and infrastructure on the new Bhagalpur Water Treatment Plant site:

a. The exixtance entrance shall be new for proposed WTP. The internal roads shall be provided to have easy access to the units of WTP.
b. Underground piping on the plant site shall generally be routed to follow the road alignment for ease of location and access. Shoulders areas along the roadways shall be designed to accommodate this pipe routing scheme.
c. The finished floor elevations of the buildings shall be preferably 900 mm above the finished grade level outside of the building. The grade shall be sloped away from all buildings for drainage at a minimum slope of 2%.Plinth protection concrete shall be provided around the building at FGL.
d. The Contractor shall design a storm water drainage plan for the WTP campus and get it approved by the Employer's Representative prior to the finalization of the site layout. Storm water shall be routed to drains if they are available and have adequate capacity to accommodate the increase in impervious areas resulting from the construction of the plant. Otherwise the storm water shall be collected and pumped to a drainage system of adequate capacity, as approved by the Employer's Representative.
e. A septic tank and leach pit shall be constructed to treat any sanitary waste generated at the WTP site.
f. The existing compound shall be suitably extended to cover the proposed WTP. The compound around WTP shall be provided of 2.2 m height. A coiled barbed wire 400 mm in height shall be fixed to the top of the boundary wall. The boundary wall shall conform to the requirements of relevant standard.
i. Finished ground level of WTP campus shall be 1m or more above high water level and finished Ground level shall be get approve from the Employer.
j. Minimum grade of RCC for Liquid retaining structure – M30,
Minimum grade of RCC for Buildings and structure – M20,
Minimum grade of PCC for Liquid retaining structure – M20,
Minimum grade of PCC for Buildings and structure – M15.

539. This is applicable for other units, unless otherwise specified.

540. Technical specifications of different components of the Water Treatment Plant are as given below.

h. Pre-Settling Tank

541. The existing pre-settling tank shall be used during high turbidity period. Suitable by pass shall be provided to pass the flow from the existing pre-settling tank to WTP during low turbidity. When settling tank is used, the settled water pumping is required to convey the settled water to inlet of WTP.

542. The Sump well shall be designed for low inlet detention period (Ultimate stage). The pumping machinery shall be designed for Intermediate stage flow.

543. **Pre-Settling Tank Pump House:** The Pre-Settling Tank Pump House structure shall be designed and constructed to meet the capacity requirements of ultimate requirement. The individual pumps shall only be installed to accommodate the intermediate stage capacity in this project and the capacityof the pumps will be altered to increase the flow capacity in the ultimate stage of the project.

544. The civil works required at the pre-settling pump house structure shall include, but not be limited to:

i. The Contractor shall make necessary geotechnical investigations for substrata at the proposed location for the pump house and reservoir for the design of the foundations.
ii. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.
iii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.
iv. The clear ceiling height of the overall structure shall be at least as tall as required to pull the settled water pumps and accommodate the EOT crane. The Electrical and Control Rooms shall have drop (false) ceilings to maintain a clear ceiling height of 3.6 m.
v. The Pre-Settling Tank Pump House design shall include:

- The pump house building shall be designed in accordance with Subsection (General requirements of Building).
- A double or roll-up type door (Type C) equipment entrance at the end of the pump house, large enough for the pumps and electrical panels to pass through generously. A single door (Type A) shall be adjacent to this equipment door.
- An electric overhead traveling (EOT) crane of adequate capacity to lift out the pumps shall be installed. The crane and pump house floor area shall be designed with adequate space for the EOT crane to be able to lower equipment onto a truck bed.
- A separate electrical switchgear room separated from the pump area shall be provided. The electrical equipment shall be elevated 2500 mm off of the pump floor level to avoid wash down. The electrical room shall have double door leafs (Type E) at the entrance.
- The floor in the pump room area shall be coated with a concrete sealer / hardener (Coating System No. 7) applied at a rate of not less than 4.5 m^2/liter.
- Provide permanent access platforms to service the pump motors. Platforms shall be constructed of steel beams and columns with a GI checker plate walking surface.

- Valves shall be accessible from the pump house floor level. If that are not, operating platforms shall be constructed so the operators are not more than 1.5 m above the floor or walkway level.
- The platforms and walkways shall have a 2 rail system of 1.0 m in height made of galvanized steel tubes of 32 mm diameter (pillars and upper railing) and 25 mm diameter (lower railing). The walkways shall be accessible from the upper floor of the control building and by means of 800 mm wide stairs.
- A separate control room of not less than 20 m^2 floor area for the instrument control panel (ICP) and SCADA interface. The control room shall have a single leaf aluminium entrance door (Type D). The control room shall have an exterior window (Type C) and an interior window into the pump room (Type E). The room shall be air conditioned. The room shall be furnished in accordance with Subsection (General requirements of Building).
- A separate duty room 15 m^2 floor area. The door shall be Type D. The room shall be furnished in accordance with Subsection (General requirements of Building).
- A separate storeroom of not less than 10 m^2 floor area. The door shall be Type D and lockable. The storeroom floor shall have acid resistant tiles installed in a dedicated 4 m^2 area for battery and acid storage. This area shall be curbed in for containment.
- A bathroom furnished in accordance with Subsection (General requirements of Building).
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.
- Windows shall be installed on the 3 exterior walls of the pump house not occupied by the reservoir. Each window shall be Type A.
- Thrust blocking shall be provided at pump discharges and the deadhead end of the pumping header.
- The utility (potable) water pumps shall be installed in the pump room. They may take their suction from the clear water pump suction manifold, or a separate suction manifold can be installed directly into the reservoir.
- A 62 mm diameter drain line shall be installed at the invert of the pumping header. The drain line shall contain a sluice valve at the connection to the header. The pumping header shall be sloped at least 1% in each direction to the low point at the drain connection.
- A first aid kit and a fire extinguisher shall be supplied and mounted in the pump room area.
- A potable water supply service line of at least 25 mm diameter to be provided. The potable water service shall supply drinking water, the toilet facilities and bearing lubrication, if required for the pumps.
- Wash down water shall be obtained from tapping the pumping main header and installing a backflow preventer, service piping, valves and hose bibs as required.
- Ventilation shall be provided near the ceiling level with a mesh for birds protection.

545. The Pre-Settling Pump House shall be divided into rooms as shown in the following schedule:

Table 37: Room Schedule

Room	No.	MinArea Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Pump Room	1	See note 2	7	1 & 3	1--A	4-A
Control Room	1	40	8	1 & 4	F	1-C, 1-E
Duty Room	2	15	8	1 & 4	F	1-C, 1-E
Storeroom + Acid Room	1	12	7[3]	1 & 3	G	None
Bathroom	1	6	5	5	F	None
Electrical Room	1	TBD	1 & 3	G	G	None

Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works

1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
2. The remaining area of the pump house shall be the pump room
3. Acid resistant tiles shall be installed in a 2 m^2 area
4. To be determined by the Contractor
5. Refer Painting Schedule

i. Cascade Aerator

546. The unit shall provide for removing undesirable smell and odour if any and possibly Iron content. The unit shall be capable for flow of requirement of ultimate stage requirement . The Contractor is free to decide on the type of cascading, giving due consideration to 1) total head loss of the unit, 2) operation point of view and 3) available area. The work shall be of reinforced concrete.

547. The freeboard, in outlet launder shall be at least 50 cm. The unit shall be connected to the drainage system by means of a wall duct and a gate valve of minimum DN 200.

548. The aerator provided shall comprise a series of circular concentric falls of 0.3 m at every level with a perimeter collecting channel. Raw water shall be discharged from the inlet pipe to the centre of the structure.

549. The Contractor shall ensure that the head loss across the aerator is such that the design flow can be maintained through the works based on the initial and final hydraulic levels provided for the Works.

550. Pre chlorination shall be done downstream of the aerator and is described later in this section.

551. The outlet flow from the aerator shall be measured by a parshall flume with proper clear distance of at least ten times the throat width on the upstream for steady state of flow and at least five times the throat width downstream of channel and fitted with an ultra-sonic level measuring device to provide local and remote read out of the flow into the plant.

552. The cascade aerator is proposed to be bypassed from the process when pre-settling tank is in operation.

Design Criteria

Rated Flow Capacity	:	Corresponding to Ultimate stage
Space requirement	:	0.03$m^2/m^3/h$
No. of Unit	:	1 No.

Tip Level of Inlet Shaft : 52.00 m (Indicative)

j. Raw Water Measuring Channel and Flume

553. Water from cascade aerator will be further lead to raw water channel. The raw water inlet flow will be measured in the open channel by means of a Parshallflume. An open channel flow measuring system comprising of ultrasonic type level sensor, indicating type flow computer cum transmitter unit, digital flow indicator cum integrator and Lightning Protection Units (LPUs) shall be provided. The flume shall be designed according to the IS 6063 amended upto date. The top of the channel shall be made accessible by a lateral walkway along the channel. The freeboard shall be at least 30 cm design flow. The Parshall flume shall be provided for measurement of flows.

Design Criteria

Rated Flow Capacity - Ultimate stage		Corresponding to maximum flow requirement of (including 20% overload)
Head loss in flume	-	≤ 0.7 m

554. On line water quality analyzers shall be provided for continuous monitoring of pH and turbidity values of the raw water. The signals from these analyzers shall be connected to the PLC system for remote monitoring and control.

k. Main Distribution Chamber

555. The main distribution chamber shall be of reinforced concrete construction. The inlet and the outlets of the distribution chambers shall be designed to provide Ultimate stage flow distribution by adjustable weirs. The freeboard shall be 50 cm.

556. The outlets of the Distribution Chamber shall lead to the clarifier distribution channels and shall be provided with electrically operated sluice valves on the outlet pipe from Flash Mixer. The top of the distribution chamber shall be made accessible by the general walkway along the measuring channel. Chamber shall be provided with washout arrangement of 200 mm dia pipeline.

Design Criteria

Design Flow	:	Corresponding to requirement of Ultimate stage
Detention Time	:	30 sec. minimum
Sluice Gates	:	Adequately sized

l. Flash Mixing Unit

557. The raw water channels will deliver water to flash mixing chambers. The mixing chambers shall be of reinforced concrete. The freeboard shall be at least 30 cm.

558. The alum and flocculant (food quality non-toxic polymer) will be injected prior to flash mixing tank with feeder pipes.

559. The chlorine solution (for pre-chlorination) shall be injected by bottom mounted diffuser disks or pipes of CPVC minimum 10 bar rating or another suitable material. The diffuser system installed in the chamber shall be designed to guide the incoming water and to ensure a complete diffusion of the chlorine solution before it leaves the chamber. The

chlorine solution-feeding unit must be detachable for easy maintenance without interrupting the flow. There shall be no smell of chlorine at a distance of 10 m from the chamber.

560. The Contractor is free to decide on number of mixing chambers preferred 4 Nos. for Intermediate stage and 2 Nos. for ultimate stage. Each mixing chamber should correspond to a stipulated number of clarifiers it feeds. The outlet from mixing chamber should then go to a corresponding clarifier distribution chamber for distribution of flow to the corresponding clarifiers. The outlet velocity for flash mixture shall be less than 1.8 m/s and shall be greater than 0.8 m/s.

561. Each mixing chamber shall be equipped with an impeller type, high-speed mixer. The driving motor of suitable capacity and other accessories shall be totally enclosed but easily accessible for maintenance. The shaft with the impeller shall be freely suspended from the driving gear mounted on a platform on top of the chamber. No thrust or guide bearing shall be located below the liquid level. The shaft of the mixer and the impeller shall be of stainless steel SS-316.

562. The top of the mixing unit shall be made accessible by the general walkway along the measuring channel. Each chamber shall be connected to the drainage system by means of a wall duct and a gate valve of minimum DN 100.

563. Flash mixing device shall be designed according to the IS 7090, 1985(amended upto date).

Design Criteria

Rated Flow Capacity	:	Corresponding to requirement of intermediate stage requirement
No. of units	:	4 for intermediate stage
	:	2 additional for ultimate stage
Detention Period	:	At least 45 s
Mixing Energy (G value)	:	At least 500 to 800 s^{-1}
Type of Mixer	:	High speed turbine type (SS 316)316
Gear Efficiency	:	85%
Mixer Speed	:	100 rpm (max)

564. Mechanical arrangement will be for intermediate stage, with provision for augmentation as per requirement of ultimate stage, without any interference in operation of running plant. Scope of civil structure will be for ultimate stage requirement

m. Flocculation unit

565. Flow splitting shall take place between the flash mixers and two rows of flocculators and clarifiers between them. Flow splitting shall be carried out using weirs or other hydraulic arrangements where equal flows are produced by equalizing hydraulic losses.

566. The clarifiers shall be rectangular shape Inclined Plate/Tube type with bottom slopes. It shall be possible to manually isolate each flocculator-clarifier unit from service for cleaning, maintenance, etc.

567. One possible arrangement could comprise two rows of flocculator units and the associated Inclined Plate/Tube Clarifier units fed by a central inlet channel.

568. Flocculation basin with mechanical flocculation shall be provided. For each clarifier two nos of flocculator are provided.

569. Mixing strength for mechanical type of the flocculation basins shall be adjustable and they shall be designed to prevent short circuiting flow patterns. Retention time of at least 20 minutes.

570. Mixing strength of flocculation, G-value shall be in the range of 40 to 50 sec^{-1} and GT value shall be not less than 48,000.

571. The Flocculators shall have stirring arrangement capable of stirring the water to promote formation of flocs for efficient sedimentation.

572. Uniform distribution of flocculated water to the clarifier process shall be provided. Aconcrete diffusion wall shall be provided to separate flocculation basin from the clarifier. Each diffusion baffle wall shall have circular ports of adequate size. Sludge removal system from flocculation basin shall be provided.

n. Mechanical Type Flocculation Basin

573. Mechanical flocculator shall be either vertical or horizontal rotating flocculator. Other types of flocculator shall not be used. The design of the flocculation basin with mechanical flocculators shall take the following provisions:

- Providing perforated or baffle type partition wall between compartments to prevent short circuiting flow patterns.
- Providing means for easy removing of settlement in compartment of flocculation basin.
- Flocculators shall be designed to produce a tapered mixing effect toward the effluent end of the flocculation basin.
- The flocculator shall be designed to transmit energy to the water (a velocity gradient, G s^{-1}).
- Mixing energy shall be designed adjustable.
- The vertical type flocculators shall be placed in equal distance and so arranged that distance between flocculators shall be not more than two (2) times of the width of each flocculator compartment.
- The horizontal type flocculator shall be straight line shaft with paddles mounted type and arranged transverse to the flow in each compartment. Paddle diameter shall be greater than 80% of width of each compartment and paddle length shall be less than 3.5 meter. A total area of paddles shall be approximately 10% of sectional area of the flow.

574. Contractor shall follow IS 7208: 1992 Flocculation devises Guidelines.

Design Criteria

Rated Flow Capacity	:	Corresponding to requirement of intermediate stage
Detention Period	:	At least 20 min
Mixing Energy (G value)	:	40 to 50 s-1

575. Provision should be kept for augmentation as per requirement of ultimate stage, without any interference in operation of running plant of intermediate stageI. No. of units 4 for intermediate stage and additional 2 for ultimate stage

o. Clarifier – Plate Settler clarifier

576. Each clarifier shall include, flocculation basin, rectangular vertical flow clarifier having inlet and outlet stilling zone with sloping plates, mechanical sludge collectors, sludge removal valves and piping, with air scouring system for cleaning plates.

577. Surface loading rate shall be not greater than 1 $m^3/m^2/h$.

i. Minimum Technical Requirement

- The flocculation tank and plate settler clarifier are one, built integral with each other
- The clarifiers are rectangular RCC construction, with two perfect squares so that it is possible to provide the bottom with circular configuration, for providing two sludge scraper mechanisms in each clarifier. Clarifiers shall be provided with bottom slope 1:12
- Installation angle of settling plates shall be proposed, not less than 55° with horizontal.
- Special exercise shall be taken to avoid short circuit flow, not passing through sloping plate or tube module.
- Each module of lamella settling plates shall be designed and manufactured appropriate size so as to be installed and maintained easily. It should be possible to take out each plate individually for cleaning and maintenance process
- Each module shall be firmly fixed each other by means of fixture, clip and others.
- All modules shall be suspended from beam and/or supported by support brackets, beams and others. Means shall be provided for easy installation and assembly and disassembly of modules.
- Material of the plate shall stainless steel (SS 304) or materials suitable for service required and approved by the Employer.
- Materials to be used for sloping plate or tube shall be non-toxic material and suitable for drinking water service. The Contractor, if so requested, shall submit evidence which state material suitable for drinking water service.
- Module shall be designed to take load of walking man during cleaning.
- Minimum thickness for plate should be 1.0mm
- Material should be UV-rays protected.
- Any other types of the plates having any fins and other projections will not be accepted.
- All submerged support beams on which the module will be installed shall be of pre-cast concrete. Beams which will be located above water level shall be either structural steel beam or pre-cast concrete beam.
- All support beams and brackets, fixtures and clips, and other to be used for installation of sloping plates which are submerged or may contact with water shall be type 304 stainless steel.
- All support beams which will be located above water level shall be structural steel beam and/or pre-cast concrete beam.
- Spaces between sloping plate modules and the walls of clarifier shall be completely sealed.
- Fixed sludge concentration hoppers in the center and/or side of the clarifier and fixed sludge concentration hoppers in the bottom of the clarifier shall be provided.
- The mechanical sludge collectors shall be designed to sweep sludge accumulated on the entire area of bottom of the clarifier.
- All sludge extraction piping under the water level and wall pipes passing through concrete walls shall be flanged stainless steel pipe Type 304

schedule 20S. Sludge extraction valves and guard valves for sludge extraction shall be pneumatically operated plug valves and manually operated gate valves, OS & Y respectively. Mean shall be provided with fail safe system and auto skipping system for sludge extraction.

- Weir loading of clarified water collection shall not exceed 200 m^3/d/m.
- Spacing between plates 50 mm to 80mm.

Design Criteria

Rated Flow Capacity	Corresponding to requirement of Intermediate stage
Minimum number of units to be provided	
Intermediate stage	4
The velocity in inlet shaft in clarifier	less than the velocity in outlet of flocculator
The velocity in launders	< 1.0 m/s
Minimum free fall from outlet weir to clear water channel in filter	20 cm
Velocity in pure water channel	1.0 to 1.5 m/s

578. An ultrasonic level measurement system comprising of level sensor, indicating type transmitter, digital panel meter and lightning protection units shall be provided at the clarified outlet feed to Filters. The signal from the level transmitter shall be connected to the PLC system for remote monitoring on the local SCADA system.

579. Provision of walkway (Access) for inspection to be made for all important units i.e. raw water inlet channel, Flash mixtures, Flocculators, clarifiers, location of all gates, valves etc. from the clarifier. The width of walkways shall be 1200 with Kota stone flooring. M.S. railing of 1.0 m in height made of galvanized steel tubes of 32 mm diameter (pillars and upper railing) and 25 mm diameter (lower railing) of approved design shall also to be provided. All walkways shall be connected with Ladder with M.S. railing of approved design & specification.

p. Rapid Sand Filters (Filter House)

580. The clarified water shall be brought into a common inlet channel leading to one or more bank of filters as per the layout arrangement decided by the Contractor, with approval from Employers representative.

581. The filters shall be rapid gravity, constant head, constant rate sand filters. About 9 nos of filter units shall be provided. The filters shall be designed so as to have a minimum runtime of 24 hrs. The filter banks shall be arranged on either side of a central access gallery. The gallery shall house the filter outlet channel, the backwash and air scour pipe work mains and outlet, backwash and air scour valvegear. The gallery shall have a minimum width of 10.0 metre and shall permit free access of personnel to observe the operation and maintenance of the valve gear and pipe work. The gallery shall be adequately ventilated and lighted.

582. The filter floor shall provide access to the filter installation and shall permit the observation of the water surface in each filter and to allow maintenance and necessary manual operation of the inlet and wash water outlet penstocks. Hand railing of stainless steel 304 shall be provided around each filter. The filter installation shall be completely covered by a shell type roof without walls on gallery side and on the clarifier side.

583. The backwash pumps, backwash air blowers and associated plant shall be located in a plant room area at any one end of the filter installation.

584. The filter building shall be provided with a control room for the plant. This shall be located on the filter floor in such a manner as to provide a clear view over the filter floor. It shall house the central HMI described elsewhere. The filters and associated superstructure shall be of reinforced concrete construction.

585. The filter power and control panel shall be located in an area accessible to the operator for effective and efficient operation of the plant. Filter washing consoles shall be located on the filter floor overlooking each filter pond.

586. An overflow shall be provided from the common inlet channel which shall discharge into the backwash water channel. The outlet of each filter shall be fitted with a means of automatically limiting the flow rate immediately after backwash to a value which will not cause an unacceptable reduction in filtrate quality at the start of the run when the filter is clean. Each filter shall be fitted with a head loss indicator ultrasonic digital type. Each filter shall be fitted with a minimum 250 mm diameter drain gate valve to allow complete emptying of the filter.The filters shall be equipped with inlet and wash water outlet penstocks, and with outlet, backwash and air scour butterfly valves all electrically operated. The filters shall be designed for backwash by simultaneous air scour and water wash.

587. The Contractor shall decide the exact dimensions and layout of the filters, and the design of the filter floors and under drains based on the design criteria and shall have approval of Employers representative.

588. Rapid Sand Gravity filter shall be proposed. The Filter House structure shall be designed and constructed in RCC structure. The individual filter cells will only be constructed to accommodate the Phase 1 capacity in this project.

589. The Filter House shall preferably be a single story or multi storied structure designed to accommodate the following equipment and ancillary items:

a. Backwash Water Pumps (Provided in Clear Water Pumping Station) and piping system
b. Backwash Air Blowers and air piping system
c. Electrical Equipment in a separate room
d. Control Room
e. Bathroom (1)
f. Storage in a separate room
g. Stairway
h. Pipe gallery
i. Preferably with (800 m3 or as per design) elevated over head Back Wash Water Tank

590. Suitable floor height shall be provided.

591. The civil works of the building shall include:

i. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.
ii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.

iii. The clear ceiling height of the overall structure shall be at least as tall as the ceiling of the filter operations gallery. The Electrical and Control Rooms shall have drop (false) ceilings to maintain a clear ceiling height of 3.6 m.

a. The Filter House design shall include:

- The building shall be designed in accordance as per requirements of the Standard Specifications.
- Providing internal and external lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.
- A first aid kit shall be provided and mounted in each of the following areas:
  - Blower Room (1)
  - Control/ Duty Room (1)
- A fire extinguisher shall be supplied and mounted in each of the following areas:
  - Electrical Room (1)
- A potable water supply service consisting of a 500 liter HDPE roof tank shall be furnished. The potable water service shall supply drinking water and the toilet facilities. The roof tank shall be filled from the utility water pumps, through a 38 mm diameter pipeline. A float switch shall signal to close of a solenoid valve in the pipeline when the roof tank is full. A low level float switch in the tank shall signal the solenoid valve to open to fill the roof tank.
- Building drainage shall be conveyed to the septic tank / leach pit site. .
- The Filter House floor shall be finished with 450mm x 450 mm x 20mm thick Kota stone tiles.
- Proper ventilation at the pipe gallery area shall be provided
- All filter beds& valves, Back wash system, Blowers etc. shall be operated through control consol installed on floor of filter house
- Back Wash Tank may be constructed over the roof of Filter House to reduce cost for construction separate reservoir at alternative location as shown in GA drawing.

b. Room Schedule

592. The Filter House shall accommodate rooms as shown in the following schedule:

Table 38: Schedule of Filter House

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring[5]	Walls[5]	Doors	Windows
Pump Room	1	TBD[4]	7	1 & 3	1-C, 2-A	4-A
Control/ Duty Room	1	TBD[4]	8	1 & 4	F	1-C, 1-E
Storeroom	1	TBD[4]	7[3]	1 & 3	G	None
Bathroom	1	6	5	5	F	None
Electrical Room	1	TBD[4]	1 & 3	G	G	None

Notes: For Coating System or type refer clause 1355 of Specification Civil, Building and Road works

1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
2. The remaining area of the filter house shall be the pump room

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring[5]	Walls[5]	Doors	Windows
[3.] Acid resistant tiles shall be installed in a 2 m^2 area [4.] To be determined by the Contractor [5.] Refer Painting Schedule						

593. The Contractor shall design the filters on the basis of constant rate principle. RCC roofing shall be provided for the filter beds.

c. Filter beds and inlet channels:

594. The filter beds shall be supplied clarified water from secondary channels through a main channel coming from the clarifiers. The filters shall be of the constant rate type. All filters shall be identical in internal dimensions. The top level of the filters is the same as that of the feeding channels to avoid overflow in the filter area.

595. In constant rate filters, the constant rate shall be achieved by having the inlet valve and weir above the maximum water level in filter or through a simple device like a Siphon with a level sensing device.

596. The filter inlet valve shall be above water level for constant rate filter.

d. Filter Media

597. Filtration shall be by gravity, downwards through a bed of filter sand supported by a layer of suitably graded filter gravel. The filter sand shall consist of hard, durable grains of silica and shall have a specific gravity of not less than 2.5. All grains of sand shall be preferably water- worn. The filter gravel shall consist of hard; preferably rounded stones with an average specific gravity not less than 2.5, shall be free from clay, sand, loam and organic impurities of any kind and shall not disintegrate with the action of water and backwashing. The supporting media depths shall be such as to ensure adequate and uniform distribution of wash water and air after leaving the orifices with the minimum risk of mixing sand with the gravel of the supporting media.

598. The filter media (sand and gravel) shall conform to IS: 8419 (Part I) amended up to date. Filter sand when immersed in 40% hydrochloric acid for 24 hours, the soluble matter shall not be more than 5% by weight. It shall not contain more than 1.5% of calcium and magnesium calculated as $CaCO_3$. Ignition loss should not exceed 0.7% of the weight. The solubility of supporting gravel in 40% hydrochloric acid after 24 hours shall not exceed 10% for 10 mm or larger size gravel and 5% for smaller than 10 mm size.

599. All filter media shall be packed in polythene bags. Suitable care should be taken to protect the media from spillage or contamination. Storage on site shall only be in an approved area, well drained and free of mud and silt. The filter media shall be carefully placed in the filter beds and shall not be dropped or dumped or machine handled so as to be detrimental to the floor media, nozzles or sealant, etc.

600. It shall be deemed that the Contractor has investigated all potential sources and verified that sufficient quantities of satisfactory filter sand can be obtained, packed and stored on site. Dual media filters shall not be acceptable.

e. Under drainage System

601. The Contractor shall be responsible for the detailed design of the filter floor and underdrains. The filters shall be designed for backwashing by the simultaneous use of air scour and washwater.

602. A filter false bottom floor with nozzles to be provided for under drains and contain polypropylene nozzles of reputed and approved make. The under drain system shall be designed to provide uniform draw-off of filtered water and uniform distribution of wash water and air over the whole area of the filter. Particular provisions have to be made for the handling of the high air velocities at the inlet zone of the manifold.

f. The nozzles shall:

- incorporate separate air and water entrances**;**
- be set at an exactly uniform level;
- be capable of replacement;
- be designed to avoid ingress of sand
- purge valve

603. Before filling the supporting layers and the sand of the filter beds the whole under-drains system shall be thoroughly cleaned and tested for equal distribution of water and horizontally to the floor.

604. The water conveying system of pipes or channels connected to the floor are free from any debris, concrete, sand or other material which could otherwise block or partially block nozzles.

605. The Contractor shall remove any debris before he commissions laying of filter floors or laterals and shall remove unwanted materials, which could block the filters until the O&M period.

606. Each filter shall have central and lateral wash water troughs that shall be connected with adequate slope to the wash water outlet to prevent deposits of silt. They shall allow an equal withdrawal of the wash water during backwashing the filter. However suspended troughs for wash water removal shall not be accepted. The filter backwash water shall ultimately be discharged to back wash waste water holding tanks for recycle OR directly discharge to river.

607. In case of constant rate filters, the filters shall be backwashed when the level in the filters rises to a preset high level or the preset differential pressure level

608. Dual Media filters shall not be acceptable.

609. The filter house shall be built in RCC. Filter gallery shall be provided with RCC roof. Roofing shall be provided for the filters. The filter gallery shall have a minimum width of 7m.

Table 39: Design Criteria

Filters:

	Design Flow	As per requirement of intermeidate stage As per requirement of ultimate stage
	Filtration rate	≤ 5.0 $m^3/m^2/h$
	Water column	1.2 m minimum
	Free board	Minimum 600 mm
Filter media:		
	Depth of sand bed	At least 750 mm
	Effective size of sand particles	0.45 to 0.65 mm
	Uniformity coefficient of sand	1.3 to 1.7
	Graded Gravel (6 to 50 mm)	At least 500 mm
	Minimum number of filter units with two halves (twin bed filter)	
	Phase-I	6 numbers
	Phase-II	Additional 3 numbers
Velocity of water inlet to filter		<1.0 m/s
Velocity in inlet to wash water		2.4 to 3.5 m/s
Velocity in outlet of wash water		1.2 to 1.8 m/s
Velocity in outlet of filter water		0.9 to 1.8

g. **Filter operating platform and pipe gallery**:

610. Filter operating platform shall be provided at the freeboard level of filter beds for inspection/observation and control of filter operation from the platform. Access stair shall be provided for access to pipe gallery for accommodating wash water pipeline, Air wash pipeline, wash water pipeline and rate of flow controls, outlet chambers and other appurtenances such as filter head loss indicator. The valves and control shall be operated from the operating platform.

611. Minimum guaranteed filter run shall be at least 24 h under all conditions. Each filter shall be provided with necessary electrically operated butterfly valves having control through PLC and push buttons provided on the filter-operating console. The valves shall have the provisions for manual operation also from the pipe gallery in case of problems with the drive. The following electric motor operated valves/gates shall be provided.

- Filtered water outlet (electric)
- Backwash water inlet (electric)
- Air inlet (electric) Sludge water outlet (electric)
- Inlet gate (electric)
- Drainage of the filter (manual)

612. The valves shall be installed on pipe branches coming out of the filter box. These outlet and inlet pipes shall be provided with proper wall puddles and shall be leak proof.

613. In line full bore electromagnetic flow meter with 4-20 mA signal output, flow transmitter with local and remote display with totalizer shall be installed in the backwash water pipe coming from the tank. It shall be located in a horizontal stretch with required straight lengths on both up- and down- stream sides. There shall be a locking arrangement for regulation valve that can be locked after adjustment of rate of back wash water flow. The flow (m^3/h) shall be transmitted to adequate number of wall mounted digital indicator of suitable sizes so that the flow reading is visible and readable from each filter-operating console. Analogue signal multipliers should be provided for multiplying the signal from the flow computer cum transmitter unit for connection to the PLC based ICP and digital flow meters.

614. The electrically driven valves and the inlet gates shall be operated from individual control consoles positioned adjacent to each filter onthe operation gallery with visibility to the respective filter bed. These consoles shall allow for the following control functions (C) and indicators (I):
The filter beds shall be inside the filter house and not in open air.

h. Filter Controls

615. For operation of the inlet gate and the valves (open/closed/intermediate position).

616. For operation of the air blowers (on, off, failure).

i. I**ndication**

617. Status of the gate and the valves (open, closed, intermediate, motor failure)

618. Signal lamp with acoustic signal if the water level in filter bed has reached the top level and the backwash cycle has to be started for constant rate filters.

619. The washing cycle of the filter shall be controlled manually, step by step, or automatically. The duration of the cycle has to be prescribed by the Contractor. Before backwashing, the filter water level has to be lowered to its minimum by filtering the water and keeping the inlet valve closed in order to avoid wastage. The above provisions for monitoring and controls shall be through SCADA system. Contractor shall quote for both the options/systems as per process requirements

620. The pipe gallery shall have the following piping arrangement:
- Backwash water pipe with connection to each filter
- Air pipe with connection to each filter

621. A weir at inlet and outlet to all filters shall be provided as per provision in CPHEEO for constant rate of filtration or rate of flow controller at filter outlet line shall be provided.

622. The dirty wash water outlet and the drain outlet shall be directly draining into an open channel by side of all the filters. This channel shall lead to a chamber that is connected to the pipe leading to the waste backwash water holding tank for further disposal.

623. In the pipe gallery easy access to all valves and drives, cables etc. has to be ensured. If required, walkways and ladders shall be provided.

j. Arrangement for Backwashing of the filters

624. The control logic for the back wash water system for filter beds shall be as follows:

625. A three-position selector switch 'Auto/ Semi auto/ Manual' shall be provided on the ICP-A located in the control room for selection of the mode of operation of filter beds. The ‘auto’ and ‘semi-auto’ modes of operation shall be PLC based.

626. In auto mode, backwash operation sequence shall start automatically under either of the following condition as selected:
- Fixed interval of time (0-60) hours adjustable from MMI
- Differential pressure across filter bed very high

627. A Differential Pressure (DP) transmitter shall be provided across each filter bed for measuring the head loss across each filter bed. The DP signal shall be displayed on the filter consoles and shall also be connected to PLC-A for remote monitoring and control.

628. In the semi-auto mode, backwash sequence shall be carried out through a backwash start push button provided on each filter console.

629. In the manual mode, the backwash sequence shall be carried out through open/ close push buttons provided on the filter consoles located near the filter beds.

630. PC based operator station/ MMI and a printer shall be provided near the Instrument Control Panel. The time for various steps in backwashing shall be adjustable from this MMI. All the time setting shall be adjustable from this MMI. The MMI shall also be used for programming the PLC system.

631. After the various backwash operations are carried out for the programmed time, the filter beds shall come into operation automatically.

632. During backwash operation if any abnormal condition occurs, then by pressing reset push button the filter beds operation should stop.

633. The filter backwash shall generally include following sequence:

- Stop inlet
- Stop outlet
- Drain down
- Air scouring
- Backwashing
- Rinsing
- Service

634. The filters shall be backwashed with water and air according to the prescribed cycle as designed. Therefore, the following capacity requirements are only tentative. One full filter unit(i.e. the twin filters bed) shall be backwashed at the same time (simultaneously) to reduce down time of filters.

635. The water shall be delivered from a backwash water tank providing the required volume and head. The backwash tank shall be filled by pumps, which will take the water from the clear water reservoir.

636. The backwash water lifting pumps shall be installed clear water reservoir at clear water pumping station.

k. Backwash water pumps

637. The Contractor shall provide vertical turbine pumps (1W+1S) for first phase for operating on 415 V, 50 Hz frequency supply. The system shall be complete with suction pipe from the clear water reservoir, sluice valve in the suction, delivery pipe with spring loaded non-return valve and sluice-valve. The delivery pipe shall be connected to the back wash tank. The pumps will be designed to fill the full capacity of the tank so that there will be sufficient water for backwashing 2 (two) filter units (of twin bed each) at a time. The system shall include the following:

- Pipes and electrically operated butterfly valves for the suction and delivery pipes;
- Pressure gauges with stop cock at the pressure side of the pumps;
- Spring loaded non return valves in the delivery pipes;
- Ultrasonic type water level transmitter and a local Level Gauge for level measurement of the backwash tank;
- Low level /high level Conductivity level switches for backwash tank to automatically start/stop back wash water pumps;
- Conductivity level switch in the sump for hardwired tripping of the pumps on detection of low-low level;

638. The signal from the level transmitter and level switches shall be connected to PLC-A in control room for remote monitoring. The signals from the level transmitter and the level switches shall be interlocked in the PLC system for backwash operation of filters.

I. Compressors/Blowers

639. Air for scouring shall be provided by positive displacement (Roots) blowers. Three blowers shall installed, one duty, two standbys in a filter house. An acoustic enclosure will be fitted over each air blower to reduce noise. A ring main will convey the air to the filter under floor plenum. Typically, the air scouring rate shall be up to 50 m/h.

640. This 'Roots' type blower will be capable of delivering oil-free air at the specified output pressure and volume. The horizontal inlet and delivery lines shall be sized so that air velocity does not exceed 25 m/s. Blowers shall have the following components but not limited to

- Inlet silencer and filter
- Non-return valve in delivery branch
- Butterfly valves resilient in both inlet and delivery branches
- Pressure relief valve or excess pressure safety device
- Bellows type couplings on inlet and delivery branches.
- Direct Coupling

641. The air blowers shall be installed at an elevation above outside finished ground level. The speed of the blowers shall not exceed 1000 rpm.

642. The delivery pipe work shall be carried to a height above the maximum possible water level in the filters so that, under all circumstances, it is impossible for water to flow back to the blowers. The delivery pipe work and valves shall be sized to limit the air velocity to a maximum of 25 m/s.

643. An electrically actuated air dump valve and flow meter with local indication shall be installed in the pipe work feeding the filters. Each blower shall be fitted with an inlet air silencer and discharge air silencer, pressure relief valve, delivery pressure gauge, delivery isolating valve and non-return valves. The noise emitted from the blower shall not exceed 85 dBA at 1.0 m from the blower. (ISO 10816-1995) The blower unit sizing and design of the blower room with acoustic enclosure shall be made such that the acceptable noise levels are met.

644. The Contractor shall provide compressors (minimum two numbers working and50 % stand by units) along with suitable induction motor coupled suitable for operating on 415 V, 50 Hz frequency supply. The compressors/blowers for the air delivery for scour of the filter

beds have to be provided. Each unit will be provided with a suction air filter and silencer, delivery pressure relief valve, unloading valve, non-return valve and isolation sluice valve. A non-return valve shall be provided on common air main to each battery of filters.

645. The capacity of each blower shall be provided such that it is adequate to backwash one twin bed filter.

646. The air pipe to the filter shall be laid with an apex above the maximum water level of the filters and a vacuum breaker at the point to avoid backflow and siphoning of water in the compressor. The capacity of air piping for backwash shall be provided such that it is adequate to backwash one twin bed filters.

647. Pressure gauges with stop cock at the pressure side of the compressors shall also be provided.

648. The air piping system from the blowers to the filters shall be laid out on the ring main principle. There shall be a provision for the release of air from the system at the end of the scour before backwash commences.

Table 40: Design Criteria

Type of Filter Back-washing	Sequential Air then Water Back wash System	Conjunctive Air and Water Wash System
Configuration	Minimum 1+1 for blower	Minimum 1+1 for pumps
Specific flow rate of free air	36-45 $m^3/m^2/h$	45-50 $m^3/m^2/h$
Vol. of water applied	24-36 $m^3/m^2/h$	12-15 $m^3/m^2/h$
Air pressure at under drain	0.35 kg/cm^2	0.35 kg/cm^2
Speed of Compressor	< 750 rpm	< 750 rpm
Air velocity in pipe and valves	< 20 m/s	< 20 m/s

m. Filter Control Room

649. A filter control room shall be provided including machine room, duty room, control panel etc. in the filter house. The blower room of adequate size shall be provided to house the required numbers of air blowers and backwash pumps. A drainage sump shall be provided at the deepest point of the lower area. The pit is connected to the drainage system leading to the back wash holding tank.

650. The control panel for the units is also installed in that room. The following control functions (C) and indicators (I) shall be provided:

<u>Pumps</u>

a) Controls(at Clear Water Pumping Station)
   - (i) Remote start, stop with manual override
   - (ii) Auto start when backwash tank level middle
   - (iii) Auto stop when backwash tank level high
   - (iv) Auto stop when sump (at filtered water channel) level low
   - (v) Trip in case of failure of the motor

b) Indications
   - (i) On, off, failure (repeat indications at ICP-A)
   - (ii) Voltmeter, ampere meter, operation hours
   - (iii) Low level in the sump
   - (iv) High, middle, low level in the backwash tank
   - (v) Flow of the backwash water coming from the tank

Compressors

a) Controls
   (i) Remote start, stop with manual override
   (ii) Local start, stop
   (iii) Manual start, stop from each filter control console
b) Indications
   (i) On, off, failure (repeat indications at ICP-A)
   (ii) Voltmeter, ammeter, operation hours

651. The status of the backwash pumps and the compressors are also indicated at the main control panel of the treatment plant. The status of the compressors/blowers shall be indicated on the filter control consoles. However the above provisions for monitoring and controls shall be modified suitably if it is decided to go for fully automatic SCADA system. Contractor shall quote for both the options/systems as per process requirements

n. Filter Building Lifting and Handling Equipment

652. The Contractor shall provide a comprehensive system of lifting beams, runways, pulley blocks, trolleys, slings, etc. to permit the removal of pumps, blowers, motors, valves and actuators for maintenance. The Contractor shall provide handling equipment to enable the removal of the aforementioned items from the building and to load it with ease onto a suitable vehicle. The Contractor shall demonstrate to the satisfaction of the Employers representative the lifting and handling equipment and procedures to be adopted in using it to remove equipment from the filter building.

653. The electrically operated lifting/handling equipment and any plant provided shall also facilitate the placing and removal of filter media.

o. Backwash Tank

654. The backwash tank shall be of reinforced concrete. It shall be constructed at WTP site preferably near clear water pump house or at suitable location preferably over the roof of Filter house to optimize the cost and structural stability. The capacity of the tank shall be sufficient to provide for quantity of water required for backwashing of 2 (two) twin bed filter units approx.800 m^3. It will have a minimum free board of 50 cm. The elevation of the tank shall be fixed according to the requirement of the backwash pressure. It shall also provide for the following:

- Filling pipe(inlet to backwash tank)
- Backwash pipe (outlet)
- Gate valve in the outlet pipe
- Overflow pipe to the plant drainage
- Washout with gate valve
- Ultrasonic type level transmitter for continuous level measurement Top level conductivity switch (stop pumps, signal to control panel of pumps)
- Middle level conductivity switch (start pumps, signal to control panel of pumps)
- Adequate water-yes, signal to each filter console
- Low level conductivity switch (signal to filter consoles, backwash impossible)
- Internal wall mounted water level scale or Reflex type local level gauge on the Tank as approved by the Employers representative

655. All pipes passing through the walls of the reservoir shall be provided with suitable pipe ducts so that there shall be no leakage.

656. The tank shall have an access to the roof, a mild steel cover, a galvanized steel ladder for the access to the tank and two mild steel or CI ventilation pipes at least DN 100 with cowls and wire mesh.

p. Chemical House

657. The chemical house shall be designed and constructed for the requirement of Ultimate stage output capacity in one building. Building shall include space for sixty + seven days storage of Alum and thirty + seven days for other chemical (lime) proposed by the Contractor.

658. The chemical house shall be provided for accommodating 3 chemical solution tanks at appropriate level for preparation of alum and lime solution respectively of design size and depth. Paddles and motor with electric panels shall be provided along with weigh machine, lifting machine and pipeline.

659. The chemical house shall have sufficient space for unloading of the chemicals, wide corridors, office space, toilets, shower room and other associated space. The chemical dosing floor shall be used for the 7 days storage of alum and lime. Suitable staircases, platforms, and other associated facilities shall be provided to have clear access to different units. Storage water tank of adequate capacity shall be provided on the roof of the chemical house for supply of requisite quantity of water for smooth operations of different units located in the building. The supply of water to the roof top storage tank shall be made from the net-work of treated water supply system in different buildings within WTP. The minimum requirements are as follows:

- Ground floor; room height not less than 6 m
- Storage space for chemicals (alum, lime, flocculant). The Contractor will calculate required area according the mean dosing rates.
- Staff toilet blocks (Indian) (not less than 6 m^2)
- Lobby, staircase (not less than 35 m^2)
- First floor, room height not less than 4 m
- Alum dosing unit (not less than 32 m^2)
- Lime dosing unit (not less than 32 m^2)
- Devices for dust removal (lime and alum)
- Ventilation system
- Over Head Dosing pipe lines with pipe tray both indoor & out door.

660. The architectural layout of the chemical house shall be functional, adapted to the regional climate conditions and has to give an aesthetic appearance bearing in mind the local environment and culture. It shall be in harmony with the other buildings in proximity and the treatment units.

661. The Chemical House shall be a two story structure. The clear ceiling height of the overall structure shall be at least 4.7 m. The Electrical and Control Rooms shall have drop (false) ceilings to maintain a clear ceiling height of 3.6 m.

662. The following equipment and ancillary items shall be housed in the chemical house:

a. Alum Storage Room with monorail, hoist and trolley
b. Lime Storage Room with monorail, hoist and trolley and weigh scale
c. Alum Dilution and Mixing Tanks
d. Lime Dilution and Mixing Tanks
e. Chemical Solution Pump and Dosing Room

f. Electrical Equipment in a separate room
g. Control Room
h. Duty Room
i. Bathroom (1)
j. Parts Storage in a separate room
k. Poly-Electrolyte solution Tanks with pumps etc.

663. The lime and perhaps alum will be stored and handled in the dry powder form. This will create an environment containing a significant amount of air born dust. The Contractor shall provide an above normal ventilation exhaust rate of 15 air changes per hour in the alum and lime storage and mixing rooms.

664. **The civil works required at the building shall include,**

i. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.
ii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.
iii. The Chemical House design shall include:

- The building shall be designed in accordance with Standard Specifications and subsection (General requirements for Building)
- A double type door (Type B) shall be provided at the entrance for the equipment and electrical panel entry. A single door(Type A) shall be adjacent to this equipment door.
- Valves shall be accessible floor level. If that are not, operating platforms shall be constructed so the operators are not more than 1.5 m above the floor or walkway level.
- The platforms and walkways shall have a 2 rail system of 1.0 m in height made of galvanized steel tubes of 32 mm diameter (pillars and upper railing) and 25 mm diameter (lower railing). The walkways shall be accessible from the upper floor of the control building and by means of 800 mm wide stairs.
- A separate control room for the instrument control panel (ICP) and SCADA interface. The room shall be air conditioned. The room shall be furnished in accordance with the specification given under General requirement of Building i.e. subsection (General requirements of Building).
- A separate duty room. The duty room shall be furnished with:
- 2 sets of lockers of Mark L2
- 1 washbasin, 1 water faucet, 1 mirror and 1 set of towel rails in accordance with Subsection (General requirements for Building)
- 2 wood benches (32 mm thick wood plank not laminate) 500 mm wide by 1,500 mm in length on steel pedestals, located facing the lockers.
- 3 tables of mark T8
- A separate storeroom. The door shall be lockable. The storeroom floor shall have acid resistant tiles installed in a dedicated 2 m2 area for battery and acid storage. This area shall be curbed in for containment.
- A bathroom furnished in accordance with Subsection (General requirements of Building).
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.

- Windows shall be installed on the 3 exterior walls. Each window shall be Type A.
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas. The indoor lighting fixtures shall be 'sealed' and gasketed to prevent the intrusion of airborne dust.
- A first aid kit shall be supplied and mounted in each of the following areas:
  - Duty Room (1)
  - Control Room (1)
- A fire extinguisher shall be supplied and mounted in each of the following areas:
  - Control Room (1)
  - Electrical Room (1)
- A potable water supply service consisting of a 500 liter HDPE roof tank shall be furnished. The potable water service shall supply drinking water and water required for other facilities. The roof tank shall be filled from the utility water service piping, through a 38 mm diameter pipeline. A float switch shall signal to close of a solenoid valve in the pipeline when the roof tank id full. A low level float switch in the tank shall signal the solenoid valve to open to fill the roof tank.
- Sanitary drainage shall be conveyed by gravity to the septic tank
- The Chemical House floors shall be finished with a concrete sealer/hardener (Coating System No. 6), except for the Control Room and the Bathroom.

a. Room Schedule

665. The Chemical House shall be minimum of 225 m^2 floor area.

666. The Chemical House shall be divided into rooms as shown in the following schedule:

Table 41: Chemical House Room

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring[4]	Walls[4]	Doors	Windows
Alum Storage Room and alum mixing area	1	TBD[3]	7	1 & 6	C	None
Lime Storage Room and Lime mixing area	1	TBD[3]	7	1 & 6	C	None
Control Room	1	40	8	1 & 4	F	1-C, 1-E
Duty Room	1	25	8	1 & 6	F	1-C
Storeroom	1	20	7[3]	1 & 3	G	None
Bathroom	1	6	5	5	F	
Electrical Room	1	TBD[3]	7	1 & 3	G	None

Notes: For Coating System or type refer clause 1355 of Specification Civil, Building and Road works

1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
2. Acid resistant tiles shall be installed
3. To be determined by the Contractor
4. Refer Painting Schedule

b. Alum and Lime Solution Dosing tank

667. The alum dosing shall be made by gravity dosing. The solution tanks and dosing devices have to be installed at a level to be in a position to feed into the inlet chamber. Duplicate dosing solution lines with isolation valves shall be provided between the gravity dozers and the dosing point such that dosing of chemical need not be stopped to do maintenance on the solution lines. Isolation and flow regulating valves shall be provided at both the gravity dozers and dosing point ends. The diameter of the pipes in the chemical plant and to the injection points shall be designed and provided as per practice.

668. The regulation for (Intermediate stage and II) dosing shall be made with the adjustable dosing using gravity dosers. The control over dosing rates shall be capable of being exercised from the control room consoles. The solutions shall be conveyed through pipes to the injection points

669. The dosing shall be automatically adjusted based on the quantity of inflow of raw water to WTP as described below:

i. The signal from WTP inlet raw water flow meter shall be connected to the dosing system PLC –B.
ii. An electromagnetic flow meter shall be provided on each line of the gravity dosing system. The flow rate readings shall be available on PLC and SCADA System.
iii. A control valve having SS 316 body and SS 316 Trim shall be provided on each line of the gravity dosing system.
iv. Look-up tables shall be provided in the PLC – B for the flow of liquid alum proportional to various flow rates of Raw Water Inflow, at different values of Inlet Turbidity.
v. From the operator station of the local SCADA system, the operator shall select the suitable flow table to suit the inlet turbidity and switch to the automatic operation of the dosing system. (this operation will be required occasionally to cater to change of turbidity in various seasons).
vi. Based on the appropriate values of RW inflow in the pre-programmed tables, the set point of the alum dosing flow will be selected by the PLC System and the alum flow rate shall be controlled automatically by adjusting the control valve position.
vii. When the raw water inflow changes to a different value, the PLC will adjust the set point of the alum dosing flow as per the values in the look-up table and adjust the control valve position so as to achieve the alum dosing flow at the required value.
viii. Optionally the operator shall be able to remotely adjust the control valve position from the operator station of the SCADA system so as to achieve the desired flow rate of alum dosing.

c. Tanks and Agitators

670. Minimum 3 numbers of alum solution tanks (2W+1S) and 3 numbers of lime solution tanks (2W+1S) having minimum capacity for 8h of operation each for 5% of alum solution shall be provided. The tanks shall be of reinforced concrete lined internally with adequate thickness of FRP to resist corrosion by the chemical solution. There shall be suitable platforms on top of the tank for mounting of the agitators. Another platform or walkway shall be provided along the front of the tanks for easy inspection and maintenance. Strainer troughs of stainless steel 316 shall be provided for the dissolution of alum bricks. The

sprinkler pipes above the strainers. The freeboard shall be at least 30 cm. The Contractor shall provide the means to check the concentration of the alum solution.

671. Each alum solution-mixing unit shall be provided with electrically driven paddle type agitators. The driving motor of suitable capacity including reduction gear and other accessories shall be provided for rotating the agitator at a speed between 30 to 50 rpm. The fan cooled driving motor and reduction gear shall be totally enclosed but easily accessible for maintenance. The sweep area of paddle shall cover a minimum of 25% of the tank area. The shaft shall be freely suspended from the driving gear mounted on top of the tank. No thrust or guide bearing shall be located below the liquid level. The shaft of the agitator, the speed reduction gear of the motor and the paddles shall be of stainless steel-316.

672. Each alum tank shall be provided stainless steel 316 float operated (tilt type) level switches for detection of low, low-low and high level signals. An aluminium level indicator (epoxy coated) shall be provided on each tank for local monitoring of level.

673. For preparation of polymer solution the package type solution system is recommended for ease of operation of polymer solution. Dosage of polymer to the point application will be by gravity pipeline arrangement shall be provided for that.

d. Pipes and valves in the Dosing Plant

674. The pipes, fittings and valves shall be such that any of the alum / lime tanks can be used individually with any of the metering devices. The tanks shall be filled from the process water pipe system. Each tank shall have an outlet with strainer to the dosing unit, an outlet for complete drainage and an overflow. The service outlet shall be at least 20 cm above the bottom level of the tank. The entire piping and the fittings shall be in SS 316 Sch 80 rating or of material suitable for the respective service, of suitable diameter. All valves for solution delivery up to the injection point and for wastewater from the tank shall be rubber lined diaphragm valves.

675. The solution pipe between the solution tank and the dosing device as well as the pipe from the dosing device to the injection point shall be of SS 316 Sch 80 or of material suitable for the respective service, of suitable diameter. They shall be connected to the process water circuit so that a rinsing of the pipes between the solution tank and the dosing unit and downstream the dosing unit is possible after each stop of the plant. The valves in the solution pipes shall be installed accordingly.Chemical store shall have chemical resistant tiling from inside for walls.

676. The washout pipe shall be connected to the drainage system.

e. Solution pipes to the injection point

677. The solution pipes to the injection point in the inlet chamber shall be of SS 316 Sch 80 or of material suitable for the respective service, of suitable diameter. They shall be laid on pipe racks or trays to be fixed to walls of tanks and buildings or in covered pipe channels so that they are always accessible. They shall not be exposed to direct sunlight. The chemical pipes shall be fixed and jointed in such way that individual runs can be changed without dismantling adjacent pipes. No individual pipe run shall be longer than 5 m. The pipe diameters must correspond to the hydraulic parameters between the chemical house and the injection point.

678. Duplicate dosing lines with isolation valves have to be provided between the gravity dozers and the dosing point.

679. There shall be washouts at suitable points of the chemical pipelines at distances not exceeding 30m. The pipes shall be clearly identified throughout the whole run as chemical pipe for alum/lime by means of plates every 20 m and by the colour code, which is used, on the display screen.

f. Alum and Lime solution feeder

680. There shall be at least 3 (2W+1S) dozers both of Alum and Lime. Gravity dozers are preferable.

681. They shall be connected to all the tanks such that they can be operated individually from each tank. They shall feed into the dosing line leading to the injection point. Motorized valves shall be provided on the outlet lines for starting or stopping the dosing by remote commands from the control panel. The dosing devices and their components shall be fabricated of (stainless steel 304), the tank made of FRP may be accepted.

g. Handling of alum bricks

682. Contractor shall provide lifting system to bring the bricks from the ground floor to the strainer troughs in the solution tanks.

683. Electrically operated monorail hoist with trolley, with loading platform/bucket, traveling from above a hole in the floor minimum (1.2 x 1.2 m, with 1.0 m railing) to the strainer trays in the solution tanks; the hoist should cover the area of lime dosing too; a curved beam shall be provided if required; capacity of the hoist shall be 1000 kg. The hoist shall have an automatic brake in case of power failure.

684. Manual operating system shall be provided as standby.

685. Two trolleys for the transportation of the alum bricks to the loading platform of the hoist at the chemicals store at the ground floor; capacity 250 kg. One platform weighing machine for the alum bricks; capacity 500 kg.Stacking of chemicals shall be done on first floor, if sufficient space for chemical building is not available.

h. Operation and Control of Alum/ Primary Coagulant Dosing Unit

686. Alum and lime feed will be controlled by PLC in the chemical building ICP. A dosage of each chemical will be selected by operation staff based upon their jar testing to optimize flocculation. The chemical feed rates required will be calculated based by PLC based upon measured raw water flow and concentration of chemical in tank, entered by operation staff. The values of dry chemical and water added to tank will be entered by operation staff at PLC MMI.

687. The operation of the alum dosing unit shall be as under:

Table 42: Operation and Control of the Alum Dosing Unit

Operation	Activity
Filling of solution tanks	Manual Alum bricks: with electric hoist
Stirrers of the solution tanks	Manual Automatic at intervals according to timer settings
Operation of the gravity dozers	Manual

Operation	Activity
	Automatic when raw water flow is detected
Flushing of the dosing pipes after the stop of the dosing unit	Automatic
Handling of chemicals with the hoist	Control unit suspended from the hoist; to be operated from the dosing room

i. Lime Dosing System

688. A lime dosing system shall be provided to enable pH correction both at the inlet chamber and Rapid Mixer for ensuring effective coagulation and achieving stipulated limits of pH in water. The system shall be provided as per the relevant Standards and Good Engineering Practices. The plant shall consist of the following but shall also incorporate any other requirement for its satisfactory performance:

Location	:	in Chemical House
Design Flow	:	Corresponding to requirement of intermediate stage
Design dosing rate	:	As per requirement
Solution Strength	:	5 % (5 g/l)
Dosing location	:	Rapid Mixing Chamber
Dosing Tanks	:	3 (2+1), for each shift, each minimum capacity for 8h of operation
Others	:	Piping, valves and instrumentation as required

j. Polymer Dosing System

689. **Polymer Dosing System:** Polymer dosing system shall be provided in centrifuge building. Provision shall be provided for use food grade nontoxic polymer as flocculant, coagulation aid and dosing arrangement shall be installed.

690. The tanks shall be cylindrical, vertical with closed lids hinged and nozzles for changing polymer, inlet, Agitator, Level Gauge, Overflow, Drain and Solution Outlet. The tank shall be provided with a propeller type agitator and drive unit.

691. The Contractor may supply prefabricated compact unit for Polymer Dosing System. Package type solution system is preferred.

k. Chemical Storage area

692. Alum Storage provided in the Chemical House shall be provided for 2months dosing requirements. Lime Storage provided in the Chemical House shall be provided for 1 month dosing requirements.

693. Handling arrangement shall be provided in this building for loading and unloading of the block alum from the trucks to the bulk storage area by providing EOT crane. 2 trolleys of 250 kg/each shall be provided for the handling of the alum bricks within the building. These are required for chemical storage shall be provided to satisfy above requirements.

Table 43: Dosing plant capacity

Medium	Maximum dosing rate	Solution Concentration	Solution Tanks	Storage For Intermediate stage
Alum	To be specified by the Contractor, about 30 mg/l	10 %	3each for one shift	7 days +2 month
Lime	To be specified bythe Contractor	5 %	3each for one shift	7 days +1 month

Note: Min. storage areas – Alum storage – 60 sq.m and lime storage – 50 sq.m

I. Service cum Dosing water tank

694. It shall be constructed at suitable elevation, preferably as an elevated tank over Chemical house . The capacity of the tank shall be sufficient to provide for quantity of water required for full water requirement for alum, lime and polyelectrolyte dosing + 10% extra for other utilities over the dead storage. It will have a minimum free board of 30 cm. Water requirement for chlorination shall also be met from the tank. The elevation of the tank shall be fixed accordingly, to fulfill the requirement of pressure parameter. It shall also provide for the following:

- Filling pipe
- Branches for the supply to the Administration and Control Building, Chemical House and Chlorine Building, Laboratory, Guard Room (if any)
- Gate valve in the outlet pipe
- Overflow pipe to the plant drainage
- Washout with gate valve

695. All pipes passing the walls of the water tank shall be provided with suitable pipe ducts so that there shall be no leakage.

696. The tank shall have an access to the roof, a mild steel cover, a galvanized steel ladder for the access to the tank and two mild steel or CI ventilation pipes at least DN 100 with cowls and wire mesh.

m. Chlorination

697. Pre-Chlorination as well as Post-Chlorination shall be provided in the Treatment Plant. The pre-chlorination shall be done at main distribution chamber and post chlorination at Clear Water Reservoir. A chlorine dose of max 3 mg/l for pre chlorination and max 3 mg/l for post chlorination shall be provided. The injectors shall be fed from the filtered water channel. The chlorine solution shall be injected by bottom mounted diffuser or pipes of Polyprolene or any other suitable, approved material. The diffuser system or/and baffle walls installed in the chamber shall be designed to guide the incoming water and to ensure a complete diffusion of the chlorine solution before it leaves the reservoir. The chlorine solution-feeding unit must be detachable for easy maintenance. There shall be no smell of chlorine at a distance of 10 m from the reservoir.

698. Adequate protection shall be provided against attack from chlorine solution for the channel or conduit 5 m upstream and 5 m downstream of the dosing point, by means of epoxy paint or tile lining.

699. Notwithstanding anything herein specified, the Contractor shall comply at least the provisions contained in IS 10553 (Part 1 to 4) and IS 4263 regarding handling, storage and safety of chlorine. A separate Chlorine building shall be provided to house the chlorinator room, chlorine storage and a chlorination control room.

700. The chlorine control room shall be equipped with necessary power and water points.

701. Separate arrangements shall have to be made to accommodate 30 days requirement of chlorine for pre-chlorination of maximum 3 mg/l and a post–chlorination of max 3 mg/l together. The storage area shall have minimum area of 550 m^2 to accommodate 30tonners. The storage area shall be in Chlorine Building. A loading and unloading bay of 5 m width shall be provided at the entrance. Clear spacing between stored tonners shall be equal to diameter of tonners. Exhaust ventilation shall be provided at floor level.

702. In the tonner storage area, the chlorine tonners shall be placed on concrete supports with two steel rollers each for easy rotating of the tonner as per relevant BIS code. The handling of the chlorine tonner will be made with an EOT crane which shall confirm to BIS 3177. The crane shall have an automatic brake. It shall have a safety type hook and a suitable drum-lifting beam and an in-built weighing device with a dial indicator.

703. The on-line drums shall be arranged in streams in the following manner:

704. Automatic stream changeover arrangement with panel shall be provided for each battery.The chlorine system shall be so designed, such that chlorine gas pressure reducing valve and remote vacuum regulator are both located in the drum storage area, thereby ensuring that the pipes leaving the drum storage area are all under vacuum.

705. The Contractor shall provide all the chlorine tonners i.e. 20 numbers (Requirement of Intermediate stage) in full condition at the start of O & M period. At the end of O & M period also, all except cylinders in on line rows, shall be supplied in full condition.

a. Chlorine Building

706. The Chlorine Building structure shall be designed and constructed to meet the capacity requirements of Ultimate stage, including the cylinder storage room. The chlorinator room shall be sized to install additional chlorinators, ejectors if the need for them arises in the future.

707. The Chlorine Building shall be a single storied structure designed to house the following equipment and ancillary items:

i. Chlorine Tonne Cylinder Storage Room with monorail, hoist and trolley and weigh scale
ii. Chlorinator Room
iii. Dry Chlorine Mixing and Booster Pump Room
iv. Electrical Room
v. Chlorine Gas Neutralization System

708. The conceptual design and dimensions of the proposed Chlorine Building is included in the Drawings.

709. The civil works required at the building shall include, but not be limited to:

vi. The Contractor shall make necessary geotechnical investigations for

substrata at the proposed location for the building for the design of the foundation.

vii. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.

viii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.

ix. The clear ceiling height of the overall structure shall be at least 4.7 m. The Electrical and Control Rooms shall have drop (false) ceilings to maintain a clear ceiling height of 3.6 m.

x. The Chlorine Building design shall include:

- The building shall be designed in accordance with Subsection (General requirements of Building) and the requirements of the Standard Specifications.
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas. The indoor electrical and lighting fixtures shall conform to NEMA 4X or an equivalent international standard.
- A first aid kit shall be supplied and mounted in each of the following areas:
  - Pump Room (1)
  - Cylinder Room (1)
- A fire extinguisher shall be supplied and mounted in each of the following areas:
  - Chlorinator Room (1)
  - Electrical Room (1)
- An emergency shower / eyewash unit shall be supplied and mounted in each of the following areas:
  - Cylinder Room (1)
  - Dry Chlorine / Pump Room (1)
- A weathercock shall be installed at the top of the highest buildingnearby.

b. Room Schedule

710. The Chorine Building shall be divided into rooms as shown in the following schedule:

Table 44: Chlorine Building Room Schedule

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring[4]	Walls[4]	Doors	Windows
Cylinder Storage Room	1	TBD[4]	7	1 & 6	1-D, 1-A, 1-F	1-C, 1-D
Chlorinator Room	1	TBD[4]	7	1 & 6	1-B[3]	1-C
HTH Mixing and Booster Pump Room	1	TBD[4]	7	1 & 6	None	1-E
Electrical Room	1	TBD[4]	7	1 & 3	G	None
Chlorine Gas Neutralization System[3]	1	TBD[4]	7	N/A	N/A	N/A

Notes; For Coating System or type refer clause **1355** of Specification Civil, Building and Road works

1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
2. Doors shall be only 600 mm in width

3.	To be located outdoors under a canopy roof
4.	To be determined by Contractor

c. Chlorination System

711. **Chlorination System Description:**

i. Unloading chlorine tonner
ii. Storing chlorine tonner on cradles,
iii. Replacing with 2numbers of new chlorine tonners with 2numbers of empty tonnersin the battery,
iv. Setting new 3 number of chlorine tonners on other weighing scale,
v. Connection with all 4chlorine tonners with manifold header with use of auxiliary tonner valves,
vi. Opening tonners and withdrawing chlorine gas through automatic changeover system,
vii. Flowing chlorine gas to chlorinator/s through filter/s,
viii. Measuring chlorine gas by chlorinator/s
ix. Mixing measuring chlorine gas with water byuse of injector/s located near chlorinator/s,
x. Flowing chlorine solution to dosing point,
xi. Diffusing chlorine solution at dosing point,
d. Chlorinator

712. Two numbers (1W + 1S) vacuum type chlorinators of 12 kg/h each shall be provided for pre-chlorination at Intermediate stage. Similarly 2 numbers (1W + 1S) Chlorinators of 12 kg/h each shall also be provided for post-chlorination at intermediate stage. Each chlorinator shall be provided with a dedicated injector. Chlorinators shall be of Penwalt, Meteto or equivalent make as approved by Employers representative.

713. Chlorinators shall be installed in a separate chlorinator room in the Chlorine building. The extra space for each chlorinator for ultimate stage shall be provided in the room. The room shall be reasonably gas tight and shall be provided with a ventilation system delivering at the roof level of the chlorine storage area. A set of continuously running exhaust fans at floor level shall exchange the air fourtimes per hour with ventilators at 2.0m level. Emergency blower shall exchange it 20 times per hour. The doors of the room shall open outward.

714. The Chlorinators shall be adjustable within a range of 1:10 according to the chlorine requirements of the raw and treated water. The tolerance of adjustment is not more than +/-4 %. Pressure gauges, indicating chlorine gas pressure and injector pressure shall be mounted on the front of the chlorinator and calibrated in metric units.

715. An injector module to suit the capacity of the chlorinator shall be provided with each chlorinator. A spring diaphragm check valves (to close injector suction port when the injector is not operating) a ball check valve or both shall be incorporated in the injector to prevent the back flow of water from the injector into the chlorinator. The injector has to be designed according to the available pressure conditions, which are governed by the available head in the service water tank at its lowest level. If the pressure is not sufficient a booster pump system with small air vessel shall be provided to increase the pressure to the required level.

716. All parts of the Chlorinators, the injector and its accessories shall be of suitable material resistant to the chlorine (silver, silver plated Hastelloy C, PVC, Teflon, Borosilicate glass, ebonite lined cast iron).

717. The Chlorinators and their injectors shall be panel mounted with anchor bolts. All connections, valves and other parts of the Chlorinators shall be easily accessible for cleaning, maintenance and repairs. Pipe connections shall be flexible.

718. The complete chlorinator and injector units shall be piped, and pre-tested as a system with all necessary valves, inlet connections, gauges and orifice control.

719. The sets along with booster pumps will be provided for capacity for Intermediate stage but the space will be for the Ultimate stage capacity.

e. Dosing plant capacity

Table 45: Dosing Plant Capacity

Medium	Average dosing rate	Solution	Solution tanks	Storage	
				For Intermediate stage	Additional For Ultimate stage
Chlorine (pre-chlorination)	2 mg/l Max 3		-	10 tonners for 30 days	5 tonners for 30 days
Chlorine (post-chlorination.)	1 mg/l Max 3		-	10tonners for 30 days	5 tonners for 30 days

f. Operation of water and booster pumps for the chlorinators

720. The water supply shall be made from the internal system. The pressure required for pre chlorination injectors and post chlorination injectors shall be boosted separately by 2 (1W+1S) centrifugal booster pumps for pre chlorination and 2(1W+1S) for post chlorination (one for each chlorinator) to be installed in the chlorine building, adjoining to chlorinator room if plant water pressure is not enough for chlorine dose. Pumps shall be supplied with isolating valves and the pressure gauges on delivery and suction line and valves by pass with pressure release valve from delivery to suction for each pump. The pump shall be connected to the common pipe fed from the back wash water tank.

721. The pumps shall be directly coupled to drive motor by flexible couplings. The pump and the drive motor shall be mounted on a common base plate. Foundation or ground bolts shall be supplied for each base plate.

722. The drive motor shall be of horizontal shaft, totally enclosed fan cooled squirrel cage motor and shall be manufactured, tested and provided with insulation to class B or better. The rating of the motor shall be at least 20% higher than the maximum power required by the pump over its operating range. The operating voltage of drive motor shall be 415V, 3 Stage, 50 Hz.

g. Chlorine and solution pipes

723. Duplicate chlorine gas lines with isolation valves from the chlorinators to the injectors shall be provided. Similarly duplicate chlorine solution lines with isolation valves shall be provided from the injectors to the dosing points. The isolation valves shall be provided at the chlorinator and injector ends.

724. The gas and water piping system shall be designed according to the chlorine and injection water flows and the hydraulic/pressure conditions of intermediate stage. The pipes

shall be laid as straight as possible on the shortest route from the drums to the chlorinators. They shall be fixed on well supported trays / brackets and adequately sloped to allow for drainage. All steel supports shall be heavily painted in chlorinated rubber paint.

725. The connections of the chlorine gas pipes to the cylinders and the chlorinators shall be coiled for flexibility during operation and maintenance. Each connection shall have a valve, a solenoid valve and a pressure gauge. All pipes and valves of the connection shall be placed out of the reach of gas cylinders hanging on the hook during manipulation.

Table 46: Pipe Material for the Chlorine Dosing Plant

Medium	Construction material	Test pressure
Chlorine gas	Soft seamless copper tube with compressed fittings	35.2 kg/cm²
Injector water (with or without boosting)	Galvanized iron pipes and fittings, class C	10 kg/cm²
Chlorine solution	PVC pipe or steel pipe lined with rubber or approved plastic material	As per code

726. After installation, the chlorine gas piping system shall be cleaned and dried. After drying, the system shall be pressurized with dry air up to the test pressure and tested for leaks by application of soapy water to the outside of all joints and connections. Leaking joints shall be repaired, and only when all joints are made leak proof chlorine gas shall be gradually introduced and the system shall again be tested for leaks. The pipes for water and chlorine solution shall be tested with water with the respective test pressure.

h. Chlorine leakage control system and security equipment

727. Chlorine leakage sensors connected to chlorine leak detectors shall be provided at following locations:

- One (1) sensor for each set of drums connected in the duty or standby stream manifold
- Two (2)numbers sensors in the chlorinator room.

728. The chlorination plant shall be provided with an emergency ventilation system. A ducting arrangement shall be provided in the drum storage which will evacuate all leaking chlorine gas from leaking chlorine drums connected to the manifold. As Chlorine gas is heavier than air, the mixture air and chlorine should be extracted at the bottom of the rooms. Two numbers (1W + 1S) blowers fans shall evacuate the air to a NaOH scrubbing tower where NaOH solution shall be sprayed neutralizing the leaked chlorine. NaOH solution storage tank of capacity adequate to neutralize a full chlorine drum shall be provided.

729. Two numbers pumps (1W+1S) shall be provided for pumping caustic solution. The material of construction of the scrubbing system shall be Poly propylene. The packing material inside the scrubbing towers shall be suitable plastic Rashig rings.

730. Normal ventilation fans shall provide for 4air changes per hour. The emergency ventilation blowers discussed above shall be designed 20 air changes per hour. On detection of a chlorine leak, the normal ventilation fans shall be stopped automatically and the emergency blowers and NaOH pumps shall start automatically evacuating and neutralizing the leakage. Suitable arrangement for evacuating leaking chlorine gas from drum storage area shall be provided.

731. The Contractor shall provide as a minimum, following safety equipment in the works, which shall be common for the chemical dosing area and the chlorination plant area :

- Canister type respirators with full face coverage masks suitable for chlorine gaseous atmosphere - min. 3 numbers
- Spare canisters for the respirators - min. 3numbers
- Self-contained compressed air breathing apparatus complete with working whistle and two spare air cylinders - min. 3 numbers
- A facility to recharge the compressed air cylinder or from a self-contained machine
- Protective clothing such as PVC overall and gloves and rubber boots shall be provided - min 3 sets
- Warning Lights –2 numbers
- Hoses – 2 numbers

732. The Contractor shall provide visual and audible alarm system. Flashing warning lights shall be provided over each door of the chlorination room store and near the chlorine drum storage area. The lights shall be RED in colour and shall be clearly visible at a distance of 20 meter under normal daylight conditions. They shall be activated automatically from the leak detection devices. Behind the lights, a rear engraved perplex label having red letters on a white background shall be mounted at each door and at visible place. The lettering shall be a minimum of 50 mm high and one legend shall read in English and the other in Hindi language and local language.

"DANGER –
WEAR BREATHING APPARATUS BEFORE ENTERING WHEN LIGHT IS FLASHING"

733. One emergency drum leakage repair kit shall be provided in the workshop or in the chlorinator room.

734. Two (2) numbers Safety showers and one (1) Eye wash fountain with accessories shall be provided in the chlorination plant area at easily accessible location.1 No of weather cock shall be installed at the top of Chlorination Building.

Operation and control of the chlorine dosing plant

735. A dedicated control panel shall be provided in the chlorination control room. The operation of the chlorination plant is as follows:

Table 47: Operation of the Chlorine Dosing Plant

Operation	Pre-chlorination and Post-Chlorination Control Scheme
Regulation of the chlorine rate	Manual, according to flow measuring channel and instructions passed from the control room through PLC on the basis of Raw Water quality and Treated water quality and RW & FW flow meters.
Regulation of the process water	Automatic based on demand signal from RW or FW flowmeter.
Stop of chlorine gas flow	Manual normally
	Automatic when raw water flow is zero
	Automatic when injector stops
	Automatic when chlorine pressure low (gas drums empty)
Stop of injector water	Manual; (normally). Automatic when chlorine pressure low (gas drums empty) or in case of leaks
Stop of chlorine flow at the chlorine drums	Manual; automatic in case of leaks; automatic in case of stop of injector

Operation	Pre-chlorination and Post-Chlorination Control Scheme
Acoustic alarm	Automatic in case of leakage in the chlorinator room or in the chlorine storage area; low chlorine level/ high chlorine level
Continuous fan in chlorinator room	Manual; running continuously
Start of emergency blower in chlorinator room	Automatic in case of leakage in the chlorinator room
Start chlorination	Automatic when raw water flow starts/final waterflow starts
Continuous fans in Drum Store	Manual, running continuously
Start of blower in Drum Store	Automatic in case of leakage in Drum store with automatic stopping of continuous fans
Start of NaOH solution pump	Automatic in case of leakage in Drum store or in Chlorinator room

i. Neutralization system

736. The chlorine neutralization system in the form of scrubber shall be provided. The capacity of neutralization shall be minimum 200 kg / hr with the help of NaOH solution. Minimum storage of NaOH shall be 1140 kg with water quantity of 900 Litrs. in order to neutralize 900 kg of chlorine.

737. The NaOH tank shall be preferably FRP with PP internal lining. Level indicator to NaOH solution shall be provided. The absorption tower shall be internally PP lining. The centrifugal Air blowers shall be provided of adequate capacity considering Cl2 + Air mixture volume. The connected tonners to the system shall be covered with half hood in order to collect chlorine leakages from the tonner valves / copper flexible tubing. The temperature of the neutralization solution should be maintained within the limit of chlorine absorption in NaOH.

j. Standby chlorination system

738. As a backup to the gaseous chlorination system, in case of disruption in cylinder delivery or for any other reason, a standby dosing system is to be provided. The system with use of HTH (High Test Hypo) in powdered form as disinfectant shall be provided. Such system is already installed and is in use in existing WTPs of Bhagalpur water supply scheme.

739. HTH, with approximately 65% chlorine content will be dissolved in solution in day tank with addition of utility water and will be conveyed to point of application with small metering pumps. For this 2 days tanks for intermediate stage (95 MLD) and 1 day tank for ultimate stage (46 MLD) shall be provided in this project. Each day tank shall have capacity of 7000 liters.

k. Sludge Handling and Disposal

740. **Dirty Back Wash from Filters:** A waste (dirty) backwash water holding tank (WBWH) shall be provided to equalize the WBW water being conveyed via. a pipeline or dedicated RCC channel to river. The WBW water will be conveyed to discharge point in the river under gravity flow from this storage tank and at least 3 m below normal water level of the river. The pipeline / channel shall be designed accordingly. The volume of the tank stores the flow from one unit (two beds) of filter and equalize the flow to river. The tank will have a capacity to hold balance quantity of inflow and outflow. The approx. capacity will be about 450 m^3. The provision shall also be made for utilization of the back wash waste water by conveying it again to the treatment process i.e. conveying back wash waste water just after Parshall Flume.

741. **Sludge from Flocculator and Clarifiers – Sludge Buffer Tank:** Sludge from Flocculator and Clarifiers shall be collected to Sludge Buffer Tank. Adequate number and size of tanks shall be provided. The total capacity provided shall be at least the volume of sludge extracted during 8h. The tank(s) shall be equipped with submersible mixer to prevent sludge settling. The tank(s) shall have a provision for feeding the thickener with the sludge with adjustable timer and electrically actuated valves and sludge pumps. A DI pumping mains of suitable size shall be provided from these pumps to Thickener. They shall also have overflow pipe connected to plant drainage. 2W +1S level actuated pumps shall be provided to pump the water within 120 minutes. Sludge pumping arrangement with 1W + 1S pumps shall be provided to transfer the sludge to the sludge thickener for further treatment and disposal. The proposed capacity of sludge buffer tank is 450 m^3 (for detention time 16 hours).

Sludge waste from clarification process shall be taken into sludge sump cum pump house.

742. **Sludge Thickener and Supernatant Recycling:** The sludge from the Buffer Tank shall be conveyed through CI/DI pipes to reinforced concrete sludge thickeners designed to achieve a minimum solids concentration of 4% and supernatant turbidity not more than 100 NTU. However, for operation purpose Employers representative can relax solid concentration criteria, depending on raw water characteristics. Suitable non-toxic sludge conditioning (with coagulant and polyelectrolyte etc.) arrangements with dosing tanks, dosing pumps etc. shall be incorporated. The underflow of these thickeners shall lead to the sludge drying facilities by gravity and /or pumping, while the supernatant shall be led to the recycling tank. A recycling tank for the supernatant, adjacent to the sludge buffer tank, of appropriate capacity shall be provided with two (1W + 1S) re-circulating pumps of capacity to transfer the supernatant upstream to channel before raw water Parshall Flume. The start/stop of these pumps shall be automatic based on levels controls. Pump room shall be provided for recycling pumps. A CI/DI pumping main shall be provided up to the channel. There shall also be a provision for discharging the supernatant in to the waste water network of the WTP.

743. (2W + 2S) sludge pumps shall be provided for handling sludge to the dewatering unit in case gravity withdrawal is not possible. No. of pumps to be furnished for Phase II requirement in this project.

744. Sludge thickener shall be of scraper type or drum type thickener and subject to the following:

- The capacity shall be 24 hours of the sludge volume in term of the detention time.
- The solid load shall be minimum 140 $kg/m^2/day$
- Two or more thickeners shall be planned for the both Phases. Two thickener for Intermediate stage shall be constructed.
- Branching pipes, sludge feeding systems, supernatant branching system, supernatant pipes and sludge collector shall be provided.
- Dose nontoxic coagulation aide for dewatering, if required, in the thickener.

745. For Thickener of Scraper Type, drive shall be provided with Local and Remote operation modes. With local mode operation of the pumps shall be performed from the push button station located near the equipment (start from local pushbutton is envisaged only during start-up and maintenance). And in remote mode operator can start/stop the pumps from MMI control stations. In addition to the start/stop operation all the pumps are provided

with On & Off/Trip feedback. Signal fro-high torque switch is also taken to the PLC for interlocking and annunciation purposes. For operation scraper drive, followings shall be noted:

- Mechanism should be available to ensure the oil level in the gear reducer of scraper drive and sufficient water level in the thickener basin before switching on rake mechanism.
- Bring the scraper into operation, when the sludge started feeding into the thickener and check its smooth rotation.
- Keep the torque switch in working condition.
- Keep the bottom sludge valve closed till thickener becomes full and starts overflowing.
- The sludge thickens and the consistency increases as the supernatant overflows.
- Check the sludge consistency by drawing sludge samples.
- In case of trip of mechanism due to high torque, do not attempt to restart the drive without proper investigation.

746. For Drum type thickener, it shall be equipped with self-cleaning system. Coagulation aide for dewatering, if required, in the thickener shall be of non-toxic type.

747. Thickened Sludge Pumps shall be provided with Local and Remote operation modes (In MCC). With local mode operation of the pumps shall be performed from the push button station located near the equipment (start from local push button is envisaged only during start-up and maintenance). In remote mode operator can start/stop the pumps from MMI control station. In auto mode operation of pumps is interlocked based on the level of sludge in storage tank and the dosing of de-watering Polyelectrolyte. On &Off/Trip signals are taken PLC for interlocking and annunciation purposes.

748. When the operation of Thickener is stabilized, it shall be ensured by drawing samples from the sludge withdrawal lines of the Thickener. The consistency of thickened sludge is around 4%. With the consistency of thickened sludge reaching 4 % depending on the suspended solids in the raw water, the system shall be provided by the arrangements for de-watering.

749. Once the sludge is thickened to a consistency of 4%, it shall be send for dewatering by centrifuges.

750. **Thickened Sludge Extraction Pump House:** A Thickened sludge extraction pump house building shall be constructed to accommodate the pumping equipment required to draw the thickened sludge from the thickener and transfer to Sludge Dewatering. The pump house shall be of RCC structure and it will be a 2-stories building (basement and ground floors) depending on the elevation of sludge extraction pipe. The sludge extraction pumps shall be installed on the base floor and ground floor will accommodate electric/control panels and washroom for operator. The minimum height (net clearance) shall be 3.5 m for both base and ground floors.

751. The Building shall be divided into rooms as shown in the following schedule:

Table 48: Room Schedule

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows

Pump Room[1]	1	TBD[3]	7	1 & 3	G	1-E
Control Room[2]	1	TBD[3]	8	1 & 4	F	1-C, 1-E
Electrical Room[2]	1	TBD[3]	7	1 & 3	K	None

Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works
1. To be located on the Basement
2. To be located on the Ground floor
3. To be determined by the Contractor

752. **Sludge Dewatering Building:** Sludge Dewatering Building shall be constructed to accommodate the equipment required to dewater (dehydrate) the thickened sludge from the tube settlers. The building shall have 2 stories: an upper floor to house the dehydrator unit(s) and electrical/control room and the lower level to serve as the Sludge storage and truck loading bay. Ancillary pump, polymer shall also be included. The pump rooms shall house the thickened sludge dehydrator feed pumps and wash water booster pumps for the dehydrator unit. The electrical room shall accommodate the electrical gear for the sludge thickener also and maybe the waste water recirculation pump station for supernatant water of thickener and generates of dehydrator also, depending upon their relative locations.

753. The Sludge Dewatering Building shall be divided into rooms as shown in the following schedule:

Table 49: Sludge Dewatering Building Room Schedule

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Dehydrator Room[2]	1	TBD[4]	7	1 & 6	1-C, 2-A,	2-A
Truck Loading Bay[3]	1	TBD[4]	7	7	2-E	None
Pump Room[3]	1	TBD[4]	7	1 & 3	G	1-E
Control Room[2]	1	TBD[4]	8	1 & 4	F	1-C, 1-E
Polymer Room[3]	1	TBD[4]	7	1 & 6	G	1-E
Electrical Room[2]	1	TBD[4]	7	1 & 3	K	None

Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works
1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
2. To be located on the First floor
3. To be located on the Ground floor
4. To be determined by the Contractor

754. **Dehydrator/Centrifuge:** The sludge shall be fed to Dehydrator for dewatering it.

755. Dehydrators shall be provided for increasing the sludge consistency up to 20%. Dehydrators each of minimum 25 m^3/h capacity are provided for handling the total sludge on duty/assist basis for 16 hours operation. Three number (2W + 1S) positive displacement type screw pumps shall be provided to feed the thickened sludge to Dehydrators. Non-toxic DWPE shall be dosed in the feed line to Dehydrator for sludge conditioning to enable dewatering. The wash water required for Dehydrators shall be tapped from the site service water header.

756. Nontoxic polymer dosing tanks with agitator and dosing pumps shall be supplied. The tanks shall be cylindrical, vertical with closed lids hinged and nozzles for changing polymer, inlet, Agitator, Level Gauge, Overflow, Drain and Solution Outlet. The tank shall be provided with a propeller type agitator and drive unit.

757. The Dosing Pumps shall be positive displacement reciprocating type. The reciprocating pump shall have manually adjustable capacity controller.

758. The material of construction wetted parts of Pump shall be SS 304.

759. The Contractor shall indicate quantity of chemicals required per ton (Dry Solid Weight) of sludge dewatered by the dewatering machines.

760. The Dehydrator may be Centrifuge type.

761. Dehydrator shall be installed on an elevated platform covered with shelter to enable direct loading of sludge cake onto trucks/trolleys or the dewatered sludge cake shall be disposed to the sludge disposal destination. The centrate or filtered water from dehydrator is routed by pumping to the recycling tank.

762. The centrifuge shall be subject to the following:

- One feed pump shall be dedicated for each Centrifuge with one common standby feed pump. Proper arrangement shall be done to use the standby feed pump for feeding the thickened sludge to any of the Centrifuges.
- Relief pressure valve shall be set for pressure safety valve at 3 kg/cm2
- After start of centrifuge, dosing of DWPE solution shall be started with the help of dosing pump. After ½ minute, open the isolation valve in the sludge line to centrifuge.
- It shall be ensured that the trolley / truck is kept under the solid chute on the road, below centrifuge building.
- Proper arrangement shall be provided for opening the water valve to flush the centrifuge with water, while the machine will be slowing down.
- During a scheduled tripping of any Centrifuge, arrangement shall be provided for trip the running centrifuge feed pump followed by the running DWPE dosing pump. Disconnection of the centrifuge shall be done afterwards.
- Arrangement shall be provided to start flushing the centrifuge, opening the water valve. Supply of flushing water shall be stopped just before the centrifuge comes to a standstill.
- The centrate from the centrifuges shall reach the recycling tank inlet of the WTP.
- Ensure that the flushing of sludge lines done, at the earliest opportunity, when the Centrifuges are taken out of operation.
- The centrifuge station shall work 16 hours per day in 2 shifts. The entire system shall work in damp and dust laden atmosphere hence Contractor is required to maintain a proper working atmosphere inside the room by providing proper ventilation etc.
- Suitable mechanism support, walkway, handrails, drive system and overload protection shall be provided.
- Centrifuge shall conform to IS: 10037 (Part 3) – 1983 or any other international specifications superior to these specifications. It shall be capable of handling sludge with sludge consistency as available from the thickener. The dewatered cake shall have a minimum dryness of 20%
- Number of centrifuge with minimum 50 % standby shall be provided.

763. Drainage from the Sludge Thickener and Dehydrator units shall have a provision of being leadto the drainage system of WTP premises.

764. Sludge Handling and Final Disposal: The sludge shall be treated at WTP by thickener and dehydrator. The sludge cake produced from the sludge will be disposed to the land, available within 10 km area. The Contractor shall carry out all required disposal works and create/construct requisite facilities for final disposal of sludge cakes. The scope of work shall include selection of sites, getting clearance of Employers representative and environmental clearance for the same and development of suitably designed landfill site adequate for meeting the projected requirement of at least 10 years. The area required includes an allowance of additional 40% for roads, divider berms etc. The land required for Phase II work requires land filling. The sludge from centrifuge can be used for this land filling Contractor should study feasibility. The cost of the land will be borne by the Employer and shall be a Government owned land as far as possible.

q. Clear Water Reservoir and Treated Water Pumping Station

765. **Clear Water Pump House:** The Clear Water Pump House structure shall be designed and constructed to meet the capacity requirements of ultimate stage. The individual clear water pumps shall only be installed to accommodate the intermediate stage capacity in this project and the pumps capacity will be altered to increase the flow capacity in the ultimate stage of the project.

766. The civil works required at the clear water pump house structure shall include, but not be limited to:

vi. The Contractor shall make necessary geotechnical investigations for substrata at the proposed location for the pump house and reservoir for the design of the foundations.

vii. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.

viii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.

ix. The clear ceiling height of the overall structure shall be at least as tall as required to pull the clear water pumps and accommodate the EOT crane. The Electrical and Control Rooms shall have drop (false) ceilings to maintain a clear ceiling height of 3.6 m.

x. The Clear Water Pump House design shall include:

- The pump house building shall be designed in accordance with Subsection (General requirements of Building).
- A double or roll-up type door (Type C) equipment entrance at the end of the pump house, large enough for the pumps and electrical panels to pass through generously. A single door (Type A) shall be adjacent to this equipment door.
- An electric overhead traveling (EOT) crane of adequate capacity to lift out the clear water pumps shall be installed. The crane and pump house floor area shall be designed with adequate space for the EOT crane to be able to lower equipment onto a truck bed.
- A separate electrical switchgear room separated from the pump area shall be provided. The electrical equipment shall be elevated 2500 mm off of the pump floor level to avoid wash down. The electrical room shall have double door leafs (Type E) at the entrance.
- The floor in the pump room area shall be coated with a concrete sealer / hardener (Coating System No. 7) applied at a rate of not less than 4.5 m^2/liter.

- Provide permanent access platforms to service the pump motors. Platforms shall be constructed of steel beams and columns with a GI checker plate walking surface.
- Valves shall be accessible from the pump house floor level. If that are not, operating platforms shall be constructed so the operators are not more than 1.5 m above the floor or walkway level.
- The platforms and walkways shall have a two rail system of 1.0 m in height made of galvanized steel tubes of 32 mm diameter (pillars and upper railing) and 25 mm diameter (lower railing). The walkways shall be accessible from the upper floor of the control building and by means of 800 mm wide stairs.
- A separate control room of not less than 20 m2 floor area for the instrument control panel (ICP) and SCADA interface. The control room shall have a single leaf aluminium entrance door (Type D). The control room shall have an exterior window (Type C) and an interior window into the pump room (Type E). The room shall be air conditioned. The room shall be furnished in accordance with Subsection (General requirements of Building).
- A separate duty room 15 m^2 floor area. The door shall be Type D. The room shall be furnished in accordance with Subsection (General requirements of Building).
- A separate storeroom of not less than 10 m2 floor area. The door shall be Type D and lockable. The storeroom floor shall have acid resistant tiles installed in a dedicated 4 m^2 area for battery and acid storage. This area shall be curbed in for containment.
- A bathroom furnished in accordance with Subsection (General requirements of Building).
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.
- Windows shall be installed on the 3 exterior walls of the pump house not occupied by the reservoir. Each window shall be Type A.
- Thrust blocking shall be provided at pump discharges and the deadhead end of the pumping header.
- The utility (potable) water pumps shall be installed in the pump room. They may take their suction from the clear water pump suction manifold, or a separate suction manifold can be installed directly into the reservoir.
- A 62 mm diameter drain line shall be installed at the invert of the pumping header. The drain line shall contain a sluice valve at the connection to the header. The pumping header shall be sloped at least 1% in each direction to the low point at the drain connection.
- A first aid kit and a fire extinguisher shall be supplied and mounted in the pump room area.
- A potable water supply service line of at least 25 mm diameter to be provided. The potable water service shall supply drinking water, the toilet facilities and bearing lubrication, if required for the pumps.
- Wash down water shall be obtained from tapping the pumping main header and installing a backflow preventer, service piping, valves and hose bibs as required.
- Ventilation for RWPS & CWPS shall be provided near the ceiling level with a mesh for birds protection.

767. The Clear Water Pump House shall be divided into rooms as shown in the following schedule:

Table 50: Room Schedule

Room	No.	MinArea Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Pump Room	1	See note 2	7	1 & 3	1--A	4-A
Control Room	1	40	8	1 & 4	F	1-C, 1-E
Duty Room	2	15	8	1 & 4	F	1-C, 1-E
Storeroom + Acid Room	1	12	7[3]	1 & 3	G	None
Bathroom	1	6	5	5	F	None
Electrical Room	1	TBD	1 & 3	G	G	None

Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works

6. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1
7. The remaining area of the pump house shall be the pump room
8. Acid resistant tiles shall be installed in a 2 m^2 area
9. To be determined by the Contractor
10. Refer Painting Schedule

768. **Clear Water Reservoir:** Filtered water from filters shall be collected in a channel equipped with a flow meter (Electromagnetic) at Inlet of filter outlet chamber to measure the flow rate of treated water to the Clear Water Reservoir. In this channel it is also to be introduced chlorine for disinfection. Clear water tank will be provided with chlorine contact tank.

769. The Clear Water Reservoir is sizing for the Phase II and has a capacity corresponding to the production of one hour minimum. So it provides contact time necessary to chlorine action for disinfection (at least 30 min).Following arrangement are to be provided in the reservoir. The detention time in chlorine contact will be 30 min. and that of clear water reservoir 60 min. Thus, the total storage capacity shall be for 90 min. storage for ultimate stage. Following provisions should be kept:

- division in two interconnected parts for maintenance,
- internal partitioning to prevent short-circuit of the flow,
- making of a sump in each part for the water outlet and suction of the pump,
- creation of external valve chamber with possibility to isolate one compartment,
- discharge located at the sump, one for each compartment, and connected to the sewer of the plant,
- bottom with slope,
- overflow connected to the sewer of the plant,
- several aeration pipes of suitable diameter shared out on the roof and equipped with wire mesh against insects,
- two access to inside from the roof with fixed ladder,
- level measurement.

770. Beside Clear Water Reservoir, the Clear Water Pumping Station will be erected to discharge treated water to the service Reservoirs.

771. Slope of 1 in 150 shall be provided in floor of CWR and slope of 1 in 100 shall be provided in roof of CWR.

r. Administrative, Laboratory and Control Building

772. The Administrative, Laboratory and Control Building structure shall be designed and constructed to meet the capacity requirements of Phase II. This building shall be planned exclusively for works and operation of WTP with (CWR) and Intake only.

773. The civil works required at the building shall include, but not be limited to:

i. The Contractor shall make necessary geotechnical investigations for substrata at the proposed location for the building for the design of the foundation.
ii. He shall prepare a conceptual layout plan and architectural elevations of the facilities to be included and submit it to the Employer's Representative for approval.
iii. After receiving approval he shall prepare the complete structural, mechanical and electrical designs and working drawings for the entire work.
iv. The building may be a single or two story structure and shall include the following features.
v. The building shall have provision of administration works for WTP and intake:

774. The Ground Floor (Administration Block) shall have a minimum floor area of 350 m^2 and be divided into rooms as shown in the following schedule:

Table 51: Room Schedule (Ground Floor–Administrative Block)

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring[6]	Walls[6]	Doors	Windows
Entrance/Reception	1	60	8	1 & 4	B[2]	None
Manager's Room[2]	1	25	8	1 & 4	H	1-A
Office	1	35	8	1 & 4	H	3-A
Staff room	1	20	7	1 & 3	G	1-A
Duty Room	1	20	8	1 & 6	F	1-A
Bathroom	3	22	8	5	F	None
Pantry& Canteen	1	60	8	1 & 4	H	2-A, 1-C
Conference Room	1	30	8	1 & 4	H	3-A
Stairways	1	As required	Kota stone	1 & 4	None	None

Notes: For Coating System or type refer clauseof Specification Civil, Building and Road works
1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1.
2. To be aluminium framed (anodized finish) architectural type doors with the top half in glass.
3. To be determined by the Contractor.

775. The First Floor shall have a floor area of minimum 350 m2 and be divided into rooms as shown in the following schedule:

Table 52: Room Schedule (First Floor)

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Control Room	1	55	8	1 & 4	F	4-B
Laboratory Block		180	Terrazzo	5	3-F	6-A, 2-W

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Wet Chemistry						
Bacteriology						
Instruments						
Ovens / Driers						
Miscellaneous						
Storage room						
Mechanical & Electrical room	1	20	8	1 & 4	J	1-A
Bathrooms	2	18	8	5	F	None
Stairways		As required	Kota stone	1 & 4	None	None

Notes: For Coating System or type refer clauseof Specification Civil, Building and Road works
1. Notations such as 1-B denotes No. of Items (1) and type of Item (B) whether a door or window. If no number is given then it shall be taken as 1
2. Used for presentation for visitors and staff training
3. To be determine by Contractor.

vi. The clear room height (measured from below beam) of each of the rooms shall be at least 3.00 m and 3.5 m for ground and first floor respectively.

vii. The Control Office and Laboratory Building design shall include

- The building shall be designed in accordance with relevant Subsection and the requirements of the Standard Specifications.
- Providing lighting fixtures along with cabling, a separate lighting single phase low voltage panel, switches, starters, and other accessories for indoor and outdoor areas.
- A first aid kit shall be supplied and mounted in each of the following areas:
  - Duty Room (1)
  - Laboratory (2)
  - Conference / Training Room (1)
  - Meeting / Break Room (1)
- A fire extinguisher shall be supplied and mounted in each of the following areas:
  - Duty Room (1)
  - Laboratory (1)
  - Conference / Training Room (1)
  - Meeting / Break Room (1)
- A potable water supply service line of at least 38 mm diameter shall be run to the building. The potable water service shall supply drinking water, the laboratory, the meeting and duty rooms and the toilet facilities.
- Sanitary drainage shall be conveyed by gravity or be pumped to the septic tank / leach field site. If it is pumped, a standby pump shall also be provided.

i. Reception Areas & Entrance

776. The floors of reception areas (foyers) shall be covered with glazed vitrified tiles. Each tile shall have the dimensions of 300 mm x 300 mm square. The tile Colour shall be selected

by the Employer's Representative. The bottoms of doors shall just clear the level of the tile once installed.

777. Each reception area shall include at least the following furnishings if not shown otherwise on the Drawings or stated elsewhere in the Specifications:

- 1 desk of Mark T1.
- 1 chair of Mark C1
- 4 chairs of Mark C4.
- 2 tables of Mark T8.
- 1 ceiling fan (Mark C1)

ii. Manager's Office

778. The floor shall be covered with glazed ceramic tile. Each tile shall have the dimensions of 300 mm x 300 mm square. The tile Colour shall be selected by the Employer's Representative. The bottoms of doors shall just clear the level of the tile once installed.

779. The office shall include at least the following furnishings if not shown otherwise on the Drawings or stated elsewhere in the Specifications. The furniture Mark designations are described in Subsection (General requirements of Building):

- 1 desk with credenza of Mark T2
- Each desk shall have a chair of Mark C3.
- 1 table of Mark T7 with 4 chairs of Mark C-3.
- 1 Almirah of Mark A1.
- 2 chairs of Mark C4.
- 1 bookcase of Mark B3.
- 1 filing cabinet (control rooms only) of Mark F2. The top drawer shall have a locking device, which when activated shall lock all drawers.
- A wall split type air conditioning unit of adequate capacity to keep the room temperature at 20^{o} C accounting for all room heat loads at an ambient outdoor temperature of 37^{o} C. The compressor and fan shall be mounted outdoors in a location shaded from sunlight.
- A drop or false acoustical type ceiling with a ceiling height of 3.00 m.
- 1 ceiling fan (Mark C1)

iii. Conference Rooms

780. The floor shall be covered with glazed ceramic tile. Each tile shall have the dimensions of 500 mm x 500 mm square. The tile Colour shall be selected by the Employer's Representative. The bottoms of doors shall just clear the level of the tile once installed.

781. The room shall include at least the following furnishings if not shown otherwise on the Drawings or stated elsewhere in the Specifications. The furniture Mark designations are described in Subsection (General requirements of Building):

- 1 table of Mark T6
- 8 chairs of Mark C1.
- 4 chairs of Mark C2
- 1 Almirah of Mark A2.
- 1 bookcase of Mark Bs.

- 2 tables of Mark T8.
- 1 drawing cabinet of mark D1.
- A wall split type air conditioning unit of adequate capacity to keep the room temperature at 20° C accounting for all room heat loads at an ambient outdoor temperature of 37° C. The compressor and fan shall be mounted outdoors in a location shaded from sunlight.
- A drop or false acoustical type ceiling with a ceiling height of 3.00 m.
- 2 ceiling fans (Mark C1)

iv. Control Office Building

- The main control room shall be sited in the Water Treatment Plant. The supervision of the entire plant shall be possible from the main control room. It shall have a size of not less than 55 m^2. There shall be a Man-Machine Interface and a control console. The mimic diagram (to be available on 32"" LED colour monitor shall show the whole treatment plant in the both Intermediate stage and II configuration. In addition, it shall indicate the information about the status of the raw water and clear water pumping stations, and the raw and clear water reservoirs.
- A PC based local SCADA system having a colour monitor shall be provided in the main control room. Various screens shall be developed on the SCADA system for remote monitoring and control of treatment plant and clear water pumping station. The SCADA shall show the whole treatment plant in the both Intermediate stage and II configuration.
- Filtration PLC-A housed in Instrument Control Panel (ICP-A) shall also be located in the main control room. The clarification cum dosing PLC-B, Chlorine dosing PLC-C and CWPS PLC-D etc shall be interfaced with SCADA system for data monitoring and control.
- The control panel shall have an interface for the communication of the raw water inflow to the clear water pumping station on the same site. From there, the information will be transmitted by a wireless system to the master control center in future.
- All required Furniture like PC Tables, Chairs, Almerahetc matching with the esthetic view of Control Room shall be supplied and shall be adequately air conditioned.

v. Laboratory

782. The laboratory furnishings and equipment shall be as described in Subsection.

783. The laboratory flooring shall be terrazzo laid in-situ in accordance with Section of the Standard Specifications.

784. The walls on all of the laboratory rooms shall be covered with acid resistant glazed ceramic tile (Coating System No. 5) up to the ceiling level. The ceiling shall be coated with Coating System No. 6.

785. All rooms / sections in the laboratory shall be air conditioned, except the oven/dryer room. This area shall be enclosed in a separate insulated room which shall be ventilated to the outdoors with exhaust fans and intake louvers. The wet chemistry area shall be equipped with a fume hood and ventilation system to exhaust the fumes pulled in through the hood out at a level above the roof level. The Contractor shall provide a ventilation exhaust rate of 24 air changes per hour (acph) through the fume hood.

786. Laboratory shall have the equipment, storage space and chemicals for all the chemical and bacteriological routine analyses. The laboratory shall have 6 m of working platforms with minimum 3 sinks. The sampling pipes shall end at one of the sinks. The taps shall be clearly labeled with the type and provenience of the water. Details of sampling, equipment, glass wares and accessories and gives in next chapter.

787. The quality of the water entering, passing and leaving the treatment plant shall be monitored via CPVC 10 bar DIN / ASTM standards rating sampling pipes DN 25 from the following points leading to the laboratory:

- Raw water pipe at the inlet chamber (raw water)
- Clarified water at the common outlet of the Clarifiers (clarified water)
- End of the filtered water channel (filtered water of all filters)

788. The sampling pipes shall lead from the sampling point to small sampling pumps installed at a low area of the pipe gallery of the filters. From there, pressure pipes shall lead to the laboratory to the outlet points.

789. A separate pipeline shall be provided from the measuring flume for continuous monitoring of turbidity through the online turbidity meter.

790. Sampling at individual units shall be made with the help of a sampling bottle in the case of open reservoirs or channels and from taps. Each sampling point shall be provided with an outlet convenient for the collection of samples for laboratory testing and for the connection of a portable turbidity meter.

791. At the outlet of each clarifier (collecting channel)

792. At the filtered water outlet of each filter (taps at the filtered water pipe)

793. The following equipment and all required laboratory chemicals / reagents are to be provided by the Contractor within the scope of work and have to be replenished by him till the end of the O&M Period.

(i) Laboratory Equipment

794. All the laboratory equipment mention below should be reputed brands internationally accepted and they should be handed over to the client along with its guarantee / warranty cards.

Table 53: Laboratory Equipment

Sr. No.	Name of Instrument	Nos.
1	Bench Top digital pH meter	1
2	Portable Multi-parameter measuring instrument (Temp/pH/EC/TDS/DO)	1
3	On-line Nephelometric Turbidity Meter	1
4	Portable Nephelometric Turbidity Meter	1
5	Pocket Dissolved Oxygen Meter	1
6	Pocket Conductivity Meter	1
7	Pocket Total Chlorine Meter	1
8	Centrifuge	1
9	Chlorine analyzer (comparator)	2
10	UV-visible Spectrophotometer	1
11	Automatic BOD Analyzer set	1
12	BOD Incubator	1

Sr. No.	Name of Instrument	Nos.
13	COD thermo-reactor	1
14	Laminar air flow cabinet	1
15	Refrigerator (300 L)	1
16	Incubator (310 °K)	1
17	Serological Water Bath	1
18	Water Bath	1
19	Autoclave	1
20	Colony counter	1
21	Jar test apparatus	1
22	Single pan Electrical balance	1
23	Double pan Manual balance	1
24	Water distillation unit	1
25	Double water distillation unit	1
26	Magnetic Stirrer with hot plate	1
27	Laboratory thermometer	3
28	Electric hot air oven	1
29	Vacuum pump with 1 L suction flask	1
30	Phenol distillation apparatus	1

Table 54: Bench Top Digital pH Meter Specification

pH range	0 - 14
Milli volt range	0 to ± 1999 mV.
Resolution	0.001
Relative Accuracy	± 0.002 pH
Reproducibility	0.01 pH
Calibration Points	Up to 5 points
Temperature compensation	0 to 100°C manual or automatic
Power supply	230 V ± 10% 50 Hz (Universal adapter/9 V battery)
Accessories	2 No. of combined electrodes with electrode stand.

Table 55: Portable Multi-parameter Measuring Instrument Specification

pH	
pH range	-2 to 19.99
Accuracy	± 0.01 pH
Milli volt range	0 to ± 1999 mV.
Accuracy	± 1 mV
Accuracy	± 0.002
Calibration Points	1 or 2 points
Temperature compensation	Automatic
Power supply	230 V ± 10% 50 HZ (Universal adapter/dry cell)
Accessories	1 electrode with stand.
DO	
Oxygen concentration	0.00 to 199.9 mg/L
Oxygen saturation	0.00 to 199.9%
Accuracy	± 0.5% of value
Temperature compensation	Automatic IMT compensation from 0 to 40^0 C
Calibration	Automatic
Accessories	1 DO probe with stand.
Range	1 µS/cm to 500 mS/cm (in 4 ranges)
Accuracy	± 1% of value
Temperature compensation	Non-linear function for ultra pure and natural water

Calibration	Automatic
Accessories	1 electrode with stand.

(ii) Online Nephelometric Turbidity Meter

795. The on-line monitoring system shall be designed for the continuous measurement of Turbidity in water.

796. The full scale operating range of the system may be selected by the user from 0-4.000 to 0-4,000 NTU or from 0-10 to 0-10,000 ppm (mg/l) of SiO_2, and the sensing system shall be capable to operate on water streams with temperature from 0 to 50 °C.

797. The measured Turbidity shall be displayed on a backlit liquid crystal display on the front of the instrument. The Turbidity monitor shall be suitable for water treatment plants.

798. The measuring methods shall be Nephelometric.

799. A light source and a photocell shall be positioned with their optical axes 90° from each other. The emitted light is scattered by particles in the process and received by the photo-cell, in accordance to standard ISO 7027.

800. The assembly automatically shall deliver high pressure air to the tip of the sensor to effectively blast accumulated growth from the optical lens.

801. The Turbidity monitor shall be supplied with the cleaner with arrangement to provide the pressure air to the sensor.

802. Submersible sensors shall be designed for direct immersion in the tank or flowing stream.

803. A Suitable length cable shall be potted into the top section of the sensor assembly, and connect directly to the Turbidity monitor,

804. A separate tubing connection located at the top of the sensor assembly shall be provided for connection of a 10 m length of plastic tubing between the sensor and the monitor.

805. The Turbidity sensor assembling shall be mounted to a 1" pipe using a special mounting adapter.

806. The 1" pipe shall be provided with a bracket assembly to attach it to the tank handrail that holds the sensor at a slight angle in the tank.

807. Once installed and placed into operation, the Auto-clean Turbidity sensor shall provide months of reliable Turbidity measurement in almost any application.

808. The sensor cleaning frequency shall be user programmable, and units shall be supplied with a default cleaning frequency of once every 24 hours.

809. The sensor shall have facility to increase this frequency if needed for a specific application.

810. The installation of the Auto-Clean Turbidity system shall be quick and simple.

811. It shall be designed to operate with either a retro-scatter (180°) probe or a 90° probe. The turbidity meter shall allow the user to set up measurement parameters through a user-friendly menu system displayed on the in-built 2 line alphanumeric display.

812. Measurements can be read directly from the display at any time or downloaded to a computer/ printer through the optional RS232 output at user selectable periodic intervals.

813. The necessary power up arrangement should be provided to automatically power up turbidity meter to its last settings whenever external power is available.

Table 56: Online Nephelometric Turbidity Meter Specifications

Range	0 to 100 NTU
Display	2 line, 16-character dot matrix alphanumeric liquid crystal display.
Display language	English standard
Parameters displayed	Turbidity (NTU) – default
	Relative Turbidity Reference (NTU)
	Relative Turbidity (Turbidity-Relative Turbidity Reference NTU)
Date/Time	Default
Reading	Updated every 1 second
Averaging period	0.5 second or 10 seconds nominal - user selectable
Range Steps	1 <0.1 to 20 NTU
	2 <1 to 100 NTU
Resolution	1 0.02 NTU
	2 0.1 NTU
	3 1 NTU
	4 10 NTU
Repeatability	2% ± digit on all ranges
Data Logging	User set for one reading every 1 to 90 seconds or minutes. All readings stored in the Notepad.
Notepad	100 readings each with time and date
Setup procedures	Menu driven, including
	- Calibration
	- Automatic Logging
	- Analogue output range selection
	- Reference Turbidity value
	- Setting date and time.
Setup memory	Non-volatile EEPROM
Clock	Calendar clock displays date and time.
Analogue Output	0 - 2 volts full scale corresponding to preset measurement range. Output impedance 200 ohms nominal.
Good Laboratory Practice	All readings as well as calibration constants are stored together with the Time and Date and can be recalled at and time
Power:	
Internal	6V NiMH rechargeable battery
External	220V AC, 50 Hz Supply (with Adapter if necessary)
Power management	Automatic power down when operates from batteries after approx. 5 minutes may be selected. Automatic power up when powered externally. Low battery indication prior to shut down.
Measurement outputs	Inbuilt LCD, analogue output and optional RS232 port
RS232 Port	The RS232 port can output readings on request or at preset intervals of time from 1 to 90 seconds or minutes. The Notepad memory can also be downloaded on request. 9200 baud rate, 8 bits, no parity, 1 stop bit, Xon/Xoff protocol
Operating temperature	0 to 50°C

Operating humidity	0 to 90% RH
Storage temperature	-10 to 60°C
Case rating	IP65

(iii) Portable Nephelometric Turbidity Meter

814. The instrument should be based on the principle of Tyndall effect. The meter should be direct reading instrument between 0-1000 Turbidity in 4 ranges for accuracy.

Table 57: Portable Nephelometric Turbidity Meter Specifications

Range Five ranges	(1)	0 - 1 NTU
	(2)	0 - 10 NTU
	(3)	0 - 100 NTU
	(4)	0 - 1000 NTU
	(5)	0 - 1000 NTU
Display		4 - digit Digital display
Accuracy and reproducibility		Within ± 2% of FSD in 0-1 and 0 - 1000 NTU (up to 500 NTU) range, ± 1 % of FSD in 0-10 and 0-100 NTU ranges.
Detector		Visible range photo cell
Power Supply		230 V AC + 10%, 50 Hz.
Accessories	(a)	Flat Bottom test tubes -25 mm dia - 4 Nos.
	(b)	Cell riser
	(c)	Height shield

(iv) Pocket Dissolved Oxygen Meter

815. The D.O. meter shall digitally display the temperature of the liquid being tested from 0 to 50 °C (resolution to 0.1 °C) and the dissolved oxygen (DO) level in either percent saturation from 0 to 200% (resolution to 0.1%) or concentration from 0 to 20 ppm (resolution to 0.01 ppm), as selected by the user. The meter shall have adjustable altitude compensation from 0 to 20,000 ft in 1,000 ft increments and adjustable salinity compensation from 0 to 50 parts per thousand. The meter shall have an automatic temperature compensation of 2% per degree C and be accurate to +/- 2% of full scale on all measurements. The meter shall have the storage capacity memory for 25 data sets.

816. The meter shall consist of a DO electrode with a protective cap, rechargeable NiHM batteries and a neck strap. The meter shall be waterproof to IP 57. One (1) liter of electrolyte solution shall be furnished with the meter. The nominal dimensions of each meter shall be 175 mm long by 40 mm wide and deep. A 1.0 m long extension cable with a probe weight shall be furnished with each meter. Two (2) spare DO electrodes need to be furnished.

(v) Pocket Conductivity Meter

817. EC meter shall digitally display the temperature of the liquid being tested from 0 to 65 oC (resolution to 0.1 oC) and the conductivity level in any of 3 ranges (0 to 199.9 / 200 to 1999 / 2,000 to 19,999 □□ohms/cm2). TDS and salinity shall each be able to be measured over 3 ranges (0 to 99.9 / 100 to 999 / 1,000 to 9,999 mg/l), as selected by the user. The meter shall be accurate to +/- 2% of full scale on all measurements. The meter shall have the storage capacity memory for 15 data sets.

818. The meter shall consist of the meter body, a Conductivity cell with a protective cap, rechargeable NiHM batteries and a neck strap. The meter shall be waterproof to IP 57. One (1) liter of electrolyte solution shall be furnished with each meter. The nominal dimensions of

each meter shall be 175 mm long by 40 mm wide and deep. Two (2) spare Conductivity cells shall be furnished.

(vi) Pocket Total Chlorine Meter

819. The meter shall digitally display the temperature of the liquid being tested from -5 to 90 degree Centigrade (resolution to 0.1 degree Centigrade) and the total chlorine level I from 0.01 to 10 ppm. The meter shall be unaffected by Colour or turbidity. The meter shall be accurate to +/- 10% of the reading value. Each meter shall consist of the meter body, a flat surface Chlorine electrode with a protective cap, rechargeable NiHM batteries and a neck strap. Each meter shall be waterproof to IP 57. The nominal dimensions of each meter shall be 175 mm long by 40 mm wide and deep. Two (2) spare Chlorine electrodes need to be furnished.

(vii) Centrifuge

820. The centrifuge shall be compact, sturdy, dynamically balanced and be equipped with vibration dampeners. The speed of rotation shall be controlled with a step-less speed regulator and shall be supplied complete with a status indicator light, plug and power cord and rated to operate continuously for 60 minutes. Each unit shall have a digital speed indicator and a 0-99 minute digital timer.

Table 58: Centrifuge Specification

Parameter	Value / Range
Speed Range	0 to 4,000 rpm (minimum)
Maximum Centrifugal Force	3,000 g (minimum)
Rotor Type	Swing Out
Minimum Capacity	6 – 15 ml tubes
Connected Load	0.18 KVA
Nominal Dimensions	325 mm wide x 300 mm high x 375 mm deep

821. **Accessories.** 1 no. dust cover, 1 no. fixed angle type rotor for 15 ml tubes, 1 no. fixed angle type rotor for 15 ml tubes, 12 nos. 15 ml tubes and 6 nos. 50 ml tubes.

(viii) Chlorine Comparator

822. **Specifications.** Comparator should have capacity to measure the residual chlorine from 0.1 to 2.0 ppm by movable disc arrangement.

823. **Accessories.**Dialkyl 1,4 PhenyleneDiamine (DPD) solution, measurement tubes, a device (syringe) for taking desired quantity of sample and a separate movable discs, standardized for measuring Residual Chlorine.

Table 59: UV-visible Spectrophotometer

Measuring principle	Single beam
Lamp type	Xenon flash lamp
Wavelength range	190 – 1100 nm
Measuring modes	Concentration, Absorbance, % Transmission, Multi wavelength, Spectrum, Kinetics
Accuracy	± 1 nm
Spectral bandwidth	4 nm
Monochromator	Grating monochromator with step motor

Light sensor	Photodiode
Measuring range	A = -0.43300 to 0.43300
Linearity	< 1% for A (≤2.000 in range of 340 to 900 nm)
Stray light	< 0.1% Transmission at 340 & 408 nm
Cells used	Round cells (16mm); 13.6 mm internal dia; flat bottom
	Rectangular cells 10 mm, 20 mm, 50 mm – max. width 12.6 mm
Cell recognition	Automatic
Memory capacity	1000 datasets, 4 Mbyte internal memory
Output options	USB medium, Printer, PC

(ix) Automatic BOD Analyser

824. **Respirometric Principle.** Set of six sample bottle with six microprocessor based pressure sensors fitted with the bottles.

Table 60: Automatoc BOD Analyser

Measuring principle	Manometric with pressure sensor
Measuring range	0 to 40 (display unit)
Display	2 characters, LED
Memory	For BOD daily
Power supply	Lithium battery (280 m Ah), 2 X CR-2430
Dimension	69 X 70 mm

(x) BOD Incubator

825. Suitable to work at 230 V with automatic control heating or cooling circuits according to environmental temperature, made of mild steel wall with enamel paint, inside chamber should be anodised, adjustable shelves made of Aluminium and full inner view glass doors. Temperature control device German thermostat.

Control panel	:	Digital
Chamber size	:	840 X 500 X 410 mm
Temperature range	:	50C to 500C
Operating Sensitivity	:	±0.50C

826. Forced air circulation to maintain uniform temperature with dial thermometer.

Table 61: COD Thermo-reactor (Digestor)

(Close Reflux Method)

No. of samples for simultaneous digestion	12
Temperature selection	100^0C, 120^0C and 148^0C
Stability and accuracy	± 1 ^{0}C
Display	LCD
Cut off	automatic
Power	115 – 230 V AC; 50 Hz/60 Hz convertible
Size (approx.)	180 (H) x 256 (B) x 307 (D) mm

(xi) Laminar air flow cabinet

827. Dimension of working place: 900 X 600 X 600 mm. Tabletop (working place) should to be made of stainless steel sheet. Front of the cabinet should be provided with folded UV

resistant glass/polyacrylic material. Other two sides, except back side, should also be provided with above material, Blower assembly need to made of single Stage double shaft motor. The unit should be complete with pressure manometer, UV lamp, fluorescent lamp, movable wheel.

(xii) Refrigerator

828. The laboratory refrigerator shall be a freestanding unit with a 450 liter capacity. The inner and outer panels shall be made of stainless steel. There shall be 50 mm of polyurethane foam insulation between the inner and outer panels. The unit shall have double door with a double gasket seal. Castor wheels shall be mounted on the bottom of the unit. At least 3 shelves shall be provided. A microprocessor based temperature controller with a digital LED display shall be provided. The temperature range shall be +2 oC to +8 oC. The refrigeration compressor shall be air cooled with a low noise level (< 60 dBA) and very minimal vibration. A back-up refrigeration system shall be provided. The condenser shall have an automatic condensate evaporating system. The power supply shall be 220V/1ph/50Hz AC.

(xiii) Incubators (2 Nos.)

829. Incubator made of Aluminium sheet, inner door of glass with 3 adjustable shelves with temperature control system with accuracy of +/- 0.50C. Double wall should have proper glass wool insulation system. The incubator should be provided with an internal fan for even circulation of temperature throughout the inner chamber. Thermostatically controlled.

Control panel	:	Digital
Dimension	:	600 X 450 X 450 mm
Operating temperature:		50C above ambient to 900C
Power	:	220-250 V AC

(xiv) Water bath (Serological)

830. The tabletop Water Bath shall be housed in a rectangular shaped body, double walled type 304 stainless steel on the inside with a mild steel powder epoxy coated outer housing. The cover of the water bath shall be made of type 304 stainless steel with a hole for inserting thermometer. The temperature range of the unit shall be from ambient to 100 degree C. The temperature shall be controlled by an electronic digital temperature controller with a digital indicator and an accuracy of plus/minus 0.5 °C. The water bath shall consist of 2 pilot lamps, with an on/off switch. The water bath shall have a built-in constant level maintenance arrangement. The power supply shall be 220-230v/1ph/50hz AC rated at 1.5 kW. A stirrer with a 1/20 H.P. high speed motor and stainless steel stirring rod/blade shall be furnished. The stirrer motor shall have a speed regulator.

Inner chamber dimensions	:	750 (l) mm X 450 (b) mm X 300 (h) mm.
Accessories	:	Thermometer, Plug and chord.

(xv) Water Bath

831. Rectangular water bath, should be totally made of copper, heavily tinned inside and outside finished in enamel. The cover should be chrome plated and should have 12 holes of 7.5 cm diameter concentric rings (3 sizes of each hole) with lid made of copper. The water bath should be fitted with thermostatically controlled Swan type ejection electric heaters. It should have built-in constant level arrangement with water level indicators.

Dimensions	:	400 X 300 X 90 mm
Rating	:	1.5 KW
Temperature range	:	ambient to 1000 C
Power	:	230 – 220 V AC
Accessories	:	Thermometer, Plug and chord.

(xvi) Autoclave

832. The Autoclave shall be of the freestanding vertical type, sturdy double walled construction with the boiler made of stainless steel of adequate thickness plus a corrosion allowance to assure a 15 year life. The outer shell shall be made of stainless steel also. The boiler and outer shell should have air insulation. The lid shall be made of stainless steel plate and tightened all-round by wing nuts. Molded joint-less lid gaskets shall be made of neoprene rubber.

833. The Autoclave shall be fitted with water level elements to indicate water position inside the boiler, a pressure gauge, air and steam release valves, a spring loaded safety valve which can be set at any selected point from 10 psi (0.70 kg/cm2) to 25 psi (1.75 kg/cm2) +/-3 psi (0.2 kg/cm2) and a drain valve. An ISI marked immersion type heating element shall be provided to heat to the desired temperature between 110 ^{o}C to 140 ^{o}C in 1 ^{o}C increments. The Autoclave shall be equipped with a digital temperature indicator/controller.

834. The chamber size shall be: 550 mm high by 300 mm diameter. The unit shall be supplied complete with a stainless steel basket, cord and plug to work from a 220v/1ph/50hz AC supply. The nominal heater load shall be 3 KW.

835. An automatic low water level cut-off device shall be furnished to prevent the heaters from operating in a ‘dry’ condition. An automatic pressure control device shall be furnished to control the pressure inside the chamber mechanically. A mechanical timer shall also be provided t0 regulate the sterilization time of the media to be sterilized and when the desired time has passed, a buzzer shall be activated to indicate that the sterilization cycle is complete and media can be extracted. Two spare heating elements need to be supplied with the unit.

(xvii) Colony counter

836. An electrically operated tabletop Colony Counter with a digital LED display suitable for bacterial plate count shall be furnished complete with counting plates and lens.

837. The Colony Counter unit shall have the following features:

- Microprocessor control for determination of microbial count.
- Provide uniform lighting of round or square culture dish up to 110 mm wide.
- Viewing area shall be illuminated obliquely by a peripheral metal reflector.
- Field is magnified by a 1 to 7 mm lens, mounted adjustably on panel.
- Provide a manual electrode which touches the surface of the culture colony at
- Each point being counted.
- Count is totalized automatically on a 5 digit register, reading to 99,999.
- A rectangular pushbutton below register resets the count to zero.
- ISI mark or other equivalent quality certification.
- Nominal dimensions in mm: 300 wide x 300 long x 200 high
- Power supply: 220V/1ph/50Hz

(xviii) Jar test apparatus

838. Jar testing machine with electrically operated 6 stainless steel paddle, equipped with suitable motor to give rotation from 10 to 200 rpm in all paddles. It should be provided with motor and gear-chain system of rotation and a speedometer to note the speed. The equipment should hold 6 glass beakers of 1-liter capacity each at a time. The arrangement of paddles should be such that they can be lifted to remove the beakers without disturbing the test liquid.

(xix) Single pan electrical balance

839. A table-top electrically operated analytical balance shall be furnished complete with case and having 2 sliding side doors and a fixed front glass panel. The Balance shall have 2 scale ranges as described below.

840. The balance shall have the following features:

- Digital indication with large figures for rapid and precise reading
- Clearly lit scale window where the figures immediately above and below the measured value are also visible through green transparent shades
- A very short settling time and high weighing accuracy
- All controls conveniently located for efficient and reliable operation
- A drop weight system with built-in drop weights in anti-magnetic stainless steel
- A zeroing device for setting the loaded machine to zero reading
- A stainless steel pan
- Floor of weighing space also of glass
- Powder coated pressure die cast aluminium housing
- (1) A minimum capacity of 80 grams, with an accuracy of +/- 0.05 mg and a readout in
- 0.01 mg increments
- (2) A minimum capacity of 200 grams, with an accuracy of +/- 0.1 mg and a readout in
- 0.1 mg increments
- Power supply: 220-230v/1ph/50hz AC
- Diameter of weighing plate or pan to be nominally 75 mm.

(xx) Double pan Manual balance

841. A beam type Chemical Balance complete with case, weight box, and a ‘short’ beam of hard brass. Bearings and knife edges shall be made of best selected agates ground to optical precision. The case shall be finely polished wood with two glass side doors and a sliding glass front door. The case shall have a sun mica base. The Chemical Balance shall have a minimum capacity of 200 grams, with a sensitivity of 0.2 mg. The 2 pans shall be of the inverse type made of stainless steel and have a diameter of 70 mm each. The overall nominal dimensions shall be: 360 mm long by 260 mm deep by 460 mm high. The Balance shall require no power supply. Two (2) complete sets of weights need to be supplied with the Balance.

(xxi) Water distillation unit

842. Electrically heated with boiling chamber, lid and cooling jacket, made of stainless steel, Provided with two automatic ejection type heater, constant water level device, table-top, complete with rubber tubes, plug and chord and adapter.

Power	:	220 V AC
Capacity	:	Approx. 4.0 liters per hour
Rating of elements	:	1.5 KW each

843. Two spare heating elements need to be supplied with the unit.

(xxii) Double water distillation unit

844. Distillation unit, double stage with quartz boiler, borosilicate condenser and built-in quartz heater. The unit should be with auto-cut-off system with audio alarm in double stage unit.

Maximum output	:	2 L per hour
Power	:	220 V AC

(xxiii) Magnetic Stirrer with Hot Plate

845. A Magnetic Stirrer with a Hot Plate of 2 liter capacity shall be provided having separate stirring and temperature control regulators for setting the stirring rate and temperature. It shall have a compact stirring device utilizing a magnetic field, which induces a variable speed stirring action. Stirring shall be accomplished by means of a small (25 mm) teflon rotor, which when placed in the liquid to be stirred is capable of rotation by magnetic field applied from below the container. The unit shall be fitted with a pilot lamp and work off of a 220-230V/1ph/50 Hz AC power supply. The speed of the stirrer shall be able to be varied between 40 to 1400 rpm. The maximum temperature setting shall be 175 oC. Ten (10) 25 mm teflon stirring rotors and (6) 2 liter mixing beakers shall be furnished along with the unit.

(xxiv) Laboratory thermometer (3 nos.)

846. Beckmann type – up to 633 °K

(xxv) Electric hot air oven

847. A tabletop hot air type laboratory Oven shall be furnished. The Oven shall be doubled walled with inner chamber of stainless steel sheets and outer body made of epoxy powder coated MS sheets. The gap shall be filled with a minimum thickness of 50 mm of mineral glass wool for proper insulation. The temperature shall be thermostatically controlled, ranging from 50 to 250 °C. The temperature controller shall have an accuracy of plus/minus 2 °C. Heating elements shall be made of high grade chrome plated nicrome wire and placed on the bottom side of the unit. The power supply shall be 220-250V/1ph/50Hz AC. Air ventilation shall be provided on the top of the unit to remove the hot gases / fumes. The control switches and pilot lamps shall be mounted on the front panel. Four (4) stainless steel trays shall be supplied with GI wire mesh.

848. The chamber size of the oven shall be: 450 mm wide by 459 mm high by 600 mm deep.

(xxvi) Vacuum pump with 1 L suction flask

849. Two (2) oil free chemical resistant (acid, alkali and organic solution resistant) Vacuum pumps shall be furnished. All wetted parts shall be made of PTFE material, with the outer case covered with squeeze-casting aluminium and anti-rust treatment. The pumping mechanism shall be an air driven diaphragm.

850. The vacuum pump shall be capable of pulling a maximum vacuum of 750 mm Hg (99.9 kPa). The rated vacuum capacity shall be 22 liters per minute at 100 mm Hg and 12 liters per minute at 400 mm Hg vacuum. The maximum power draw of the pump shall be no more than 100 watts. The pump shall have a 1/6 hp 1,450 rpm motor which operates off of a 220-240V/1ph/50Hz AC power supply. The pump shall have a low-noise design with the noise level not exceeding 55 dBA. The pumps shall be equipped with a thermal protection device that will automatically shut them down and they won't be able to resume operation until their temperature cools down,

851. Four (4) 1,000 ml and (6) 500 ml glass suction flasks shall be furnished with the pumps. Each flask shall have a protruding hose connection nozzle to match the suction connection of the vacuum pump. Six (6) meters of hose need to be provided.

(xxvii) Phenol distillation apparatus

852. Complete set of glass wares of Phenol distillation apparatus with mantle heater, support rods, universal clamps and clamp holders.

853. The heater should have a single element, 200 watt mantle with adjustable heat and a variable speed, bi-directional magnetic stirring motor. The heat block should be sized for a 500 ml distillation flask. Operating panel should have control switches for heat control, stir speed control with a power switch.

854. The unit should also be provided with power and heater indicator.Power: 230 – 220 V AC.

Table 62: Laboratory Glassware

Glassware & Plastic wares required for each WTP attached Water Testing Laboratory

Sl No	Items	Capacity	Number of item (s)
1	Burettes	25 ml	1
		50 ml	1
2	Burettes (Polypropylene)	50 ml	1
3	Graduated pipettes	0.1mL	6
		1 ml (bulb)	3
		1 ml	6
		2 ml	3
		5 ml	3
		5 ml (bulb)	
		10 ml	6
		25 ml (bulb)	2
		35 ml (bulb)	2
4	Graduated pipettes (Polypropylene)	5 ml	6
		10 ml	6
5	Erlenmeyer flasks	100 ml (standard joint)	12
		250 ml	12
		500 ml	3
6	Volumetric flasks with glass stopper	5 ml	12
		100 ml	6
		250 ml	6
		500 ml	3

Sl No	Items	Capacity	Number of item (s)
		1000 ml	3
7	Beakers	100 ml	6
		250 ml	6
		500 ml	3
8	Beakers (Polypropylene)	50 ml	6
		100 ml	6
9	Measuring cylinders	25 ml	2
		50 ml	2
		100 ml	3
		250 ml	2
		500 ml	1
10	Measuring Cylinders (Polypropylene)	50 ml	3
		100 ml	3
11	Reagent bottles	50 ml	2
		100mL(amber)	2
		100 ml	2
		250 ml(amber)	3
		250 ml*	12
		500 ml	2
12	Funnels	50 mm dia	3
		75 mm dia	3
13	Separatory funnel with teflon stop-cock	250 ml	2
		500 ml	3
		1000 ml	2
14	Rectangular Cuvettes (Quartz)	10 mm	2
		20 mm	2
		50 mm	2
15	Flat bottom flask	250 mm 500 mm 1000 mm	3 3 3
16	Round bottom flask	500 mm 1000 mm	3 3
17	Distillation flask (for oil & grease)	125 ml	2
18	Petri dish	90 x 15 mm	12
19	Petri dish (polystyrene)	90 x 15 mm	12
20	Bent tube (arsine absorber)	standard joint	12
21	Scrubbers	standard joint	12
22	Watch glass	100 mm dia	12
23	Culture tubes(Borosil / Duran) with screw caps*	122 x 35 mm (30 ml)	144
		150 x 12 mm (20 ml)	100
24	Durham's vials*	40 x 4 mm	150
		20 x 40 mm	100
25	Glass Dropper with rubber teat Dropper (polypropylene)	120 mm	6
26	Test tubes	150 x 18 mm	24
		100 x 13 mm	18
27	Nessler tubes (graduated)	50 ml	6
28	Desiccators	12"	2

855. All glasswares should be of best quality like 'Borosil'/'Corning'/'Duran' and plastiwares of 'Tarson' make.

Table 63: Accessories

Sl No	Items	Capacity	Number of item(s)

Sl No	Items	Capacity	Number of item(s)
1	Funnel stands (polypropylene)	-	2
2	Test tube stands (polypropylene) for holding 30 ml culture tubes)	20 tubes	6
3	Pipette stand (polypropylene)	28 pipettes	1
4	Burette stand (polypropylene)	-	2
5	Nessler tube stand (polypropylene)	6 tubes	3
6	Metallic stand for separating funnel	with holders to hold 250, 500 & 1000 ml funnel	3
7	Stand for round bottom flasks	-	2
8	Test tube holder with adjustable clamp	-	3
9	Aspirator bottles (polypropylene)	5000 mL	2
10	Trays with handles (Aluminium)	350 x 350 mm (to fit inside the oven)	3
11	Test tube baskets (polypropylene ; autoclavable)	200x200x150 mm	6
12	Ice boxes (polypropylene)	12 litres capacity	2
13	LDPE containers (for sample collection ; with cap and screw hat)	200 mL 100 mL	12 12
14	Aluminium pipette case (required for autoclaving)	480 x 75 mm dia	2
15	Auto pipette	Tips of variable volume (1 to 10 ml)	100 tips of each vol.
16	Filter papers (Qualitative no 1)	125 mm dia	24 boxes
17	Tissue papers	-	24 rolls
18	Wide range pH papers (2-10.5)	Book of 10 leaves	10 books
19	Inoculation loops with handle	(for bacteriological inoculation)	3
20	Tong (s. steel)	250 mm long	2
21	Forceps (s. steel)	2",4" and 6" (fine tip)	2 each
22	Pipette sucker (polypropylene)	-	3
23	Glass wool	200 g (pack)	4 packs
24	Silicon grease	250 g pack	5
25	UPS (for spectrophotometer)	1 KVA	1
26	Spirit lamps (glass/s.steel)	-	2
27	Solvent for spirit lamp	5 lits. jar	1
28	Polypropylene Wash bottles	450 mL capacity	3
29	Polypropylene drop bottles	100 mL capacity	2
30	Aluminium foil	-	20 roll
31	Glass Marker pen	-	3
32	Fume preventing mask	-	3
33	Thin rubber gloves	-	6 pairs
34	Thick rubber gloves (acid proof)	-	3 pairs
35	Aprons	Free size	6 nos.
36	Laboratory slippers	-	6 pairs
37	Test tube cleaning wash- brush	200 mm long	6
38	Test tube cleaning wash- brush	300 mm long	3
39	Flask cleaning wash-brush	300 mm long	3

Sl No	Items	Capacity	Number of item(s)
40	Towel	medium size	3 each
41	Cloth duster	coarse & fine	3 each
42	Feather duster	-	2
43	Plastic bucket	15 lit. capacity	1
44	Plastic tub	600 mm dia	1
45	Waste paper basket (plastic)	Big size	2
46	Steel almirah	Standard size	1
47	Liquid detergent - Extran	5 litre can	2
48	Commercial grade HCl 1.16 purity	5 litre can	2
49	First Aid Box	-	1
50	Fire extinguisher	-	2

Table 64: Laboratory Reagents

Sl. no.	Parameter	Chemicals and Reagents required	Quantity per unit	Annual requirement of units(approx)
1	Hardness	Ammonia buffer	500 ml	1
		Disodium dihydrogenversanate solution, 0.02N (EDTA N/50 solution)	500 ml	2
		Eriochrome black T	25 gm	1
		Triethanolamine	500 ml	1
2	Alkalinity	Sulphuric acid, N/50 solution	500 ml	1
		Sodium carbonate solution, 0.1 N	500 ml	2
		Methyl red indicator (0.01%)	125 ml	1
		Phenolphthalein (0.04%)	125 ml	1
3	Iron	Spectroquant – iron reagent	500 tests	1
		Iron standard, 1000 mg L^{-1}	100 ml	1
4	Calcium	Spectroquant – calcium reagent	250 tests	1
		Calcium standard, 1000 mg L^{-1}	100 ml	1
5	Magnesium	Spectroquant – magnesium reagent	25 tests	4
		Magnesium standard, 1000 mg L^{-1}	100 ml	1
6	Manganese	Spectroquant – manganese reagent	50 tests	2
		Manganese standard, 1000 mg L^{-1}	100 ml	1
7	Chloride	Spectroquant – chloride reagent	175 tests	1
		Chloride standard, 1000 mg L^{-1}	100 ml	1
8	Sulphate	Spectroquant – sulphate reagent	200 tests	4
		Sulphate standard, 1000 mg L^{-1}	100 ml	1
9	Nitrate nitrogen	Spectroquant – nitrate reagent	200 tests	1
		Nitrate standard, 1000 mg L^{-1}	100 ml	1
10	Ammonical nitrogen	Spectroquant – ammonia reagent	500 tests	1
		Ammonia standard, 1000 mg L^{-1}	100 ml	1
11	Fluoride	Spectroquant – fluoride reagent	250 tests	1
		Fluoride standard, 100 mg/L	100 ml	1
12	Arsenic	Hydrochloric acid, 12 M	500 ml	2
		Potassium iodide	100 gm	1
		Tin (II) chloride dihydrate	100 gm	1
		Lead (II) acetate trihydrate	100 gm	1

Sl. no.	Parameter	Chemicals and Reagents required	Quantity per unit	Annual requirement of units(approx)
		Zinc granules (arsenic free)	500 gm	2
		Chloroform	500 ml	2
		Morpholine	500 ml	1
		Silver diethyldithiocarbamate	5 gm	1
		Arsenic standard (1000 mg L^{-1})	100 ml	1
13	Bacteriology	Mac Conkey broth	500 gm	2
		Brilliant green lactose bile broth	500 gm	1
		EC broth	500 gm	1
		Sodium chloride	100 gm	1
		Sodium thiosulphatepentahydrate	500 gm	1
		Sulfate API broth	500 gm	1
		Biosol (sterilizing solvent)	475 ml	2
14	Aluminium	Spectroquant – aluminium reagent	200 tests	1
		Aluminium standard, 1000 mg L^{-1}	100 ml	1
15	Lead	Spectroquant – lead reagent	50 tests	1
		Lead standard, 1000 mg L^{-1}	100 ml	1
16	Copper	Spectroquant – copper reagent	200 tests	1
		Copper standard, 1000 mg L^{-1}	100 ml	1
17	Zinc	Spectroquant – zinc reagent & zinc reagent 6	200 tests	1
		Zinc standard, 1000 mg L^{-1}	100 ml	1
18	Chromium	Spectroquant – chromium reagent	250 tests	1
		Chromium standard, 1000 mg L^{-1}	100 ml	1
19	Cadmium	Spectroquant – cadmium reagent	250 tests	1
		Cadmium standard, 1000 mg L^{-1}	100 ml	1
20	Nickel	Spectroquant – nickel reagent	250 tests	1
		Nickel standard, 1000 mg L^{-1}	100 ml	1
21	Mercury	Sodium acetate anhydrous	500 gm	1
		Acetic acid (pure)	500 ml	1
		4.4'-Bis-(dimethylamine)-thiobenzophenone	10 gm	2
		1-Propanol	500 ml	2
		Mercury standard, 100 mg L^{-1}	100 ml	1
22	COD	Spectroquant COD solution A	215 tests	1
		Spectroquant COD solution B	175 tests	1
		Potassium hydrophthalate	500 gm	1
23	Phenol	Chloroform	500 ml	1
		Copper sulphate	500 gm	1
		Phosphoric acid	500 ml	1
		Ammonium hydroxide	500 gm	1
		Sodium chloride	500 gm	1
		Potassium bromide	500 gm	1
		Potassium bromate	500 gm	1
		Sodium thiosulphate	500 gm	1
		Starch	500 gm	1
		Hydrochloric acid	500 ml	1
		Ammonium chloride	500 gm	1
		Potassium iodide	500 gm	1
		Potassium ferrocyanide	500 gm	1
		Spectroquant – phenol reagent	200 tests	1
		Phenol standard, 1000 mg L^{-1}	100 ml	1
24	Detergents	Spectroquant – MBAS reagent	200 tests	1

Sl. no.	Parameter	Chemicals and Reagents required	Quantity per unit	Annual requirement of units(approx)
25	Residual Chlorine	Microquant DPD reagent bottles	25 ml	10
26	Oil & Grease	Hydrochloric acid, 12 M	500 ml	1
		n-Hexane	500 ml	1
		Sodium sulphate anhydrous.	500 gm	1

Notes:

- Chemicals/Reagents should be of AR/GR/LR grade.
- Chemical parameters tested with 'Spectroquant Reagents' are all programmable. If tested through programme, standard solutions are not required.

s. Maintenance Building / Equipment Storehouse

856. A Maintenance Building and Equipment Storehouse shall be constructed to accommodate the requirements of Phase 2 also. The Maintenance Building and Equipment Storehouse may be a single structure or they may be 2 separate structures, at the Contractor's option. They both shall be single story buildings.

857. The shop and storage areas shall be ventilated to the outdoors with exhaust fans and lovers. The various rooms to be built are listed in the subsection below. The welding and paint shops shall be ventilated at an exhaust rate of 15 air changes per hour in each. The office shall be air conditioned

858. The clear ceiling height in this building shall be a minimum of 4.8 m in all areas except the office. The office shall have a drop or false ceiling set at a height of 3.0 meters above the finished floor.

859. This unit will be for the Intake,WTP and CWPH only. It will not be meant for accommodating facilities other than intake, WTP and pump house. The building will be located at Pre-settling tank site.

860. The Maintenance Building and Equipment Storehouse shall be divided into rooms as shown in the following schedule:

Table 65: Room Schedule (Maintenance Building and Equipment Storehouse)

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Main (Mechanical) Workshop	1	72	7	1 & 3	1-C, 1-E, 1-A	2-A
Painting Shop[2]	1	16	7	1 & 3	K	None
Electronics Shop	1	16	7	1 & 3	F	1-C
Storage						
Dry Goods/Spare Parts	1	54	7		G	None
Chemicals[3]	1	20	7[4]	1 & 6	K	None
Flammables[3]	1	16	7[4]	1 & 6	K	None
Electrical Room	1	10	7	1 & 3	G	None
Washroom	1	6				

Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works

1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
is given then it shall be taken as 1 2. The ventilation in the Paint Shop shall be designed with a hooded area to provide 2 air changes per minute to the area below the hood, when the system is activated. The air velocity shall be 0.35 m/s. The hooded area shall cover 8 m^2 of floor area. 3. Walls , doors and windows shall have a 2 hr fire rating 4. Acid resistant floor tiles shall be installed in this room						

t. Guard House

861. A Guard House shall be constructed at the main entrance gate to accommodate the Phase 2 WTP requirements and one at Intake structure.

862. The Guard House shall be divided into rooms as shown in the following schedule:

Table 66: Room Schedule (Guard House)

Room	No.	Min Area Each (m^2)	Coating System or Type No.[1]			
			Flooring	Walls	Doors	Windows
Main Room	1	12	8	1 & 4	A & F	1-B, 1-C
Covered Porch	1	5	7	Open	N/A	N/A
Notes: For Coating System or type refer clause **1355** of Specification Civil, Building and Road works 1. Notations such as 1-C denotes No. of Items (1) and type of Item (C) whether a door or window. If no number is given then it shall be taken as 1 2. Refer Painting Schedule						

u. Final Finishing

863. The Contractor shall ensure that each entire building along with all its installed equipment, furnishings, etc. are in a finished, new and fully operative condition when handed over for Commissioning. The Contractor shall have repaired and removed all signs of damage that might have occurred during the course of construction and installation of equipment. He shall also see that the entire exterior has been finished properly and the entire site has been cleared of all extra construction material, debris and excavated soil. This shall be done to the satisfaction of the Employer's Representative.

v. Water Services

864. The water supply for the whole water treatment plant shall have two circuits: Process Water and Potable / Utility Water.

865. **Process Water:** Process water shall be supplied from the backwash water tank and shall be used for the backwashing of the filters

866. **Potable/Utility Water:** The Contractor shall provide potable (drinking) water facilities throughout the WTP campus. Potable water service shall be provided to/for:

a. Administration Building,
b. Chemical House
c. Filter House
d. Chlorine Building
e. the Clear Water Pump House
f. Solids Dewatering Building
g. Guard House

h. supply for desert (evaporative) coolers
i. wash down of process tanks and walkways
j. landscape irrigation
k. and at any other location required by the Employer's Representative.

867. Each building being served potable water shall be fitted with an HDPE roof tank. Each roof tank shall be installed in a shaded location out of the sunlight. A frame with a canopy cover shall be fitted around and over each roof tank. The frame and cover arrangement shall be aesthetically pleasing and shall compliment the building's architectural scheme.

868. Potable / utility water shall be conveyed in ductile iron pipe for diameters of 100 mm and above. For smaller diameters, galvanized iron or PVC/CPVC shall be used depending upon the service and location. Galvanized iron (GI) piping shall be used in all exposed locations, unless a variation is approved by the Employer's Representative. PVC/CPVC piping may be used for buried installations.

869. Isolation valves shall be metal body sluice type valves, except that metal body ball valves may be used for valve diameters below 50 mm.

870. **Utility Water Pumps:** Potable / utility water shall be pumped from the clear water reservoir by dedicated pumps (2 duty + 1 standby) located in the clear water pump house to service reservoir. A residual pressure of 1.5 m shall be maintained at the reservoir (above full supply level).

871. **Backflow Prevention:** Either of the following 2 options shall be implemented by the Contractor, to provide backflow and cross-connection protection:

a. Install a backflow prevention device (a double check valve or reduced pressure type) with an upstream and downstream isolation valve at each building or cluster of structures. The downstream piping to uses such as wash down, irrigation, chemical dilution or dosing, evaporative) coolers, etc. shall be kept entirely separate from any potable water piping. Emergency valve connections between the 2 systems shall not be allowed.
b. Install a backflow prevention device (a double check valve or reduced pressure type) with an upstream and downstream isolation valve off of the discharge manifold of the utility water pumps and run an entirely separate non-potable water piping network within the WTP campus.

872. **Site Drainage.** The Contractor shall provide 2 site drainage systems. The systems shall be:
a. Storm water Drainage
b. Sanitary and Process Drainage.

873. **Storm Water Drainage.**Storm water drains shall be run along the proposed roads and between process units as required and shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff of pervious and impervious areas (only the areas of open tankage may be disallowed). Drains shall be made of RCC.

874. The storm water system shall have a main drain outlet leading to a public drain, as approved by the Employer's Representative. The drainage water may have to be piped along a public street to access the nearest public drain of adequate flow carrying capacity. The Contractor shall factor this into his Bid Price and not seek additional compensation later on.

875. **Sanitary and Process Drainage.** The sanitary drainage system shall accept discharge from toilets, duty rooms washrooms and the laboratory. The sanitary drainage system shall discharge to a septic tank of appropriate capacity and the supernatant shall discharge into a leach field to be located away from the WTP process units.

876. Process drainage shall consist of wash down water and some tank emptying drainage. This shall be routed with the sanitary drainage and can be combined with it.

877. All drains (except storm water drains running along the roads) shall be covered and designed structurally for appropriate loads.

878. The discharge rate of process drainage shall be regulated as to not overload the leech field.

w. Cable, Pipe and Valve Chambers

879. **Trenches.** Adequate size of Cable trench and pipe trenches shall generally be constructed out of reinforced concrete. However, trenches with cross-section dimensions of 500 mm x 500 mm or smaller, not constructed on fill may be constructed using 350 mm thick stone masonry in cement mortar (1:4) over a 150 mm thick PCC base slab. The trenches shall be plastered internally with cement mortar (1:4).

880. Trenches within the buildings or Plant areas shall be covered with G.I. checkered plates, and those outside of buildings shall be covered with Class M20 precast RCC covers. The trenches shall be suitably sloped to drain off wash down or rainwater to a suitable location.

881. The layout of trenches outside of buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future expansion. This aspect shall be brought to the attention of the Employer's Representative while planning the work.

882. **Ducts.** RCC ducts for drainage shall be provided with manhole access where required and shall have a minimum 800 mm depth of soil cover while running across a road. Access shafts / manholes of a size not less than 600 mm x 1000 mm shall be provided.

883. **Valve Chambers.** All valve chambers shall be of an adequate size to facilitate the ease of operation and maintenance. The base slab of valve chambers shall slope towards a sump pit from which water can be pumped out to make the chamber dry. All valve chambers shall be constructed of reinforced concrete. However, chambers having a size of 1,500mm x 1,500mm x 1,200 mm deep or less may be constructed using 350mm thick stone masonry in cement mortar (1:4). Chambers shall be plastered internally with cement mortar (1:4) 20 mm thick and shall be constructed over an RCC base slab. The minimum thickness of the base slab shall be 150 mm. Chambers shall be equipped with removable cast iron or precast concrete covers, approach ladders and valve supports as appropriate.

884. **Horticulture and Landscaping.** Horticulture and Landscaping shall be done according to the topography of the area and shall be planned so as to make the campus a focal point in the community. The areas left open to accommodate future expansion requirements must either be covered by a tree plantation or must be suitably grassed. Shadow trees must be planted at a maximum distance of 15 m c/c along the periphery of the campus area and along the roads. The campus shall be provided with gardens, seasonal flowerbeds and decorative plants.

885. Horticulture operations shall be performed on ground previously leveled and dressed to the required levels and slopes. In cases where unsuitable soil is encountered, it shall be removed and replaced with suitable earth.

886. **Materials.** Grass shall be fresh, free from weeds and rank vegetation but having rhizome with sufficient nodes and shall be approved by the Employer's Representative before planting. Manure used for soil amendment shall be well decayed and free from grit and any other unwanted materials. The earth to be used for gardening shall be free from kankar, moorum, building rubbish and any other foreign matter. It shall have a pH value ranging between 6.0 to 8.5.

887. **Tilling.** Tilling of the soil to depths between 300 to 600 mm shall be done in order to loosen the soil, and turn over and bury the top layer containing weeds etc. in the base and to bring up the lower layers of good earth to form a proper medium for planting grass, shrubbery and trees.

888. The earth shall be spread evenly over the surface with a twisting motion to avoid segregation of any layers.

889. **Grassing.** The soil shall be suitably moistened before the operation of planting grass shall commence. Generally planting in either direction at 10 cm spacing is done in the case of large open spaces and at 5 cm spacing for lawns.

890. **Planting trees.** Pits of square or circular shape in ordinary soil shall be excavated to the dimensions required by the trees to be planted and farm yard manure or sludge shall be added with powered neam / caster oil cake at the specified rate along and shall be uniformly mixed with the excavated soil.

891. **Tree guards.** Concrete tree guard 1,500 mm in height shall be provided as approved by the Employer's Representative.

892. **Maintenance of Landscaping.** The planted trees, gardens etc. so developed shall be maintained in good condition during the operation and maintenance period of the Contract without incurring any additional costs to the Employer.

893. The Contractor shall be required to water the landscaping as necessary during the operation and maintenance period. The water to be used for irrigation after Commissioning of the facility shall be furnished by the Employer at no cost to the Contractor.

894. The Contractor shall ensure the safety of plants and shall take on the activities such as re-planting, applying manure, fertilizing, the application of pesticides, mulching, cutting etc. to encourage the growth of trees and plants and to maintain them.

895. **Roads, paths, and hard-standing at WTP site.**Bituminous Concrete approach road from main road up-to the WTP is in the scope of the tender.

896. A comprehensive road network shall be provided to provide appropriate connectivity of the buildings and process units around the proposed treatment plant site to permit vehicular access to each unit of the plant for necessary O&M, delivery of consumables and personnel access. The internal roads shall be made as specified in the relevant subsection. Along the road, pre-cast cement concrete kerbs of approved shape and size shall be provided to prevent traffic from damaging the drainage structures.

897. The road layout shall have due consideration to the storm water drainage system so as to prevent standing water in the plant area and erosion due to storm runoff.

898. Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas.

899. Hard standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the plant area and leave again without going in reverse or carryout complicated maneuvers in order to exit the plant.

900. The work for the road construction shall include site clearance, preparation of earthen embankments, preparation of sub-grade, placement of sub-base (granular),placement of base course, placement of pre-mix carpet surfacing, drainage works, pipe culverts, shoulder construction, road markings, and other associated civil works and maintenance of the constructed road for 5 years. All the work shall be carried out as per the guidelines given under Section 13 of the Standard Specifications, the Ministry of Road Transport and Highways Specification (MoRTH IV Revision), Indian Road Congress Special Publication No. 13 (IRC13) and other relevant IRC specifications.

901. The new roads throughout the WTP campus shall have a bituminous wearing course laid on a dense graded bituminous macadam base course laid over a granular sub-base. All the roads shall be maintained and repaired as required during the entire project duration.

902. The WTP roadways shall be constructed to the following specifications (listed in order of construction sequence):

Table 67: WTP Roadways Specifications

Paving Course	Standard Specification No.	Course Thickness (mm)
Granular Sub-base	13.1	225
Prime Coat	13.6.4.5	--
Bituminous Macadam Base	13.6	200
Tack Coat	13.7.4.5	--
Bituminous Surface	13.7	75

Type of Roadway	Roadway Width (mm)
Main Road (2 lane)	6,750
Service Road (1 lane)	3,750
Parking Space	2,700 w x 5,800 l

903. **Preparatory Works.**The required survey for the planning and design of road systems shall be performed along with the survey for the pipelines. The Contractor shall, submit to the Employer's Representative for his approval, a profile along the road center line and cross-sections at intervals as required, but at no greater an interval than 50 m. The Contractor shall decide the locations for and the types of cross drainage and canal crossing structures to design. The hydraulic and structural design of all such works shall be approved by the Employer's Representative before commencement of the work.

904. The approval of the L-sections and location of cross drains will not limit the numbers of cross drains to be provided and if found necessary, during execution or maintenance, the

Contractor shall provide additional cross drains structures as directed by the Employer's Representative.

905. Considerations for Planning:

(i) The formation level of road in cutting must be kept considering that the drainage of the nearby area does not cause impounding during rains.
(ii) In embankments, suitable CD works must be provided to ensure that the embankment is not damaged during rains.
(iii) The formation levels must be kept to minimize frequent variations in the road gradient.
(iv) Suitable apron shall be provided upstream and downstream of the CD works crossing the road, if causeways, Hume pipe culverts or slab culverts are constructed.
(v) Wherever it is felt that the embankment may be damaged during heavy rains, the embankment suitable stone pitching must be done with suitable length of cut-off wall.

i. Technical Requirements

906. **Earth work.** The work should be executed as per MoRTH specification clause 300.

907. The sub-grade whether in cut or fill areas shall be well compacted. The top 500 mm portion of the sub-grade shall be compacted to achieve a minimum dry density of 97% as per IS 2720 (Part 8). In water prone areas, the level of the roadway surface shall be at least 600 mm above the 100 year flood level.

908. **Shoulder Construction.** Shoulder construction shall be as per MoRTH clause 407 shoulder (earthen/granular material) of 900 mm width on both sides of road which shall be treated with granular sub-base.

909. **Arboriculture.** The road side planting shall be executed just after the completion of the paving and shoulder construction. Shadow trees such as shisum, neem, pipal, gulmohar, semal, amaltas and morchidi, as approved by the Employer's Representative shall be planted at an average distance of 50 m c/c on one side of the road opposite to that of any pipelines. The height of saplings should be at least 1,500 mm. Plants should be replanted as soon as possible if they die off and at the time of Commissioning all plants shall be growing.

910. The arboriculture work includes:

i. Preparation of the soil including cleaning and removing of unwanted shrubs and removal of stones, rubble and garbage.
ii. Digging of pits of at least 60 cm depth, including removal of stones, maturing, application of insecticides and watering of the plants after planting.
iii. Procurement of required plants and planting.
iv. Safety and security of plants with shields, fencing, etc.

911. The Contractor shall be responsible to ensure the proper growth of trees, plants and to ensure their safety. The Contractor during the construction phase as well as during the operation and maintenance period shall under take all the following activities:

i. Watering of plants at required intervals.
ii. Re-planting at no additional cost any dead plants or damaged plants
iii. Other maintenance activities such as hoeing, weeding and fertilizing
iv. Pruning and trimming to encourage growth.

912. **Electric Service.** Suitably planned electrical works are to be installed to provide a power grid and to provide illumination along the roads, all along the boundary of the campus and at other important points within the gardens. In no case shall the spacing between two adjacent streetlight poles be at more than 30 meters along the internal roads and boundary walls.

913. All entrance doors to buildings shall be provided with light fixtures as specified in the design criteria in Subsection 7. CCTV cameras to be installed at entrance gate to monitor and avoid entry of trespassers, unwanted persons etc.

914. All cables shall be provided with clip-on identification numbers on both ends and at all terminations in between, for identification. The nomenclature shall correspond to the electrical as-built drawings.

915. The specifications for cabling, switches, junction boxes, receptacles, lamps etc. used for electrical works, shall conform to the provisions of Subsection 7.

916. **Garages.** Covered garages of 150 m^2 area each shall be constructed at 2 different locations within the WTP campus. Each floor shall be simple PCC flooring 75 mm thick with base concrete of 100 mm provided on soling stone. AC sheet roofing shall be provided and erected on a suitably designed MS framework having purlins and rafters. The garages shall not have doors.

917. **River bank protection works.** These works will be constructed by the Contractor on turnkey basis. Technical specifications of the proposed works are as below.

918. **River bank protection at WTP.** The river being major one with meandering nature and high velocity of water flow, it is proposed to construct comprehensive river protection works to the right bank of Ganga River.

919. The work is to be designed and executed according to IS 14262-1995 (Planning and Design of Revetment - Guidelines) and IS 8237-1985 (Code for Practice for Protection of Slopes for Reservoir Embankments).The work will be executed in three steps as below:

a. Revetment – Filling the uneven portion of bank with approved material to a specified level and slope with due compaction to required standard.
b. Providing and laying geo fabric layer and filter material above it.
c. Providing and laying three layers of stone pitching of specified thickness and filling lean concrete 1:5:10 in these layers to keep 7% voids.
d. Toe Protection – Providing and constructing toe-beam of concrete to protect the slope of revetment. This toe-beam will rest and will be supported on Gabion wall. Constructed on bank and resting on hard rock at the bottom.
e. Gabion Wall – Providing and constructing Gabion wall from hard rock level upto toe-beam level.

920. The relevant levels are as given below which will be verified by the Contractor before designing and got approved from competent authority specified by employer.

Top of embankment (Revetment top layer)	-	36.0m
Top of beam at the toe of revetment	-	26.00 m
Max slop to be adopted for revetment	-	1:2 (V:H)
Length of revetment	-	530 m (Approx.)
Size of beam at toe of revetment	-	As per design but not less than as

		shown on drawing of employer
Angle of repose	-	To be decided after soil analysis
Score level at 26 m bed level	-	24.00 m

921. Above levels and data to be verified by Contractor before design and execution and got approved by competent authority specified by employer.

922. **Filling on uneven portion.** The work is to be executed as per following directives and specification. The specifications of materials such as filling earth, stones for pitching sand and concrete shall be applicable as given in the standard specifications of tender.

923. The existing slopes are uneven and filling shall be provided by material consisting of loam, clay, sand, fine gravel and any other material suitable for filling and approved by Employer's representative. If required Contractor shall bring from outside the material of approved quality, as directed by Employers representative.

924. The water content of soil be kept at optimum level of moisture content. For this periodical checking of dry density of soil be done at various levels of filling as directed. The filling which fails in expected degree of compaction shall be re-excavated, replaced and recompacted upto required degree and to the satisfaction of employers representative and at no cost to the Employer.

925. Compaction of filled material to be done mechanically unless otherwise specifically directed or approved by Employers representative failing which the same will be rejected and will have to be redone at no extra cost.

926. No other mechanical plants or equipments except compacting equipments shall be allowed in the filling premises unless filling is complete and compacted to the satisfactory specified level and degree. The mechanical compaction should achieve 95% modified proctor density.

927. The degree of compaction shall complete with specified (proctor / modified proctor) density at moisture content not differing more than 4% from optimum moisture content. It will be Contractors responsibility to demonstrate / prove by field and laboratory tests that the specified density of compaction has been obtained. This all will done by Contractor at his cost.

928. The max.side slope for filling will be generally 1:2 (V:H). The flatter side slopes if required may be decided based on angle of repose of soil, arrived at after soil analysis. Such slopes of course need prior approval of Employers representative.

929. The final compacted level and degree of compaction achieved should be got approved in writing from Employers representative before starting the work of laying of geo fabric filter layer.

930. **Gabion wall.** Further step will be to construct a Gabion wall along bank from hard rock level to the bottom of toe-beam. This shall be designed as gravity retaining wall. The PVC coated GI wire crates shall be used for placing of stones. The wire mesh crates shall be used for placing of stones. The wire mesh opening should be small enough so that stones may not fall out. Stone shall be placed in such a compacted way so as to form an appearance of a stone beam. Porosity of crate shall not be more than 30%. The min. weight of stone shall be more than 45 kg.

931. Crates should be laid properly with longer dimensions and properly interlocked. The crates units shall be tied to each other by 5 mm PVC coated GI wires as additional precautions against separation and sliding apart. The wire crate shall be made of hot dipped GI mild steel wire of DI not less than 4 mm in annealed condition and having tensile strength of 300 – 450. MPa conforming to IS 280. The galvanizing coating shall be heavy coating for soft condition confirming to IS 4826. The mesh opening shall not be more than 150 mm. The wire crates built in situ shall not be larger than 7.5 metres x 1.8 metres x 1.2 metres nor smaller than 2 m x 1 m x 0.3 m. The sides of larger size crates shall be securely stayed at intervals of 1.5 m to prevent bulging. The crates should be placed in layers in staggered position so that joints should not come in one vertical line. Each layer of crate shall be tied to upper layer and lower layer of crates at suitable intervals by 4 mm PVC coated GI wire. Layers should be placed in such a way so as to form a perfect vertical retaining wall.

932. At the upper layer of Gabion wall a plain surface with M15 concrete of 15 cm thick to be prepared to rest toe-protection beam.

933. **RCC toe-beam.** Toe protection is required at the end of stone revetment so as to protect the slope of revetment against slip. This shall be in the form of concrete beam resting on Gabion wall. The beam shall be casted on plane surface prepared on the Gabion wall as described in above paragraphs. The beam shall be designed to resist horizontal force coming due to the slope of stone revetment and its weight. The proper anchorage should be provided in the Gabion wall. The size of beam shall not less than as shown on drawing provided in tender. The min. reinforcement should be 0.6% of the concrete volume and bar dia. Of min. 12 mm (TMT bars) be provided.

934. **Geo fabric, filter and stone revetment.** After the final compaction of filling material as mentioned in para 2 above and casting of toe-beam as per para – 4, the work of geo fabric laying should be taken in hand.

935. This geo fabric filter is to be laid below the stone revetment and Gabion well but above compacted filling level. The specifications of geo fabric filler are as under:

Table 68: Geofabric Filler Specifications

Type	Woven / equivalent as per IS
Opening size	0.149 mm
Material	Polypropylene, UV resistant
Wt / sqm.	More than 200 gm / sqm.
Thickness	0.6 t0 0.8 mm approximate
Tensile strength	
i) Warp wise	200 kg / 10 cm
ii) Wet wise	200 kg / 10 cm
Water permeability	More than 30 lit / s / sqm. For 10 cm head
Core penetration	Less than 2 cm
Thermal stability	0 to 120^{o}C

936. Before laying of Geo fabric and filter media the side of the bank shall be trimmed to the required slope of profiles put up by means of lines and pegs at intervals of 3 m to ensure regular straight work and uniform slope throughout. Depressions if any shall be filled properly.

937. After laying Geo fabric media a sand filter of 200 mm to prevent escape of underlying embankment material through voids of stone revetment. This Geo fabric and filter material

as laid on the prepared base be similarly compacted to the thickness as per approved drawing.

938. **Stone revetment.** After Geo fabric and filter completion, the lower portion of stone pitching (revetment) shall be started from the toe-wall and build in up in upward direction and courses in specified slope (max.1:2, V:H). The stones shall be placed by derrik or by hand to the required length. Stones shall be set normal to the slope and placed so that normal dimension is perpendicular to the face of the slope.

939. When two or more layers of stones are to be laid to obtain the design thickness of the pitching layer dry masonry shall be used and stones shall be well bonded. The revetment (stone pitching) is to be provided in three layers.

Lower layer	-	300 mm thick
Middle layer	-	300 mm thick
Top layer	-	400 mm thick

940. Lean concrete of 1:5:10 mix shall be used as mortor to keep voids in stone revetment limited to 7% of the total volume. The concrete block spacers of 1 m x 1 m x 0.3 m size shall be placed at suitable intervals in revetment as directed by employers representative.

941. Suitable drain holes / pipes are to be provided in the revetment.

942. Cement concrete nominal mix M15 of 300 mm thick shall be then laid above except that the surface of the concrete shall not be smooth finished.

943. The paving work shall then be embedded in green concrete.

944. **Measurement for payment.** It covers under turnkey contract. Length of river protection work shall be about 530 m at WTP.

945. **Riverbank protection at Intake.** The bank protection work for construction channel of about 15 m length shall be provided similar to the specifications given for river bank protection work at WTP site. Both banks of river constructedchannel shall be protected with protection work along with adjoining construction channel. The bank protection work as above shall be provided with provision of ghat between 26 m to 28 m RL. The step of 300 mm (W) and 150 mm (H) shall be provided in ghat section. The bank protectionwill start at 25 m RL up to 30 m RL near intake. The excavated exposed intake sides shall also be provided.

946. Suitable surface drainage arrangement shall be provided as per IS: 8237-1985.

x. Civil, building, road works and architectural product

947. **Standard specifications.** The “Standard Specifications (Civil Works)” (referred to as the Standard Specifications herein) issued by the Employer, establishes the Specifications that shall be followed for the construction of general civil works under the GWSP. Specifications for additional specialized items of civil works, and for mechanical and electrical works, shall be as set out in relevant subsections of this Section.

948. In the event of any discrepancy between the provisions of the Standard Specifications and the technical specifications contained herein, the provisions of these technical specifications shall take precedence.

i. Design Criteria and General Requirements

949. **Design submittals.**The Contractor shall submit complete detailed design calculations for each of the components of the foundation, substructure and superstructure together with general arrangement drawings, construction drawings and explanatory sketches as required by the Employer's Representative.

950. Separate calculations for substructures or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Employer's Representative. Calculations for the foundations may be submitted independently and prior to those of the superstructure as long as the load transfer points are identified. These calculations shall be resubmitted with the substructure and superstructure calculations for verification.

951. Design calculations shall not be submitted until the preliminary layout drawings have been approved by the Employer's Representative as to the general overall dimensions, functionality of the structure and the general layout of facilities. The design calculations later submitted shall be based upon the approved layout concepts.

952. **Design standards.** All designs shall be based on the latest Indian Standard (IS) Specifications or Codes of Practice. The design standards adopted shall follow the best, modern and sound engineering practice in the field based on other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Employer's Representative.

953. The design of water treatment facilities shall be in conformance with the requirements of the Central Public Health and Environmental Engineering Organisation's (CPHEEO) *Manual on Water Supply and Treatment (May 1999)*. Particular design criteria modified within these technical specifications shall override the stipulations of the CPHEEO Manual.

954. The design considerations described herein establish the minimum basic design requirements of plain and reinforced concrete structures, architectural details, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance fulfilling the functions for which the same is being constructed.

955. All the designs of structures and associated facilities shall generally confirm to the recommendations made in the publications (latest versions) of the Bureau of Indian Standards. Some are listed below:

a. IS 456: Code of Practice for plain and reinforced concrete
b. IS 800: Code of Practice for general construction in steel
c. IS 806: Code of Practice for use of steel tubes in general building construction
d. IS 875: Code of Practice for design loads for buildings and structures other than earthquake loads (Parts 1 to 5).
e. IS 1893: Criteria for earthquake resistant design of structures
f. IS 2974: Code of Practice for design and construction of machine foundations (Part 1 to 4)
g. IS 3370: Code of Practice for concrete structures for the storage of liquids (Part I to IV)
h. IS 11388: Recommendations for design of trash racks for intakes
i. IS 15310: Hydraulic design of pump sumps and intakes - Guidelines.
j. IS 13920: Ductile detailing of reinforced concrete structures subjected to seismic forces.

k. IS 2950: Code of practice for construction of raft foundation.
l. IS 2911: Code of practice for design and construction of pile foundation.
m. IS 5525: Detailing of reinforcement in reinforced concrete work.
n. IS 1904: Code of practice for design and construction of foundation in soils: General requirements.
o. IS 1498: Classification and identification of soils for general engineering purpose.
p. Indian Roads Congress (IRC) 6 Part II: Standard Specification and Code of Practice for road bridges loads and stresses
q. Standard Practice (SP) 34: Handbook on concrete reinforcement and detailing

956. **Design life.** The minimum design life of all structures and buildings shall be 50 years.

957. **Design loads.** All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; which includes dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials and dynamic loads.

958. **Dead load.**This shall comprise loads arising due to all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipment and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding its contents.

959. The minimum Dead Loads shall be as per IS 875 (Part 1).

960. **Live load.** Live loads shall be in accordance with IS 875 (Part 2).

961. In the absence of any suitable provisions for live loads in the IS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Employer's Representative prior to the starting of the design work. Apart from the specified live loads or any other loads due to storage of materials, any other equipment load or possible overloading during maintenance or erection/construction in part or in full, the most critical condition shall be considered in the design.

962. **Wind load.** Wind loads shall be as per IS 875 (part 3).

963. **Earthquake load.** The seismic loading shall be calculated as per IS 1893 and the structures designed in accordance with this standard. The project area falls within India Seismic Zone V (five). This is the highest (most damage potential) of any of the zone ratings in the country. The considerations for seismic design shall be reviewed with the upmost concern by the Employer's Representative.

964. **Dynamic load.** Dynamic loads (vibration forces) due to the operation of equipment items such as pumps, blowers, compressors, generators, switchgear, traveling cranes, etc. shall be considered in the design of structures.

965. **Wave load.** Wave loads (forces) acting upon the intake structures shall be estimated or calculated in accordance with standard engineering practice for the design of marine structures.

966. **Joints.** Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the requirements of their

installation. However, contraction joints shall be provided at specified locations spaced apart not more than 7.5 m in both directions at right angles to each other for walls and rafts (foundations).

967. Expansion joints for non-liquid retaining structures shall be provided as per IS 3414. A suitable gap at the location of expansion joints, which shall be spaced at a suitable intervals of not more than 30 m shall be provided in walls, floors and the roof slabs of all structures.

968. Construction joints shall be provided at right angles to the general direction of a member. The locations of construction joints shall be decided as per the convenience of the construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2.0 m of height.

969. Approved double bulb type PVC water-stops of 150 mm width shall be used for walls and of 230 mm width shall be used for base slabs.

970. **Underground liquid retaining structures–basis for design.** All underground or partly underground liquid containing structures shall be designed for the following conditions:

a. Liquid depth up to full height of wall and free board: No relief due to lateral soil pressure from the outside shall be considered.
b. Tank empty (i.e., no liquid or any material inside the tank volume): Full lateral earth pressure at rest due to surrounding saturated soil and surcharge pressure as applicable, shall be considered.
c. Partition walls between a dry compartment and a water bearing compartments shall be designed for full liquid depth up to the full height of the wall.
d. Partition walls between two water bearing compartments shall be designed as one compartment being empty and the other full.
e. Structures shall be designed for uplift in the empty condition considering the depth of the highest historical water table recorded in the area.
f. Walls shall be designed under operating conditions to resist earthquake forces developed due to the mobilization of earth and dynamic water loads.

971. Underground or partially underground structures shall also be designed to accommodate stresses developed due to any combination of full and empty compartments with appropriate ground uplift pressures on the base slab. A minimum safety factor of 1.2 shall be applied to ensure against uplift or floatation.

972. **Scope of earthwork.** This specification covers the general requirements for earthwork excavation in different materials for the construction of the Works including structures, roadways, side drains, sewers and water supply lines in accordance with the lines, grades and cross-sections shown in the Drawings or as indicated by these specifications or by the Employer's Representative.

973. This Specification includes site grading, filling in areas as shown in Drawing, backfilling around foundations, plinths and approach ramps, the conveyance and disposal of surplus spoils as shown on the Drawings or as directed by the Employers representative or Employers representative's authorized Representative and all operations covered within the intent and purpose of this Specification. It shall also include the hauling and stacking of or hauling to sites of embankment and subgrade construction, suitable cut materials as required, as also the disposal of unsuitable cut materials in specified manner, trimming and

finishing of the road to specified dimensions or as directed by the Employer's Representative.

974. Excavation for structures shall consist of the removal of material for the construction of foundations for buildings, process structures, bridges, culverts, retaining walls, headwalls, and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the Drawings or as indicated by the Employer's Representative.

975. The work shall include construction of the necessary cofferdams and cribs and their subsequent removal, all necessary sheeting, shoring, bracing, draining and pumping; the removal of all logs, stumps, grubs and other deleterious matter and obstructions necessary for placing the foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

976. **Applicable codes.** The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the Codes shall take precedence.

a.	IS 1498	Classification and identification of soils for general engineering
b.	IS 2720	Method of test of soils (All parts)
c.	IS 2809	Glossary of terms and symbols relating to Soil Engineering
d.	IS 3764	Safety code for excavation work
e.	IS 4081	Safety code for blasting and related drilling operations

y. Classification of Excavated Material

977. **Authority for classification.** The classification of excavation material shall be decided on by the Employer's Representative and his decision shall be final and binding on the Contractor. The use of explosives for excavation work will not be considered as a reason for a higher (cost) classification unless blasting is clearly necessary in the opinion of the Employer's Representative.

978. **Classifications.** All materials involved in excavation will be classified by the Employer's Representative in the following manner:

979. **Soil.** This classification shall comprise all kinds of soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar materials. All soils covered in ordinary and hard soils shall be covered in this category. Removal of gravel or any other nodular material having dimension in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

980. **Ordinary rock.** This classification shall include rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bars or pneumatic rams. This classification also includes any rock which in the dry state may be hard and requires blasting, but which when wet becomes soft and can be excavated by a means other than blasting.

981. Macadam surfaces such as water bound and bitumen bound road surfaces, paths etc. and hard core compact moorum or stabilized soil requiring a grafting tool or pick to excavate them will be considered in this category. Gravel and cobble stone having a maximum dimension in any one direction between 75 and 300 mm shall also be included.

982. Lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar below ground level, reinforced cement concrete which may be broken up with crow bars or picks and stone masonry in cement mortar below ground level shall be included in this category.

983. Boulders which do not require blasting having a maximum dimension in any direction of more than 300 mm, found lying loose on the surface or embedded and terrace material of dissimilar origin shall be included in this category.

984. **Hard rock by controller blasting.** In a case where hard rock is to be excavated by blasting, prior approval from employer shall be taken by the Contractor. It requires special precautions to prevent damage to nearby structure due to vibrations caused by blasts. The blasting will be carried out in controlled manner. The control measures shall include setting a reduced charge for blasting, covering the blast holes by steel sheets covered with sand bags, establishing precaution for underwater, etc.. This shall be carried out as per specific approval of the Employer's Representative.

985. **Hard rock (blasting prohibited).** Hard rock requiring blasting as described above but where blasting is prohibited for any reason and excavation has to be carried out by chiseling, wedging or any other agreed upon method.Note: Any surplus material or stone excavated shall be the property of the Contractor. He shall be responsible for its off-site disposal.

986. **Permits for blasting.** The Contractor shall not consider the usage of explosives to be permissible when preparing his Bid. The permitting process for getting the use of explosives approved will be very arduous, so the Contractor should not place any reliance on any approvals being given by the regulatory agencies involved.

987. **Foundations.** The minimum depth of foundations for all structures, equipment, buildings, frame foundations and load bearing walls shall be in accordance with IS 1904.

988. Care shall be taken to avoid the interference of the foundations or any other component of the new building or structure with the foundations of adjacent buildings or structures. Suitable adjustments in the depth, location and size of foundations may have to be made depending on the site conditions. The Employer's Representative shall accept no extra claims for such adjustments. Special attention shall be drawn to the danger of uplift being caused by a high ground water table. The foundation raft or mat shall be designed for uplift forces that are likely to be developed.

989. Where there is an elevation difference between the natural existing ground level and the foundations or floor slabs of a structure, this difference shall be filled up in one of the following ways:

i. In case of non-liquid retaining structures the natural top soil shall be removed until a firm stratum is reached (the minimum depth of the soil removed shall be 500 mm) and the level difference shall be made up with compacted backfill as per the specifications. The thickness of each layer of the backfill shall not exceed 150 mm. The area of backfilling for floor slabs shall be confined to prevent soil from slipping out during compaction. The safe bearing capacity of this well compacted backfilled soil for design calculations shall not exceed 100 KN/m^2.

ii. In case of liquid retaining structures, the natural top soil shall be removed as described above and the level difference shall be made up with Plain Cement

Concrete 1:5:10 mix (1 part cement to 5 parts sand to 10 parts coarse aggregate)

990. **General requirements for Concrete Work.** The following are the design requirements for all reinforced or plain concrete structures:

i. All blinding and leveling concrete shall be a minimum 150 mm thick with minimum concrete grade of Class M15.
ii. All structural reinforced concrete other than for water retaining structures shall at least be of Class M20 with 20 mm size downgraded coarse aggregates, for all structural members.
iii. The minimum grade of concrete for water retaining structures shall be Class M30 having a minimum cement content of 350 kg/m^3 with 20 mm size downgraded coarse aggregates.
iv. All design for water retaining structures including roofing shall be based upon limiting the crack width to 0.2 mm as per BS 8007.
v. The minimum clear cover over all reinforcement including stirrups and links shall be 40 mm for all water retaining structures including the bottom of the roof. For other non water bearing structures the minimum clear cover shall be as specified in IS 456.
vi. Any structure or pipeline crossing below road grade shall be designed for a minimum of Class A of IRC loading criteria.
vii. The bridges and supporting structures (for clarifiers etc.) shall be designed to safely withstand the loadings of the loads and torque transmitted through the scrapper blades, motors, gear reducers, etc. depending upon the arrangement.
viii. All pipes and conduits laid below the structural plinth and road works shall be embedded in reinforced concrete of Class M15 having a minimum 150 mm thick concrete cover all around.
ix. An approved water proofing compound (chloride free) shall be added during the concreting of all liquid containing structures, in the proportions specified by the manufacturer.
x. For the walls of liquid retaining structures, the following shall be applied:

- The minimum reinforcement shall be in accordance with BS 8007.
- The maximum length of a panel to be concreted considering any partial construction joints shall be 7.5 m. The adjacent panels shall be poured with a minimum time lapse of 4 days. The Height of each pour shall not exceed 2.0 m.

991. The following minimum thicknesses shall be used for the different reinforced concrete members, irrespective of the required design thickness:

a.	Walls for liquid retaining structures	200 mm
b.	Roof slabs for liquid retaining structures	150 mm
c.	Bottom slabs for liquid retaining structures	200 mm
d.	Floor slabs including roof slabs, walkways, canopy slabs	150 mm
e.	Walls of cables / pipe trenches, underground pits etc.	125 mm
f.	Column footings	300 mm
g.	Parapets, hajji	100 mm
h.	Precast trench covers	75 mm

992. **Concrete reinforcement.** All major structures, buildings, pump houses, treatment process tanks, reservoirs and electrical substations to be constructed in this Contract shall

use TMT (thermo-mechanical treatment) Fe 500 as defined in IS 1786 and as procured from TISCO/ SAIL /RINL or equivalent as approved by the Employer's Representative, for concrete reinforcement. The minimum yield stress of the bars shall be 500 N/mm^2.

993. Other concrete work including thrust blocks, pipe supports, sidewalks etc. may use HYSD (high yield strength deformed) Fe 415 steel bars as procured from TISCO/ SAIL /RINL or equivalent as approved by Employer's Representative. The minimum yield stress of the bars shall be 415 N/mm^2.

z. General Requirements for Buildings

994. Unless otherwise specified, all the building works shall comply with the following requirements:

995. External walls and framing:

i. All buildings shall have reinforced concrete framework.
ii. A 75 mm thick RCC damp roofing course of Class M15 shall be applied onto all exterior building walls.
iii. Anti-termite treatment as per IS 6313 Part-III (1971) with injection of chloropyriousemulsifiable concrete (1%) timber care ground treatment chemical emulsion (1:3) to create a chemical barrier under and around the column pits, wall trenches, basement excavations, top surfaces of plinth filling, junctions of walls and floors along the external perimeter of buildings, expansion joints, surrounding of pipes and conduits etc.
iv. All external non RCC walls shall be made of 230 mm thick brick masonry laid with cement mortar at 1:4 (cement to sand). Transoms and mullions shall be of nominal 115 mm x 230 mm dimensions made of Class M20 cement concrete with four number 6 mm bars and 6 mm links at 150 mm c/c to form panels not exceeding 3500 mm x 3500 mm in size.
v. All external masonry surfaces shall be plastered in two coats with sand faced cement plaster in cement mortar (1:4) and shall have a total thickness of 20 mm. Waterproofing compound of an approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
vi. For use of Fly-ash bricks prior approval of Employer's representative is necessary.

996. Internal walls:

i. All internal partition walls except for toilets shall be made of 230 mm thick brick masonry built with cement mortar 1:4 with transoms and mullions as stated above. Toilet partition walls shall be made of 115 mm thick brick masonry built with cement mortar 1:4 and shall have transoms and mullions as stated above to form panels not exceeding 1200 mm x 1200 mm in size.
ii. All internal masonry surfaces shall be finished with 12 mm thick smooth faced cement plaster in cement mortar (1:4).

997. Plinth layer:

i. Building plinth shall be a minimum of 600 mm above the average finished ground level around the building and shall be not be less than the plinth level of any existing buildings.

ii. All buildings shall have a minimum 1.0 m wide, 100 mm thick plinth protection paving of Class M15 concrete finished with stone slabs or tiles and 150mmx 300mm peripheral surface drain.

998. Doors and windows:

i. Emergency exit doorways shall be provided from all buildings in order to comply with local and international regulations. Exit doors shall be outward opening from inside of the building. Stairways and paved areas shall be provided at the exit points.
ii. Exterior single doors shall be Type A, as stipulated in Subsection (Architectural Product Specifications). Interior single doors for equipment and electrical rooms shall be Type D;the control room shall have a Type F single door.
iii. Electrical rooms shall have double door access, with two leafs as specified above. Electrical Room, Acid storage or Battery Room doors shall be 2 hour Fire rated HMPS (hollow metal pressed steel) doors.
iv. Every room located along an exterior wall in a building, except the control room and bathroom/toilet, shall have an exterior window of at least the dimensions of Type A, as stipulated in Subsection (Architectural Product Specifications).
v. The control room shall have a Type C exterior window and a Type E interior window.
vi. Glass shall be a minimum of 5.0 mm thick, pin headed, opaque or fire rated with embedded wire mesh, as required.

999. Painting (Note: All colours shall be selected by the Employer's Representative):

i. Exterior Concrete and Masonry Walls: Coating System 1, followed by Coating System 2.
ii. Interior Plastered Masonry Walls and Ceilings (Equipment Areas): Coating System 1, followed by Coating System 3.
iii. Interior Plastered Masonry Walls and Ceilings (Office and Control Rooms, etc.): Coating System 1, followed by Coating System 4.
iv. Interior Walls (Bathrooms): Glazed ceramic tile, Coating System 5, from floor to ceiling level. Tile sizes to be selected by the Employer's Representative.
v. Interior Plastered Masonry Walls and Ceilings (Chemical Areas.): Coating System 1, followed by Coating System 6.
vi. Equipment Room Floors: Coating System 7.
vii. Office, Control Room and Bathroom Floors: Glazed ceramic tile, Coating System 8. Tile sizes to be selected by the Employer's Representative.
viii. Submerged Concrete: Coating System 9.
ix. Un submerged Ferrous Metal: Coating System 10.
x. Submerged Ferrous Metal: Coating System 11.
xi. For reinforcement bars of all structures – Epoxy painting for corrosion protection.

1000. **Preparation of surfaces prior to painting.** Surface preparation shall consist of primary surface preparation and secondary surface preparation. The primary surface preparation shall remove mill scale, rust, corrosion products, and foreign matter from a steel surface prior to application of a shop-primer or paint. The secondary surface preparation shall remove rust and foreign matter, if any, from a steel surface that has been already coated with a shop-primer or paint, prior to application of a finish coating. All rust, rust scale, heavy chalk or deteriorated coatings must be removed by a combination of solvent or

detergent washing, hand or power tool cleaning or abrasive blasting. Glossy areas of sound previous coatings need not be removed but should be mechanically abraded or brush blasted to create a surface profile which increases coating adhesion.

1001. **Ferrous Metals**: Ferrous metals shall be cleaned to SSPC-10 (Society for Protective Coatings) standard to “Near White Metal”. No rust shall be visible prior to the application of paint. In addition to the cleaning requirement, a surface must also have a sufficient profile (anchor pattern or tooth) to permit bonding of the primer. Generally the profile height of steel shall be in between 15 and 65 microns and shall not more than one third of the total dry film thickness of the coating system.

1002. **Galvanized Iron and Steel**: Remove any oil or grease. Any white zinc corrosion products should be removed by high pressure fresh water washing or fresh water washing with scrubbing. Even if sweep blasting to SSPC-7 “Brush-off Blast” is performed, it shall be followed by water washing to ensure removal of soluble zinc salts.

1003. **New Concrete Surfaces**: New concrete surfaces shall be allowed to cure at least 30 days before coating is applied. The moisture content of the concrete/masonry shall be less than 6%. In case of large areas and for severe exposure conditions, the surface shall be prepared by light blasting to SSPC-6 “Commercial Blast” standards. In less critical areas where blasting is not practical, wire brushing shall be adopted to remove laitance, followed by treating with dilute hydrochloric/muriatic acid (10% concentration). Remove the acid and contaminants by liberal washing with fresh water. Ensure that the acid solution does not retain on the surface and joints. Allow the surface to dry thoroughly before applying primer.

1004. **Old Concrete Surfaces**: Remove the surface contaminants like grease, oil, etc., by solvent wiping or with a 10% caustic solution. Prepare the surface by light blasting (SSPC-6). In case, blasting is not practical, etch the surface to get a good profile with dilute hydrochloric/muriatic acid (10%). Remove the acid and contaminants by liberal washing with fresh water. Ensure that the acid solution does not retain on the surface and joints. Allow the surface to dry thoroughly before applying primer. Any cracks should be cut out and filled with suitable filler prior to painting.

1005. **Application of Paint.** Areas shall be painted by air spray application whenever possible, as determined by the Employer’s Representative. In case where spraying is not warranted, paint shall be applied by roller. Brush painting shall only be allowed for touch-up work, painting small hard to reach areas, or on surfaces with slightly raised or indented surface details.

1006. **Air Spray.** Conventional air atomization spray application shall be used which uses compressed air to atomize the coating sprayed. Air and paint shall enter the gun through separate passages and be mixed and ejected at the air nozzle to provide a controlled spray pattern. The amount of paint leaving the gun shall be controlled by the pressure on the fluid container, the viscosity of the paint, the size of the fluid orifice, and by the fluid needle adjustment.

1007. The following shall be adhered to for effective air spray application:

- Use the lowest possible air and fluid pressure when operating a spray gun.
- Use the proper fan width for the job.
- Spray from the proper distance (15 to 25 cm).
- Hold the gun perpendicular to the work throughout the spray stroke.
- Move the spray gun parallel to the work surface throughout the spray stroke.

- Move the spray gun at a speed which assures that a full wet coat is applied to the surface.
- Overlap strokes by at least 50%.

1008. **Roller.** Only 'short napped' rollers shall be used on smooth surfaces such as plaster and steel. Solvent thinned coatings shall be applied with either lamb's wool or synthetic covers and water reduced coatings shall be applied with synthetic covers. When using rollers to apply coating systems such as epoxies and polyurethanes which contain strong solvents, the roller covers selected shall be constructed with glues which are resistant to these strong solvents.

1009. The following shall be adhered to for effective roller application:

- On large areas, material should be applied at no more than 0.75 m^2 at a time.
- The roller cover shall be thoroughly saturated with the coating. Paint shall be loaded onto the cover until just before it drips.
- The first strokes with the loaded roller shall be done in a "W" pattern within the 0.75 m^2 area. The "W" pattern shall then be fixed in with successive strokes.
- Work shall proceed from dry areas back into wet areas. In this way a more uniform film thickness can be maintained.
- When a material is applied to warm surfaces in direct sunlight or when fast drying coatings are used, work shall be done in smaller areas to maintain a wet edge.

1010. **Brush.**Either natural or synthetic bristle brushes shall be used for use with 'solvent based' coatings. Natural bristle brushes shall not be used 'water based' coatings because natural bristles tend to swell in water.

1011. The following shall be adhered to for effective brush application:

- Use only high quality, clean brushes of the proper shape and size. Brushes may be reused no more than twice before they shall be replaced.
- Assure that all holidays or voids are eliminated, but avoid excessive brushing which may reduce film thickness and decrease protection.
- Avoid filling the heel of the brush with material. Approximately only the top half of the bristle length of the brush shall be wet.
- Stroke the brush at a 45° angle. Light strokes at this angle ensure even flow.
- The brush application shall be by up and down strokes, then crosswise and finally with up and down strokes lightly. This is called cross lapping and helps eliminate brush and lap marks. Fast drying materials often do not permit cross lapping which may cause paint to pile up. If it is necessary to brush apply fast dry material, it shall be brushed on rapidly and generously and then left undisturbed. To go back over such a surface usually results in excessive brush drag, leaving ridges and brush marks.

1012. **Epoxy Coatings**: Air drying epoxy and polyurethane coatings are normally two component systems, consisting of a base and a hardener. The two components have to be mixed in the ratio recommended to ensure proper and complete curing of the coatings. An improper mix ratio leads to problems like soft/non-dried film, poor performance, etc. The base and hardener shall be separately mixed first to obtain a homogenous mixture. The hardener shall be added to the base slowly, with continuous mixing and not the reverse. After complete addition, mixing is to be continued to achieve a homogenous mixture. Hand mixing shall not be allowed.

1013. Any addition of thinner to achieve the application viscosity shall be made only after the components are thoroughly mixed and shall not be added to the base/hardener or while mixing the two components. Avoid using thinner in excess of the recommended volumes, since this can lead to lower DFT buildup, sagging, longer curing time, etc.

1014. After thorough mixing of the product, the maturation time as indicated in the product data sheet shall be allowed to lapse before applying the product. The mixture thickens as the time progresses, and at the end of the pot life period the mixture becomes highly viscous and unusable.

1015. The coating systems to be used on the buildings and other structures shall conform to the Painting Schedule given in the table below.

Table 69: Painting Schedule

Coating System No.	Coating Description	No. of Coats	DFT each Coat	Applicable Product[1]
1	Waterborne Cementitious Acrylic (Masonry Filler)	1 or 2[2]	50[2]	Envirofill Series 130[3] or Equivalent
2	Acrylic Emulsion (Flat Finish)	2	75	Asiacryl CF 522 or Equivalent
3	Acrylic Emulsion (Semi Gloss finish)	2	75	Asiacryl CF 521 or 522 or Equivalent
4	Synthetic Enamel (Semi Gloss finish)	2	50	Apcomin Enamel or Equivalent
5	Ceramic Tiles (Satin finish) / vitrified tiles	1	6 mm	Kajaria or Nitco Ltd[4] , Johnson, RAK or Equivalent
6	Chlorinated Rubber based (Semi Gloss finish)	3	35	Asiochlor CF 621 or Equivalent
7	Concrete Sealer/Hardener	2	4.5 m^2/liter	TK-5329[4] or Equivalent
8	Ceramic Tiles (Satin finish)	1	8 mm	Kajaria or Nitco Ltd[5] or Equivalent
9	Polyamide 2-part Epoxy	2	150	Pota-Pox Series 20[3], Johnson, RAKor Equivalent
10	2-part Epoxy Primer followed by 2-part Epoxy Finish Coats	2 Primer + 2 Finish	25 Primer/ 35 Finish	Asian Epoxy ROZC Primer / Asian Epoxy Finish Paint or Tuff Coat PU-102 Primer / Tuff Coat PU-101 Finish Coat or Equivalent
11	Polyamide 2-part Epoxy	2 / 3	150 / 100	Hi-Build Epoxoline Series 66[3] orApcodur CF 699 or Tuff Coat HB-285 or Equivalent
12	Marble stone green shade 5 mm thick	1		

Coating System No.	Coating Description	No. of Coats	DFT each Coat	Applicable Product[1]

Notes:
1. Product specification numbers have been based upon those of Asian Paints Limited, Mumbai and Tuff Coat Polymers Pvt Ltd, Pune, unless noted otherwise. They are shown as a guide for comparative purposes with products by other manufacturers.
2. As required based upon the severity of the void spaces and recesses to be filled
3. Product specification numbers have been based upon those of the Tnemec Corporation, Kansas City, MO, USA.
4. Product specification numbers have been based upon those of TK Products, Englewood, CO, USA or equivalent by Endur-O-Seal, Pinehurst, TX, USA.
5.Products have been based upon those as manufactured by Kajaria, New Delhi, or Nitco Ltd, Mumbai.

a. Stairways

i. Unless otherwise specified, staircases shall be finished with high grade 25 mm thick marble stone (Green shade) treads and 20 mm thick marble (Green shade) Stone skirting or equivalent as approved by the Employer's Representative. The flooring and landings of Stair case room shall be finished with high grade 25mm thick marble stone (Green Shade). The stair riser shall not exceed 150mm in height and the minimum width of the tread shall not be less than 275 mm. All steps shall have a 20mm nosing. R.C.C. stairways shall be provided to permit access between different levels within buildings. All roof tops and tops of overhead tanks shall be made accessible with ladders provided. Vertical ladders fitted with landing point extensions will be permitted where considered appropriate by the Employer's Representative to access areas not frequently visited. Exposed edges of skirting shall be chamfered and nosing of treads shall be half rounded.

ii. All staircases shall be provided with steel railing with PVC covers or wooden handrail. Stair case rooms should be provided with fixed glazed panes for adequate lighting as approved by the Employer's representative...

b. Roofs

i. The reinforced concrete roofs shall be made waterproof by the application of approved cement/ lime based waterproofing treatment, to be guaranteed for 5 years. The finished roof surface shall have an adequate slope to drain quickly the rainwater to down-comer drain points

ii. For roof drainage, cast iron rainwater down-takes with khurra and door bends with CI grating at top shall be provided. For roof areas up to 40 m2 a minimum of two 100 mm diameter down-take pipes shall be provided. For every additional area of 40 m2 or part thereof, at least one 100 mm dia. down take pipe shall be provided. The rainwater pipes shall be concealed.

iii. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rainwater.

iv. Suitable MS or CI/SS ladder from outside of the structures/ buildings shall be provided to attain roof top and exposed structures.

c. Offices and Control Rooms and administrative buildings

i. The floors of offices and control rooms shall be covered with glazed vitrified tiles. Each tile shall have the dimensions of 600 mm x 600 mm square. The tile Colour shall be selected by the Employer's Representative. The bottoms of doors shall just clear the level of the tile once installed.

ii. Each office or control room shall include at least the following furnishings if not shown otherwise on the Drawings or stated elsewhere in the Specifications. The furniture Mark designations are described in relevant Subsection.

- 2 desks of Mark T1
- Each desk shall have a chair of Mark C1.
- 1 layout table (control rooms only) of MarkT4.
- 4 side chairs of Mark C2.
- 1 bookcase of Mark B1.
- 1 filing cabinet (control rooms only) of Mark F1. The top drawer shall have a locking device, which when activated shall lock all drawers.
- 1 PC workstation (SCADA control rooms only) of Mark T3. A chair of Mark C1 shall be furnished.
- A wall split type air conditioning unit of adequate capacity to keep the room temperature at 20^{o} C accounting for all room heat loads at an ambient outdoor temperature of 37^{o} C. The compressor and fan shall be mounted outdoors in a location shaded from sunlight.
- A drop or false acoustical type ceiling with a ceiling height of 3.00 m.
- 1 ceiling fan (Mark C1)

d. Bathrooms / Toilet Facilities

i. Bathroom floor slabs shall be sunk by 40 cms. and filled with brickbat coba (broken bricks set in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company. The finished floor level in the Bathroom areas shall be normally 12 mm below the finished floor level on the outer side. One leakage spout of 25 mm with PVC pipe to be provided. Adjustable glazed louvered ventilator of size 600mmx750mm with iron grill should be provided in each toilet block.

ii. Each toilet facility shall include at least the following fixtures if not shown otherwise on the Drawings or stated elsewhere in the Specifications:

a. 1 Water closet with a white porcelain European type /Orissa pan a minimum 580 mm long with a PVC flushing cistern of 10 liters capacity.

b. 1 Urinal of 600 mm x 400 mm x 300 mm size of the flat back type in white porcelain.

c. 1 Wash basin of 510 mm x 400 mm size in white porcelain with inlets, outlet with bottle trap.

d. 1 chromium-plated brass water faucet with separate hot and cold water handles.

e. A hot water heater (geyser) of minimum 25 liter capacity, electrically operated, with a wall mounted on switch and a timer controlled shutoff.
f. 1 Mirror of 400 mm x 600 mm size with PVC molding of the wall mounted type to be fitted over the washbasin.
g. 1 Plastic liquid soap bottle
h. 2 Chromium plated brass towel rails each a minimum of 400 mm long.
i. The toilets shall have an epoxy coated steel partitions, 25 mm thick, on all sides not adjacent to a wall. The entrance shall have a hinged shutter with a latch. The Colour to be selected by the Employer's Representative.
j. The urinals shall have half height epoxy coated steel partitions 680 mm x 300 mm on each side of 25 mm thickness each. The Colour to match that of the toilet partition.
k. Toilet blocks in process building shall be provided with two drinking water taps of 12 mm size and sink with appropriate drainage
l. All stopcocks, valves and pillar cocks shall be of chromium-plated brass, and of heavy duty construction.
m. All fittings such as `P' or `S' traps, floor traps, pipes, down-take pipes etc.

1016. The sewage from toilet blocks shall be led to a septic tank with a soak pit. The Contractor, at a suitable location, shall provide a septic tank having appropriate capacity, as per the specifications.

e. Duty Rooms

i. The floors of duty rooms shall be covered with glazed vitrified tiles. Each tile shall have the dimensions of 600 mm x 600 mm square. The tile Colour shall be selected by the Employer's Representative. The bottoms of doors shall just clear the level of the tile once installed.
ii. Each duty room shall include at least the following furnishings if not shown otherwise on the Drawings or stated elsewhere in the Specifications:
- 1 meeting table of Mark T5.
- 6 chairs of Mark C1.
- 2 chairs of Mark C2.
- 2 sets of lockers of Mark L1.
- A kitchen type countertop with cabinetry shall be provided. The countertop shall be made of 150 mm x 150 mm tiles and shall be nominally 1,800 mm long by 750 mm deep. The countertop shall have a 600 mm x 600 mm square sink installed to one side (not centered). The cabinet shall be made of wood with 200 mm deep drawers beneath the countertop, except under the sink, and cabinets with swing-out opening doors beneath.
- 1 refrigerator/freezer unit of Mark R1. The unit shall have a frost-free defrosting system. The unit shall be made of steel with a stainless steel or white Colour .
- 2 ceiling fans (Mark C1)

f. Building Arrangement General

i. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as possible permit the entry of natural light.
ii. All offices containing computer equipment and electrical rooms containing variable frequency drives (VFDs) shall be air conditioned with wall mounted split type units, having the compressor unit mounted outdoors in a shaded area (protected from sunlight).
iii. All rooms in the treatment plant buildings and pump stations shall be provided with appropriate signboards indicating the function of the rooms involved.
iv. Wherever equipment and machinery is required to be moved for inspection, servicing, replacement etc., suitable movable (wheeled) gantry cranes of the required capacity shall be provided.

g. Miscellaneous:

i. All floor cutouts and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and galvanized iron (GI) checkered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with GI hand railing fixed with two rails. The top railing and vertical posts shall be 32 mm diameter GI Pipe of Class-A rating. The lower railing shall be 25 mm diameter GI pipe of Class A rating.
ii. All concrete channels and ducts used for conveying liquid shall have smooth finish from inside. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with GI hand railings.
iii. Curbs to be provided below the hand railing on the catwalks/pathways should be as per the relevant sections of the Factory Act. Curbs shall nominally be 75 mm in height and width.
iv. All checkered plates shall be hot dip galvanized at the factory.

1017. **Architectural Product Specifications.** Product Specifications for the various products, materials and systems used in building architectural detailing shall be as follows:

a. **Doors.** Doors shall be as described below. Exterior doors may be fitted with louvers at the Contractor's option. All doors shall have lock sets and separate keys. There shall be a master key system for each building.

(i) **Metal (Steel) Doors**: All exterior doors shall be steel doors with frames as specified in Section 21 of the Standard Specifications. Metal doors shall be painted in accordance with Coating System 10 as described in 1355. Each door leaf shall have a window of 300 mm x 300 mm x 5.0 mm thickness with wire reinforcement and suitable for a 1 hour fire rating. The door hardware shall be stainless steel.
(ii) **Metal (Aluminium) Doors**: All interior equipment room (such as the pump and electrical rooms) doors and doors subject to the splashing of water shall be aluminium doors with frames as specified in Section 21 of the Standard Specifications. Aluminium doors shall have an anodized coating. Interior aluminium doors shall have a window of 300 mm x 300 mm x 5.0 mm thickness, unless otherwise specified. The door hardware shall be brass.

(iii) **Wood Doors**: All office, control room, laboratory, bathroom and other non-process area doors shall be wooden. Bathroom doors shall have aluminium sheeting in the side of the leaf inside the bathroom. Wooden doors shall have solid cores of the same type of wood as the fascias. The doors shall be a minimum of 32 mm in thickness.

(iv) **Door types and sizes.**Unless specified otherwise doors shall be sized in accordance with the door schedule given in Table 6-3. Door types to be furnished shall be as described in the following subsections to this specification section. The door types referred to shall be those identified in the Door Schedule in Table 6-3.

Table 70: Door Schedule

Door Type	Door Description	Door Width[1] (mm)	Door Height[1] (mm)	Material	Window
A	Exterior Single Door	900	2,100	Steel	Yes
B	Exterior Double Door	800[2]	2,100	Steel	Yes[3]
C	Exterior Double Door	900[2]	2,450	Steel	Yes[3]
D	Exterior Double Door	1,250[2]	3,500	Steel	No
E	Exterior Roll-up Door	3,800	4,400	Steel	No
F	Interior Single Door	800	2,100	Aluminium	Yes
G	Interior Double Door	800[2]	2,100	Aluminium	Yes[3]
H	Interior Single Door	800	2,100	Wood	No
J	Interior Double Door	800[2]	2,100	Wood	No
	2 hour Fire Rated Door	as above for similar size		HMPS	No

Notes:
1. Door leaf dimensions only and does not include the frame.
2. Each leaf
3. In only 1 of 2 leafs

b. **Windows.** Windows shall be of the single pane type with the glass a minimum thickness of 5.0 mm. Wire mesh reinforcing (diamond pattern) shall be installed in the glass where specified. The glass installed in doors shall have the same fire rating as the door. Windows shall be insulated and designed to have an overall heat transfer coefficient (U) not in excess of 0.85 W/m2*K, where W is the heat transfer rate and K is the log mean temperature difference.

(i) Windows that are designated to open may be of 3 or more panes where the 2 outside panes rotate outward along a vertical axis. The Contractor may submit an alternative design for the window opening method for the approval of the Employer's Representative.

(ii) Panes in exterior windows shall be tinted. The tint shall be of a grayish hue and allow 75% visible light transmission (VLT). The tinting shall not be applied by means of an externally applied film.

(iii) **Windows types and sizes**. Unless specified otherwise windows shall be sized in accordance with the window schedule given in the table. Window types to be furnished shall be as described in the following subsections to this specification section. The window types referred to shall be those identified in the Window Schedule in the table.

Table 71: Window Schedule

Window Type	Window Description	Window Width[1]	Window Height[1]	Frame Material	Features	Wire Mesh

		(mm)	(mm)			
A	Exterior[2] (Equipment Room)	1,200	1200	Steel	Shutters can Open[3]	No
B	Exterior[2] (Office / Control Room)	1,200	1000	Steel	Shutters can Open[3]	No
C	Exterior[2] (Office / Control Room)	800	600	Steel	Shutters can Open[3]	No
D	Interior (Office / Control Room)	1,200	600	Aluminium	Fixed Pane	No
E	Interior (Office / Control Room)	900	500	Aluminium	Fixed Pane	No
F	Interior (Conference Room)	1,600	800	Aluminium	Fixed Pane	No
G	Door Leaf or Other	300	300	Door	Fixed Pane[4]	Yes

Notes:
1. Glass dimensions only and does not include the frame.
2. Exterior window panes shall be lightly tinted to reduce UV transmittance
3. The windows shall be constructed with shutters of of 400mm width. Windows in doors to electrical or chemical storage rooms shall be 2 hour fire rated

(iv) Notes:

i. Every room located along an exterior wall in a building, except the control room and bathroom/toilet, shall have an exterior window of at least the dimensions of Type A, as stipulated above.

ii. The control room shall have a Type C exterior window and a Type E interior window.

iii. Glass shall be a minimum of 5.0 mm thick, pin headed, opaque or fire rated with embedded wire mesh, as required.

c. **Ceramic tile.** Ceramic tile shall be manufactured in accordance with the requirements and tolerances specified in IS 777 (1988) and IS 13753. The ceramic tiles and their installation procedures shall be in accordance with Section 23 of the Standard Specifications. The minimum thickness of each tile shall be 6 mm for wall installations and 8 mm for floor installations. The tile dimensions (length x width) and finish shall be as selected by the Employer's Representative, but shall normally be not less than 150 mm x 150 mm. Tiles shall be glazed unless specified otherwise.

d. **Terrazzo Laid In-situ.** The materials for terrazzo flooring (marble chips) its installation procedures shall be in accordance with Section 23 of the Standard Specifications.

e. **Concrete sealer/hardener.** All concrete floor surfaces not to be covered with ceramic tile or another type of floor covering shall be sealed with an approved concrete sealer/hardener. The sealer/hardener shall be aclear liquid water based, high solids, acrylic resin compound meeting the ASTM C-309 criteria. The sealer/hardener shall be water, oil, salt and mild (commercial grade muriatic at 10% concentration) acid resistant. The sealer/hardener shall be spray applied in 2 coats at a rate of not more than 4.5 m2 per liter.

f. **Furniture.** Furniture for offices, control rooms, duty rooms, conference/meeting rooms and reception areas shall be as listed in the

schedule in Table 6-5. Fixtures for bathroom and toilet areas shall be as described in Subsection (General Requirements for Building). Furnishings for the laboratory at the water treatment plant shall be as described in Subsection or as per approved drawing & design.The particular furniture to be furnished for a particular room at a particular facility shall be as described in the following subsections to this specification section. The piece designations (marks) referred to shall be those identified in the Furniture Schedule in the table. Unless specified otherwise the furniture shall be in accordance with the schedule given in the Table below.

Table 72: Furniture Schedule

Mark	Item Description	Nominal Dimensions (mm)			Material[1]	Features
		Length	Width	Height		
T1	Desk	1,675	865	750	Wood	per 3.2.11.6.1.1
T2	Desk (Manager) w/ Side Return	1,800 1,200	900 600	750 720	Premium [2] Wood	per 3.2.11.6.1.2
T3	PC Workstation	2 wings @ 1,000	850	750	Wood / Metal Legs[3]	U-shaped with a raised 2nd level in the center for the monitor
T4	Table (Layout)	1,665	900	750	Wood / Metal Legs	Rectangular shape Godrej T-401 or equivalent
T5	Table (Meeting)	2,100	1,100	780	Wood Laminate / Metal Legs	Rectangular shape, with a maple (light) veneer finish with PVC edging
T6	Table (Conference)	3,000	1,200	780	Premium Wood / Wood Legs or Pedestals	convex shape, with a satin wood (medium dark) finish
T7	Table (Meeting)	900 diameter		750	Wood Laminate / Metal Legs	Round shape, with a glass top (6 mm thick w/ beveled edge)
T8	Table (Printer)	600	600	750	Wood / Metal Legs	Rectangular shape with PVC edging
C1	Chair (Desk) Swivel type	750	750	440 to 565[4]	Steel / Fabric / Padded	Adjustable height, medium height back, on 5 casters, with arms. Godrej PCH-7002 or equivalent
C2	Chair (Side) Fixed type	610	550	440[4]	Steel / Fabric / Padded	Fixed height, medium height back, on frame, with arms Godrej PCH-7003 or equivalent
C3	Chair (Side) Fixed type	610	525	440[4]	Steel / Fabric / Padded	Fixed height, half height back, on legs, without arms.

Mark	Item Description	Nominal Dimensions (mm)			Material[1]	Features
		Length	Width	Height		
						Godrej PCH-7004 or equivalent
C4	Chair (Manager) Swivel type	750	750	440 to 565[4]	Steel / Leather / Padded	Adjustable height and back position, full height back, on 5 casters, with arms. Godrej PCH-7001 or equivalent
C5	Chair (Visitor) Fixed type				Wood / Fabric / Padded	Fixed height, medium height back, on frame, with arms
B1	Bookcase	850	450	1,800	Steel	3 intermediate adjustable height shelves, open front
B2	Bookcase	850	450	900	Steel	1 intermediate adjustable height shelf, open front
B3	Bookcase (Manager)	790	400	2,010	Premium Wood	
F1	Filing Cabinet				Steel	4 drawer A3 width, lockable
F2	Filing Cabinet				Steel	4 drawer A4 width, lockable
1	Drawing Cabinet	1,170	865	625	Steel	6 drawer, lockable
A1	Almirah (Manager)	900	400	1,800	Premium Wood	2 vertically opening glass doors (wood frames) above and vertically opening wood doors below
2	Almirah	900	400	1,200	Premium Wood	2 vertically opening glass doors (wood frames)
L1	Lockers (6) Half height	300 Ea (900)	450	1,800 (total)	Steel	2 tiers of 3 each
L2	Lockers (6) Full height	300 Ea (1,800)	450	1,800	Steel	1 tier of 6 each
1	Refrigerator / Freezer (Double Door type)	600	655	1,440	Steel	230 liter total / 60 liter freezer compartment / frost-free defrosting. A BEE Star rating of 4. Godrej Eon, GFE 25, Kelvinator, LG, Whirlpool productor equivalent.
C1	Ceiling Fan	900 diameter			Steel	3 blade type

Notes:
1. All metal shall have a factory applied baked on epoxy coating
2. Premium wood shall include cherry, mahogany, maple and African limba
1. Metal table legs may be chrome plated instead of painted
2. Seat height

(i) **Specification of furniture.** Specifications for furniture are based upon items as manufactured by Godrej or equivalent, as accepted by the Employer's Representative.

(ii) **Desk (T1)**. The desks shall be a Model Enzo manufactured by Godrej or an equivalent make with an all wood laminate (particle board laminated with veneer) frame of 18 mm wood thickness. Each desk shall have 3 drawers on one side, with 1 drawer and a hinged door cabinet on the other side. Each top drawer shall be lockable. A separate key set shall be furnished for each desk. The shade of the veneer top shall be approved by the Employer's Representative. Each drawer shall have a U-shaped handle.

(iii) **Desk (T2).** The desks shall be a Model Maestro manufactured by Godrej or an equivalent make with a premium laminate all wood frame of 25 mm wood thickness. Each desk shall have a 2 drawer mobile pedestal unit on one side, with a 3 drawer fixed return mounted at a 90^{o} angle to the main desk. Each top drawer shall be lockable. A separate key set shall be furnished for each desk. The shade of the veneer top shall be approved by the Employer's Representative. Each drawer shall have a U-shaped handle.

(iv) A separate standalone matching credenza unit of 1,400 mm width, 470 mm depth and 760 mm height shall also be furnished. The credenza unit shall have a minimum of 6 drawers and a hinged door cabinet (2 total) on each end.

(v) A separate standalone matching bookcase unit shall also be furnished. The bookcase unit shall have 3 adjustable shelves with hinged glass door above and 2 wood hinged cabinets below.

(vi) **Revolving chairs with arms (C1 and C4).** The chairs shall be Godrej or equivalent make with revolving seat on tubular pipe frame of 25 mm diameter ERW MS pipe of 14 gauge having a high or medium back as noted with a push back system and polyurethane (PU) arms on a five pronged base with ball coasters and a pneumatic seat height adjustment. Molded PU foam shall be applied on the seats and backs, which shall then be covered with good quality tapestry.

(vii) **Side chairs (C2 and C3).** The chairs shall be Godrej or equivalent make of 25mm diameter ERW MS pipe. Molded PU foam shall be applied on the seats and backs, which shall then be covered with good quality tapestry.

(viii) **Filing cabinets.** Filing cabinets shall be Godrej or equivalent made 4 drawer lateral filing cabinets made of premium quality CRCA corrosion resistant steel of 20 gauge with powder coated epoxy finish. Drawers shall move on precision ball slides with an anti-tipping and anti-rebound mechanism provided with full length drawer pull tracks.

(ix) **Lockers.** Personal storage lockers shall be Godrej or equivalent made industrial lockers of 16 gauge premium quality CRCA anti corrosive steel fitted with a precision lock or an attachment for portable padlocks. Each locker shall have a handle and a label holder.

(x) **Drawing Cabinets.** Drawing cabinets shall be made of premium quality corrosive resistant 20 gauge steel. The integral casing shall be seamless and framed through careful welding of sheet metal components. Drawers shall move smoothly on accurately fabricated precision slides having nylon rollers. Drawers shall be fitted with label holders, continuous pull out handles, and multi lever lock with anti-tipping and anti-rebound mechanisms. The cabinet shall have 6 drawers each 1,040 mm wide by 780 mm deep by 65 mm high.

aa. Technical Specification of Mechanical and Electrical Equipment

1018. This subsection covers technical specification of mechanical works for raw water and clear water pumping stations. The mechanical works includes all pumps, valves, MS pipes and specials and other equipment used in the pumping stations.

1019. The subsection also includes technical specification of electrical equipment. The electrical equipment are main and secondary transformers, HV /LV switchboards, energy efficient motors, LV Neutral soft starters, LV capacitors, HV and LV power cables and control cables, DC supply system with DCDB; APFCR, PMCCs, MCCs, Distribution Boards; Protective Relays and other associated equipment.

1020. **Raw water pumping system**. The Jack well shall be designed to accommodate (4W +2S) nos of VT Pumps in each well so as to make 95 MLD supply during Intermediate stage and additional pumps for 46 MLD during Phase II after installation of additional pump during Phase II. The Contractor shall accordingly design, supply and install the pumping machinery. Supply and installation of pumping machinery for Phase II is however not included in the present contract and only space has to be provided in the pump house by the Contractor.

1021. The pumping machinery to be supplied and installed under this contract will be suitable for pumping water up-to Intermediate stage requirement.

1022. **Raw water pumps–vertical turbine.** This section outlines the specifications for self-water lubricated V.T. pumps on overhead pump house on jackwell for raw water pumping stationat headworkson Ganga river.

1023. Details of jack well, pump house and pumping with tentative levels are given below:

Table 73: Details of Jack Well, Pump House
with Tentative Levels

1.	Total raw water demand for Intermediate stage	95.00	MLD
2.	Hours of Pumping	23.00	Hours
3.	Jack well / pump house-Twwin D shapedwell. Length 9 m and semi hemispherical diameter is 4.5 m of each D-shaped well.	1.00	Nos.
4.	Number of pumps to be installed (intermediate stage)-(2 Working + 1 Stand by) on each section of well	6.00	Nos.
5.	No. of pumps to be operated	4.00	Nos.
6.	Sludge Pumps	2.00	Nos
7.	Foundation level (tentative)	4.50	MSL
8.	Bottom Level at top pluging	14.50	M
9.	Invert Level at jackwell of connecting pipe	17.50	M
10.	Lowest Water Level in river	24.00	M
11.	Min. water level considered for pump design	28.00	M
12.	Flood level of pump house (well cap top)	36.00	M
13.	Average length of column pipe	16.00	M
14.	HFL of river	35.00	M
15.	Normal water level of river	27.50	M
16.	Inlet level of Sedimentation Tank	52.35	M
17.	Inlet level of Aeration Basin	52.00	M
18.	Minimum Head on Pump (avg)	21.00	M
19.	Maximum Head on Pump (avg)	32.00	M
20.	Average Pump Head	29.00	M

21.	Pump House: Panel Floor Level Corbel Level Top Slab level of Pump house	 36.00 42.50 45.50	 M M M

Note: M.S Pipe 1321 mm (O.D.)

1024. Each V.T. pump water lubricated type shall be of approved make and suitable for following duty conditions and operating conditions.

Table 74: Pump Duty Condition and Operating Range

1.	Discharge of each pump	1120	Cu.m per hour
2.	Head	29	M
3.	Head range (Operating)	21 to 32	M
4.	Shut off head (more than)	35	M
5.	RPM of pump	985	RPM
6.	Number of stages (not more than)	Single stage	
7.	Bowl efficiency (more than)	82	%
8.	Lubrication	Self -water	
9.	Total suspended length (including strainer)	16	M (approx)
10.	No. of pumps (2 Nos working in parallel + 1 Nos. standby)(2 Nos. for each section of Jackwell)	(4+2)	Nos.

1025. The pump head referred above is inclusive of all losses in the pipeline from discharge head flange of the pump. Inlet losses in column pipe, discharge head for individual pump shall be calculated by the tenderer and included in the design head of bowl assembly. The tenderer shall submit design of V.T. pump and its accessories for approval prior to placement of supply order. The capacity of settled water sump shall be 10 min of ultimate demand. Depth of sump shall be 3.5 m (mimimun). The settled water pump shall be V.T. pump, water lubricated of approved make and suitable of following duty considerations:

Table 75: Pump Duty Considerations and Operating Range

1.	Discharge (Intermediate stage)-each pump	1120	M3/hour
2.	Minimum Pump Head	7.50	M
3.	Maximum Pump Head	9.50	M
4.	Average Pump Head	8.00	M
5.	Designed Discharge	95	MLD
6.	Hours of Pumping	23	Hours
7.	No. of Pumps	(4w+2s)	Nos

1026. Alternatively horizontal centrifugal pumps with positive suction will also be accepted. The V.T. pumps shall be installed on overhead pump house to be constructed on settled water sump. The static head shall be mean water level of settled water sumpto inlet chamber/aeration fountsin tip level.

1027. **Clear water pumping system.** The treated water from WTP is to be collected in clear water storage reservoir which is to be constructed under contract for phase II water demand.

1028. There are two transmission systems for Bhagalpur Water Supply Scheme i.e. Southern transmission system and Western Transmission System, operating need for bothe the transmission systems will be about 38 m and designed discharges will be 44 MLD for

Southern transmission syatem and 56 MLD for Western transmission system. The pumping will be for 23 hours.

1029. The following table (Table 76) gives the broad details of both the transmission systems

1030. (4w+2s) pumps shall be installed on clear water sump located at WTP premises for intermediate stage water requirement. In the IInd stage (2w+1s) pumps is to be installed.

1031. The pump house shall be common for intermediate stage and phase II pumps installation. The spacing of the pumps shall be uniform for all sections and minimum c/c distance shall be 2.5 m.

1032. Inlet connections to the clear water reservoir shall be from bottom. The design ststic head on pumps shall be the difference between high water level of main reservoir and mean water level of clear water reservoir.

Table 76: Clear Water Transmission Mains from Clear Water Pumping Station to Storage Reservoirs

S.N.	Details	Western Transmission System	Southern Transmission System
1	Dischargeintermediate stage	56 MLD	44 MLD
2	Design Discharge ultimate stage	74.30 MLD	58.10 MLD
3	Pump Hours	23 hours	23 hours
4	Average water level in clear water sump	46 m	46 m
5	Lowest water level in clear water sump	44 m	44 m
6	Maximum water level in clear water sump	47.50 m	47.50 m
7	Diameter of clear water transmission pipe lines (DI CA Class)	150 to 900 mm	150 to 800 mm
8	Length of transmission network	16.35 km	12.30 km
9	Operating Head	38 m	38 m

1033. Clear Water Pumps – VT Pumps. This section outlines the specifications for self water lubricated V.T. pumps to be installed on sump and pump house for pure water pumping stations at WTP. The details of sump, pump house and pumping with tentative levels are mentioned below.

Table 77: Details of Sump, Pump House -Tentative levels

S.N.	Items	Quantity	Units
1	Treated water demand at intermediate stage	90.00	MLD
2	Pumping hours per day	23	Hours
3	Capacity of treated water sump (excluding chlorine contact time)	1 (ultimate demand)	Hour
4	Pump delivery pipe floor level	48.50	M
5	Operating Head	38.00	M
6	No. of Pumps (4w+2s)	6	Nos
7	Flow per pump	978	M3/hour
8	Head Range	36 to 40	M
9	RPM	985	-

10	Bowl Efficiency (more than)	82	%
11	Lubrication (Self water)		

1034. The pump head referred above is inclusive of all losses in the pipeline from discharge head flange of the pump. Inlet losses in column pipe, discharge head for individual pump shall be calculated by the tenderer and included in the design head of bowl assembly. The tenderer shall submit design of V.T. pump and its accessories for approval prior to placement of supply order.

1035. Characteristic Curves for Raw, Settled and Clear Water Pumps. System head curve for the raw, settled and clear water pumping system is furnished along-with the tender. The tenderer shall furnish characteristic curves of pump after deducting column pipe losses etc. upto pump delivery flange. The tenderer shall furnish along-with his tender the characteristic curves so prepared superimposed on system head curve for single and multi-pump operations (up-to 3 pumps in parallel operation).

1036. The pump shall have stable characteristics over the entire range of working head. The pump shall be suitable for starting against closed sluice valve i.e. shut off condition. The efficiency curve should be reasonably flatter between head range proposed in the tender.

1037. **Codes and standards**. The design, manufacture and performance of the V.T. pump shall comply with all currently applicable status, regulations and safety codes in the locality area where the equipment will be installed. The equipment shall also confirm to the latest applicable Indian Standards. In particular, the pump shall confirm to the latest revisions of IS below mentioned.

IS 1710-1989/2004	:	Specification for vertical turbine pump mixed flow, axial flow for cold, clear fresh water
IS 5120-1977 / 2007	:	Technical requirements for roto-dynamic special purpose pump
IS 9137 – 1978 / 2002	:	Code of acceptance test for centrifugal mixed flow and radial flow pumps – Class C

1038. Where the above standards are conflict with the stipulation of tender specifications, tender specification supersedes them.

1039. Design requirements for raw, settled and pure water pumps. The pump shall be capable of developing the required total head at rated capacity for continuous operation. The total head discharge curve shall be continuously rising towards the shut off with highest shut off point. Pumps shall be identical and shall be suitable for parallel operation with equal load division. Impellars shall preferably be of non-overloading type. Pumps shall run smooth without undue noise and vibrations. The magnitude of peak to peak vibration at slip will be limited to 100 microns at the bearing housing.

1040. **Features of construction**. Pump shall be vertical turbine self-water lubricated type with required number of stages not exceeding the requirement given above and suitable for the service condition stipulated.

1041. Suction bell mouth and strainer. M.S. / C.I. bell mouth not less than 900 mm dia. shall be fitted to the suction nozzle (of the bowl assembly) to limit the Inlet velocity. The shape and curvature of the bell mouth shall be designed to streamline the flow of bowl suction. Thickness of bell mouth shall not be less than 10 mm. The suction strainer shall be of stainless steel. Net opening area in strainer shall not be less than 3 times of entrance area of bell mouth.

1042. **Bowl assembly**. Pump bowls shall be of Cast Iron (IS 210 Grade FG200) and shall be flanged type with machine matching of faces. The suction bell mouth to bowl assembly to column pipe and to discharge head all joints shall be flanged joints. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice the duty head or 1.50 times of shut off head whichever is greater.

1043. **Impeller.** The impeller shall be dynamically balanced so as not to cause any vibrations during operation.

1044. The impellers shall be closed type and shall be made in one piece and securely fixed to the stainless steel shaft to assure accurate adjustment of each impeller. The water passage shall be furnished smooth. Balancing holes or devices for reducing hydraulic thrust shall not be provided.

1045. Impeller shall be of stainless steel CF8 m or CA-15.

1046. Wearing rings. Wearing rings shall be renewable type. These shall be held in place by screwing against rotation, press fit or locked with pins, flanged and screwed. Wearing rings shall be provided on both casing and impeller. Wearing rings shall be of same material as impeller however hardness of wearing rings shall be less by at least 50 BHN than the impeller.

1047. **Impeller shaft.** The impeller shaft shall be of stainless steel (AISI 410 / 416) and finished to the close tolerance at the impeller / bearing fixing sizes.

1048. The design of the shaft shall also take into consideration the critical speed of the shaft, which shall be at least 20% above / below the operating speed. The shaft shall be properly balanced so as not to cause any vibrations during operation.

1049. The impeller shaft diameter shall be minimum 45 mm or nearest to commercial size.

1050. The pump shaft bearings i.e. bush bearings shall be of stainless steel, water lubricated type. Extra long bearings shall be provided for suction and discharge case of bowl assembly. The hardness of bush bearing shall be less by at least 50 BHN than that of shaft.

1051. **Column pipe assembly.** Column pipes shall be of M.S. (ERW) fabricated heavy duty, flanged type each pipe in 1.50 m length or less so after complete erection of the pump the bottom of strainer shall be located as per CPHEEO manual provisions.

1052. The column pipe diam. (ID) shall be 600 mm and thickness shall be minimum 10 mm.

1053. The column assembly length (including column pipes, bowl assembly, bell mouth and strainer) shall be adjusted considering the pump delivery floor level as given above. A matching pipe piece with shaft shall be provided if required. The stiffness shall be provided to all the pipe flanges. The discharge head diam. and column pipe diam. shall be of 600 mm diam. The discharge head shall incorporate full 600 mm diam. elbow. But bolts and washers of column assembly shall be of S.S. (AISI 410).

1054. **Line shafts.** Line shafts shall be of solid circular section of minimum 45 mm diam., prepared from stainless steel (AISI 410 / 416) machined and grinded thoroughly and coupled with screwed or muff couplings. The shaft sections shall be provided with non-corrosive and abrasion resisting wearing surfaces particularly at the location of each guide bearing. Length of each line shaft shall not be more than 1.50 m.

1055. **Line shaft bearings.** Line shaft bearings shall be designed to be water lubricated by the pumped water and shall be placed in bearing holders located in position at the joint of column pipes. Line shaft bearings shall be of cutless hard tuber designed for efficient water lubrication. Composite design of line shaft material and its diam and bearing center shall ensure that the entire rotating assembly is brought from standstill to full speed without any

vibrations and shaft deflection and to ensure that first critical speed is not within 80% to 120% of full speed.

1056. **Discharge head and motor stool.** The discharge head shall be fabricated from M.S. and shall incorporate mounting flange for motor stool for solid shaft motor, stuffing box with renewable gland packing and tapping for pressure gauge mounting etc. The discharge head shall be of robust construction and shall be designed to support entire load of pump assembly, water column and motor etc. and shall withstand all static and dynamic, torsional loads, hydraulic thrust imposed during operation from shut off to stipulated operating conditions and thrust due to change in direction of flow without any vibrations. The discharge head shall incorporate full 600 mm dia. Elbow. Discharge heads with sole pads will not be accepted. The discharge head shall be installed on sole pate with ISMB frame and entire load of pump and motor shall be on the pump floor.

1057. Drain arrangement for gland leakage water shall be provided at bottom of discharge head with G.I. pipe. The power shall be transmitted from motor to vertical shafting through a flexible coupling. Both halves of the coupling shall be machined all over. Securely keyed to their respective shafts. The keys (pins) shall be of stainless steel. The arrangement of two halves shall be suitable to check alignment and parallelism. A self-aligning thrust bearing shall be housed in the head gear adequately designed to accommodate entire weight of rotating pads and hydraulic thrust and shall be suitable for reverse rotation up-to at least 150% normal forward speed. Thrust bearing shall be designed for minimum 30,000 hours life. The bearing shall be of oil lubricated type with proper cooling arrangement and shall be provided with oil level gauges and with suitably positioned temperature probes. Two sets of adjustable contacts shall be provided for thrust bearing, one for an alarm and other for tripping the pure water pump motor. This shall be connected to scanner panel so that digital temperature can be read out with alarm and tripping.

1058. Motor stool shall be provided for mounting the elect. Motor. The motor stool shall accommodate the pump thrust bearing and pump motor coupling. The motor stool shall be of robust construction and of fabricated from mild steel and adequately sized with openings to work of the flexible couplings.

1059. **Miscellaneous.** The pump shall be provided with non-reversible ratchet or similar mechanism to prevent from rotation in reverse direction. Pressure gauge to each pump and manifold pipe shall be provided. Pressure gauges shall be of 150 mm diam. 0-15 kg / cm2 and with least count of 0.05. Each pressure gauge shall be filled with restrictor nozzle of brass and with G.I. pipe and 'U' tube. All pressure gauges shall be installed in pump house on wall with necessary G.I. pipe connections. The pressure gauges shall be installed at suitable height so that the reading can be taken accurately.

1060. **Sole plate**. The M.S. sole plate arrangement shall be provided under the discharge head for precise horizontal and vertical alignment. Thickness of sole plate shall not be less than 40 mm. It shall be independent of base plate integral with the discharge head. The contract surfaces of the sole plate as mentioned below shall be machined for precise leveling and shall ensure vibration free operation of the pump.

i) Corner plates and sole frame
ii) Sole frame and sole pate
iii) Sole plate and discharge head

1061. All joints between machined contact surfaces shall be with nut bolts / tapped studs / bolts. All contact surfaces shall be blue matched to ensure proper contact to the extent of 60% of contact area after necessary site finished if required. The opening in the sole pate /

frame shall be of adequate size to pass the bell mouth, bowl assembly etc. very easily M.S. base frame shall be anchored in the floor ensuring complete rigidity. Entire structural fabricated and foundation arrangement shall be designed and submitted for approval. M.S. plates shall be grouted on pump supporting R.C.C. beams provided in civil structure. Fixing of M.S. plates on the R.C.C. beams and subsequent anchoring of M.S. sole frame in proper level shall be the responsibility of pumping machinery Contractor with all related works. Size of the sole plate shall be about 1.80 m x 1.80 m x 0.04 m.

1062. **Air release arrangement**. An air cock of dia. 40 mm minimum with same size G.I. pipes shall be fixed to the discharge head. The G.I. pipe shall be suspended vertically in the sump with adequate length to release air.

1063. **Water lubrication tank and other accessories.** In order to lubricate line shaft bearings of the pump lubrication arrangement comprising the following shall be provided.

i) Lubrication tank – 2 Nos. interconnected with each other common for all pumps fabricated from sheet metal of thickness not less than 5 mm and of capacity not less than one cubic meter. The tank shall be cylindrical and shall be installed on panel mounting floor as directed during execution by Employers representative
ii) Each lubrication tank shall be equipped with following:

Water level sight gauge
Overflow lead to sump
Drain valve lead to sump
G.I. pipe connection with isolating valve and non-return valve to each pump column assembly for lubrication.The valve shall be located near the tank size of individual G.I. pipe and valve to pump shall be 40 mm.
Inlet connection with solenoid operated valve and suitable removable strainer by suitable tapping from common header.
Float valve in the tank for controlling overflow.
Any other item necessarily required for proper functioning.
All accessories required for proper and safe operation, dismantling and erection of pump. Pump shall be supplied with heavy duty clamps for column and line shaft, one pair for each pump.

1064. Testing. The Contractor shall arrange a) Factory testing and third party inspection, b) Field performance testing of all the pumps as mentioned below.
i. **Factory Test and Third Party Inspection**. All the pumps shall be subject to factory test and inspection by the third party appointed for the purpose in presence of Employers representativeor his representative.
Scope of the factory test and inspection is as under (a) review of raw materials test certificates of various components of the pump and quality control procedure, and (b) hydrostatic test.
Following accessories shall be tested at hydrostatic pressure equal to twice the duty head or 1.50 times shut off head of bowl assembly whichever is higher as per IS 5120.
Bowl assembly
Discharge head
20% quantity of column pipes
1065. Performance test at manufacturer's work. The test shall generally be carried out as per IS 9137 accepted test for pump Class C. The test shall be carried out at full speed; full load. The test shall be carried out only by the job motor which will be supplied under this contract. The test at reduced speed and reduced load will not be acceptable.
The performance test shall cover below mentioned 10 points.
Duty head point

4 points above duty head
4 points below duty head
Shut off head point
Power consumption and pump efficiency at all 10 points.

1066. Strip inspection. One number of pump set, after completion of its performance test and as selected at random by the Employers representativeor Third party Inspector will be offered for strip inspection and dimensional checking. The Contractor / manufacturer shall submit all required dimensional drawings for strip inspection. Minimum points as under shall be checked.

Condition of all components, particularly bushes, bearings and wearing rings to examine undue rubbing, wear etc.
Hardness of cut less rubber bearing.
Dynamic balancing of a) Impellers b) Flexible coupling. Maximum unbalance shall be as per relevant IS.
Clarence and tolerances between: (a) wearing rings, (b) impeller shaft and bearings, (c) impeller shaft and key, (d) shaft and flexible coupling, and (e) key and key way on shaft at (d).
Finishing of water passage in impeller and diffuser
Material test certificates of various pump components shall be furnished by the contract/manufacturer.

ii. 1067. **Field Performance Test**. The test shall be carried out as per IS 9137 code of acceptance test of pump Class C, in general and as stated below in particular.

the purpose of the field performance test is not to ensure whether pump performance as regards parameters i.e. Head (H), Discharge (Q) and power etc. within acceptance limit as per IS 9137. The purpose is to ensure that the pump performance is generally acceptable or otherwise. Final acceptance shall be as per following criteria.

1068. Verification of guarantee of H and Q specified in Clause 9.4.1 of IS 9137 shall be based on following liberalize tolerances (H± 0.06; Q± 0.09).

1069. As regards P-Q characteristic for acceptance it shall be checked whether motor is not getting overloaded within the specified head range.

1070. Volumetric measurement shall be taken on basis of rise in water level in MBR. In addition calibrated flow meter to be provided by the Contractor.

1071. Pump head shall be measured with calibrated pressure gauge of accuracy 1% or better. At least 3 pressure gauges shall be got calibrated from two different institutions with prior approval of the Employers representative The calibration shall be point to point and not mere for percentage error.

1072. The input power to electrical motor shall be measured with class 0.50 accuracy power meter with suitable CTs and test lid and PTs provided in panel. The watt-meters, CTs and PTs shall be got calibrated point to point and not mere for percentage error.

1073. Pump speed shall be measured by at least 2 Nos. non-contact techo-meters with digital display calibrated from two different institutions approved by Employers representative

1074. The field test shall be taken with entire head range in such a manner that it would cover at least 6 points (i.e. duty point, 2 above duty point, 2 below duty point and shut off). The guarantee for head and discharge shall deemed to be fulfilled as per Clause 9.4.1 of IS 9137.

1075. The field performance test at site is absolutely essential as above and the manufacturer shall also be asked to attend the same.

1076. **Dismantling joint.** A dismantling joint of 600 mm size shall be provided in delivery pipeline of each pump. The dismantling joint shall be placed between pump delivery flange and non return valve and shall be fabricated from MS plates designed to withstand 16 kg / cm2 pressure. However, plate thickness for barrels shall not be less than 10 mm. The design of the joint shall ensure that no forces are transmitted to the pump foundation, and the flanges of dismantling joints are held rigid during normal working. For dismantling of

pump, it should be possible to slide flanges at one end by at least 20 mm to enable dismantling of pump and refitting. M.S. dismantling joint shall be as per requirement including machining and rubber rings shall be suitable for 16 kg/cm2 pressure. The joint should have through bolts so that during normal working pressure there should not be sliding movement of sliding flanges. General arrangement drawing shall be got approved from the Employers representativebefore actual fabrication of the dismantling joint.

1077. **Reflux Valve (Non Return Valve).** Each pump shall be provided with a non-return valve of approved make and of 600 mm dia. With PN 1.0 rating on delivery side. The valve shall be provided with bypass arrangement. The non return valve shall be single door/ multi door type generally as per IS 5312 (Part 1 or Part 2) free acting quick opening, giving rapid non slam closure and with low head loss characteristics when in open position.

1078. A 1200 mm dia PN 1.0 rating reflux valve of approved marks shall be provided on common delivery main (rising main) as directed by the Employers representative 1200 mm dia valve shall be multi door type generally as per IS 5312 (Part 2).

Table 78: Material of Construction

i)	Body, cover, door and door face disc	-	Grey cast iron conforming to grade FG-200 of IS 210
ii)	Hinges	-	Cast Steel IS 1030
iii)	Hinge pins, door pins and door suspension pins	-	Stainless steel as per IS 6603
iv)	Bearing bushes, body hinges and door faces	-	Gen. metal as per IS 318 Grade-2

1079. **Testing**. All the reflux valves shall be tested at manufacturers work as per relevant. IS in presence of third party agency approved by the Department in presence of Employers representativeor his representative. The scope of inspection and testing is as given below:

a) Review of raw material test certificates and quality control procedures
b) Hydraulic pressure test for body and sat as per IS Kirloskar / IVC / IVI.

1080. **Sluice Valves with electrical actuator.** A C.I.D.F sluice valveof 600 mm diameter shall be of approved make and shall be provided in the delivery pipe of each pump. The sluice of cast iron body suitable for PN 1.0 rating shall be provided and shall confirm to IS 14846-2000. Sluice valves shall be double flange, water works pattern, inside screw, non rising spindle type and shall be fitted with double faced gunmetal taper made in one piece and having two machined facing rings securely fixed into machined recesses in the wedge. The guides and the lugs shall be provided to guide the wedge through its full travel and the lugs and guides shall be lined with bronze. The bronze liners provided on the guides and lugs shall be secured by counter sunk screws or rivets of non fessours metals. The clearances (radial and lugs axial) between the lugs and guides shall not exceed 2.50 mm. All sluice valves shall be provided with individual actuators, on delivery side of each pump.

1081. Sluice valve positions are tentatively indicated sluice valve shall be installed on pump delivery floor.

1082. Valve actuator for the sluice valve shall be installed on the sluice valve with all accessories. All the accessories shall be provided by the sluice valve manufacturer only. .

Table 79: Material of Construction of Sluice Valve

a)	Body, bonnet cover and wedges, stuffing box and gland	-	Grey cast iron conforming to grade FG 200 OF is 210
b)	Spindle	-	Stainless steel IS 6603

c)	Edge and body fringes	-	Leaded tin bronze conforming to grade 2 of IS 31
d)	Nuts and bolts	-	As per IS 1363
e)	Wedge nut	-	High tensile brass conforming to alloy 3 of IS 320

1083. **Valve actuators.** Each sluice valve shall be provided with an electric actuator of approved make. Elect. Actuator shall be suitable for operation on 415V, 3 phase 50 Hz electric supply. The motor shall be squirrel cage type with insulation class B confirming to IS 2613. The actuator shall be suitable for opening and dosing against duty head considering shut off. At least 50% safety margin over normal operating conditions shall be provided in motor rating for unseating the valve. A thermal contact device shall be provided to enable starting from any valve position. A local push button / rotary switch and LOCAL / OFF / REMOTE selector switch shall be provided with clear making for switch position, in addition to separate ON / OFF device on LT panel as described in detail specification. The terminal box shall be a separate unit bolted to gear case and provided with double 'O' ring sealing arrangement to prevent moisture from entering the actuator even if terminal box is removed.

1084. Drive bushing shall be provided for accommodating the valve spindle. The bushing shall be detachable type. Pair of limit switches shall be incorporated in the actuator to provide remote position and interlock signals. Similarly a torque switch for closing and a position switch for opening shall be provided Necessary mechanism to prevent tarque trip while unseating of valve shall be provided. A hand wheel shall be provided for emergency manual operation of the valve with interlocking to prevent motor operation while the valve is being operated manually.

1085. Arrangement for greasing and drain plug shall be provided in the actuator. The drive shall incorporate a backlash hammer blow feature. Thrust bearing of ball or roller type shall be provided, of oil or grease lubricated only.

1086. A reduction gear box shall be provided between actuator and valve. The torque rating of the reduction gear box shall be at least 2.0 times maximum torque required for opening and closing the valve. The reduction gear box shall be oil lubricated.

1087. The entire unit i.e. valve actuator, reduction gear box along-with valve and accessories shall be supplied by the valve manufacturer only. No local made component or manufacture from any other source shall be accepted. The valve and valve actuator combine shall be tested at valve manufacturer's works for operation against requisite duty.

1088. The design calculations of torque and HP of actuator motor shall be got approved from Employers representative

1089. Testing. All the sluice valves with actuator shall be tested at manufacturer's works as per relevant IS in presence of third party testing agency approved by the department and Employers representativeor his representative and the scope of inspection and testing is as mentioned below:

a. For Sluice Valve
i) Review of raw material test certificates and quality control procedure
ii) Hydraulic pressure testing of body and seat
iii) Test with operation of actuator and reduction gear box fully assembled with valveopening and closing with synchronizing
iv) Checking wear travel

b. For all Valve Actuators
i) Review of raw material test certificates and quality control procedure
ii) High voltage test
iii) Insulation resistance test
iv) Routine and operation test
v) Checking wiring diagram and circuit
vi) Operation test with limit switches

1090. **Butterfly valve**. Butterfly valve 600 mm dia. shall be of short wall body pattern with both ends flanged suitable for PN 1.0 working pressure. The manual actuator shall be provided to operate the valve. The shaft shall be horizontal. The valve sent on the disc shall be of synthetic rubber and renewable without dismantling the valve. All fasteners shall be stainless steel. C.I. body shall conform to grade FG-200 of IS 210. Suitable hand wheel for operating of valve shall be seamless with OPEN and CLOSE marking.

1091. **Testing.** All the valves shall be tested at manufacturer's works as per relevant IS in presence of third party agency approved by department and Employers representativeor his representative.

1092. The scope of inspection and testing is given below:

a. Review of raw materials test certificates and quality control procedures.
b. Seat and body testing for test pressure as per IS.

1093. **Kinetic air valve.** Kinetic air valves of 200 mm diam shall be of approved make and shall be provided and installed on pump delivery common manifold as directed by the Employers representative The kinetic air valve shall be of two orifice type, the small orifice releasing air from the pipe carrying water under pressure under normal working conditions while the large orifice shall admit or release air when the delivery pipe is being emptied or filled. The air valves shall be designed to operate satisfactorily at a normal working pressure of 10 kg/cm2. Kinetic air valve body shall be tested for 16 kg/cm2 pressure. Each air valve shall be provided with an isolating sluice valve of 200 mm diameter which shall be generally comply with specifications given above for the item for sluice valve except for electrical operation. The isolating sluice valve shall be provided with seamless cast iron wheel for manual operation.

Table 80: Material of Construction

Float chamber, cowl and cover	Grey Cast Iron conforming to grade FG 200 of IS 210
Small orifice float	Seasoned timber ball covered with soft rubber
Large orifice float	Seasoned timber ball covered with vulcanite
Orifices, guides	12% chromium steel conforming to IS 1370 or stainless steel to BS 970-1045-15
Sealing ring	Molded rubber for suitable quality

1094. Testing. All the valves shall be tested at manufacturer's works in presence of third party inspection agency approved by the department and Employers representativeor his representative. The scope of inspection is as given below:

a. Review of raw materials test certificates and quality control procedure
b. Operation test for functions for small orifice and large orifice

1095. **M.S. Pipes Work**. M.S. pipe work on delivery side the pumps shall be fabricated from steel plates conforming to IS 226. The fabrication of pipes shall generally conform to IS-3589. 600 mm dia. M.S. pipes and specials shall be fabricated out of 8 mm thick plate layout drawing for pipes, valves shall be submitted for approval prior to erection. All the pipes and specials shall be painted with three coats of approved make epoxy paint from inside, outside including all required material, laborer etc. complete. Rate quoted shall be on kg basis, quantity mentioned is tentative and may vary as per site condition.

1096. **Air release arrangement**. Arrangement shall be made for release for air in the column pipes of pumps. A M.S. bend of 50 mm dia. shall be provided after discharge head for air release arrangement including air release cock.

1097. **Flanges**. The flanges for pipes and specials shall be designed to withstand pressure of 25 kg/cm2. Matching faces of the flanges shall be properly machined. The flanges shall be confirmed to IS-1538. The flanges shall be confirmed to IS-1538. The flange should be of minimum 25 mm thickness.

1098. **Pipe/Flange Joint**. The joint ring shall be of rubber of proven hardness, suitable for forming water tight joint and shall be of flat section 3 mm thick.

1099. **Mode of measurement and payment.** The pipes and specials provided by the Contractor such as M.S. pipes, specials, flanges, dished ends and blank flanges etc. are payable on kg basis for complete work. For calculating weight for payment on rate per kg basis, following parameters will be applicable.

i) Weight of pipes and specials shall be based on finished fabricated component. Wastage will not be considered for payment.
ii) Thickness shall be average thickness of pipes supplied.
iii) No deduction for bolt holes in flanges will be made.
iv) Nut, bolts and washers will not be considered for weight calculation
v) Specific weight of M.S. pipes and specials shall be assumed as 7850 kg/cu.m.
vi) Cost of epoxy painting of M.S. pipes, specials is deemed to have been included in the rate per kg basis and shall not be considered for separate payment.
vii) No negative tolerance in thickness of pipe is acceptable. The thickness will be measured by ultrasonic gauge and same shall be measured by the agency in presence of departmental Engineer at site.
viii) Cost of breaking of pump house wall for pipeline work and making and finishing, after the work is completed, is included in this item.

1100. **Testing**. The Contractor shall give satisfactory testing of pipe work at hydrostatic pressure of 10 kg / cm2 in presence of Employers representative

1101. **Desilting Pumps of Jack Well.** Pumps shall be suitable vortex type submersible pump to clean the intake well within 2 hours continuous operation. 2 Working + 1 Standby number pumps shall be provided.

1102. **Design Requirements**. The submersible type pumps shall be of a fully recessed impeller design capable of handling large solid sand abrasive particles. The integral pump/motor units shall be designed to operate continuous full load duty completely submerged in liquid without the need for external cooling.

1103. The name plate ratings of the motor shall be based on a 400 C ambient environment. The pump motors shall be designed to withstand 200 psi differential water pressure at all seal locations. Heat transfer shall be accomplished by convection through the stator wall to the surrounding media. Designs that incorporate cooling jackets are not considered equal to the equipment described in this specification and shall not be acceptable.

Table 81: Basic Pump Design Criteria

Description of Item	Units	Value
Type of Pump	-- --	Submersible Vortex Centrifugal
Mounting Configuration	-- --	Vertical
Number of Pumps to be Furnished	No.	2
Normal Number of Duty Pumps	No.	1
Pump Output each, at design point	m3/hr	410
Pumping Head Required, at design point	m	16a +/-
Minimum Allowable Guaranteed Pump Efficiency, at design point	%	40%

Maximum Pump Efficiency point location	-- --	within ±5 % of the design point
Maximum Synchronous Motor Speed	rpm	1,500
Maximum Driver (Electric Motor) Rating	kW	30
Electrical Service to be Provided	v/ph/hz	415/3/50
Type of Lubrication for bearings	-- --	oil
Type of Shaft Seal	-- --	mechanical
Notes: aThe pumping head has been estimated from the river LWL to the estimated floor elevation in the RWPS with system losses. bThe above table is indicative, and to be finalized by Contractor.		

1104. Submittal drawings and information to be provided by the Contractor are the following:

General arrangement and cross-sectional drawings of pumps with materials of construction and dimensions identified.
Performance curves
Head-Capacity (H – Q) curve
Shaft Power - Q curve
Efficiency - Q curve
Factory test reports

1105. **Spare parts.** Spare parts supplied during the Operations and Maintenance (O&M) period shall be identical to respective pump components and shall be furnished by the original pump manufacturer. One set of standard and special tools, centering tools, lifting lugs, pipe, etc., required for erection and maintenance shall be supplied.

1106. At the end of the Contractor's O&M period, the following spare parts shall be furnished and delivered to the Employer's storehouse:

Table 82: Spare Parts to be delivered to Store house

Item / Part	No. to be Furnished	
	per Pump	per Set of Pumps
Mechanical Seals	1 set	
Pump Bearings	1 set	
Motor Bearings	1 set	
Wear Rings	2 sets	
Gaskets and O-rings	3 sets	
Moisture Sensing Probes		1 set

1107. Codes and standards. The design, manufacture and performance of the pumps specified herein shall comply with the requirements of the applicable Codes and Standards, including but not limited to the following:

Standard	Title
IS 6595 (Part II)	Horizontal Centrifugal Pumps for Clear, Cold and Fresh Water
IS 13537	Technical Specification for Centrifugal Pumps – Class 2
ANSI / HI 21-25	Standards of the Hydraulic Institute of the United States
ISO 1940	Mechanical Vibration- Balance Quality Requirements of Rigid Rotors
ISO 281	Rolling Bearings -- Dynamic Load Ratings and Rating Life
IS 2062	Hot Rolled Low, Medium and High Tensile Structural Steel
IS 210	Grey Iron Castings
IS 318	Specification for Leaded Tin Bronze Ingots and Castings
AISI 410	Stainless Steel Grade (heat treatable, low chromium content)
AISI 431	Stainless Steel Grade (non-hardenable chromium)

Legend:
AISI American Iron and Steel Institute

ANSI	American National Standards Institute
BS	British Standards Institute
HI	Hydraulic Institute Standards
IS	Indian Standards
ISO	International Organization for Standardization

1108. Features of construction are as follows:

Implellers. Impellers must be fully recessed out of the casing passage and must be either a radial vane or cup-type vane design. Impellers must be fitted with full back pump out vane store strict flow behind the impeller and must bekeyedtotheshaftandsecuredbyashroudedsecuringboltandlockwasher. The minimum thickness at the front edge of the impeller vane shall be 5 mm for impeller dia meters upto 200 mm, 12 mm for impeller dia meters over 200 mm and upto 300 mm and 16 mm for impeller dia meters over 300 mm.

1109. **Casing.** Where radial vane impellers are used, the pump casing shall consist of a one piece casting with integral suction and discharge nozzles plus a back plate with integral wear element. For cup type impellers the casing shall consist of are movable suction piece large enough for the impeller to be withdrawn without the need to disturb the discharge piping; a center volute casing with integral discharge flange plus a separate rear wear liner. Casing thickness shall be a minimum of 20 mm pumps up to 150 mm and 25 mm for 200 mm pumps with normal casting tolerance.

1110. **Shafts.** The pump shaft shall be accurately machined and ground to size. The shaft shall have sufficient strength and cross section to transmit the maximum required torque at the maximum rotational speed without distortion providing a maximum shaft deflection of 0.8 mm. Themotor/pumpshaftshallbeone-piece.

1111. **Mechanical Seals.** Two independent, tandem mounted, mechanical face type seals shall be provided to isolate and protect the air-filled motor from the pumped media. The inner and outer seal shall be separated by an oil filled chamber. The oil chamber shall act as a barrier to trap moisture and provide sufficient time for a planned shut- down. The inner mechanical seal shall be constructed of a solid block carbon rotating face and a solid block silicon carbide face. The outer mechanical seal faces shall be tungsten carbide. All other seal components shall be type 316 stainless steel. Mechanical seals shall be readily and commercially available from third party sources other than the pump and motor manufacturer.

1112. **Bearings.** All bearings shall be rated for a minimum L10 life of 50,000 hours at 75% of the flow at the best efficiency point (BEP).Bearings shall be permanently lubricated with a premium moisture resistant grease containing rust inhibitors and shall be suitable for operation over a temperature range of–25 0Cto+120 0C.

1113. **Wearing Rings.** Pumps with radial vane impellers shall be fitted with are arcasing wear plate and integral radial wear element, which will protect the area behind and at the periphery of the impeller from the brunt of abrasive wear. The radial wear element will be of a tapered design to promote flow of solids out of the impeller recess. Minimum thickness at the base of the radial wear element shall be 22 mm for impeller diameters upto 200 mm and 28.5 mm for impeller diameters over 200 mm. Minimum thickness at the tip of the radial wear element shall be 7.5 mm for impeller diameters upto 200 mm and 20 mm for impeller diameters over 200 mm. Wear elements must be self-centering, with jacking screws provided to facilitate removal. Pumps with cup type impellers shall have a separate removable suction piece to absorb wear in the suction area, where this impeller directs abrasive material. The suction wear piece shall have a minimum thickness of 32 mm for pumps up to 150 mm and 33 mm for 200 mm pumps.

1114. **Moisture Protection System**.A dual (2) probe sensing system shall be provided to detect the presence of moisture within the motor. The moisture sensing probe leads shall terminate at a separately supplied conductance relay located in the control panel which shall provide an alarm in the event of moisture intrusion. The sensing relay shall be provided by the pump/motor manufacturer.

1115. **Cable Entry System**. The power and control cable entry system shall be designed to provide a positive, leak-free seal to prevent liquid from entering the air filled motor housing. The design shall incorporate provisions which prevent moisture from wicking through the cable assemble even in the cable jacket has been punctured. The power and control cable entry into the lead connection chamber shall be encapsulated for positive moisture sealing.A Buna-N cable grommet shall be provided in addition to the epoxy sealed leads. Compression type grommet fittings employed

as the primary sealing system shall neither be considered equal or acceptable. Separate power and control cables shall be provided to prevent false sensor warnings.

1116. **Motors**. Submersible motors shall be NEMA Design B or IEC equivalent with torque and starting current in accordance with NEMAMG-12 or equivalent. The submersible motors shall be of an air filled, high efficiency design with copper windings and shall be rated for continuous full load operation. The motor construction shall be of TENV-TEXP design. The insulation system shall be Class F minimum, utilizing materials certified per IEE 117, and shall be rate data temperature of 1550 C. At least two (2) normally closed, automatic reset, thermostats shall be connected in series and embedded in adjoining phases of the stator windings. The drive motor power rating shall be the maximum of the following:

115% of pump input power including losses in transmission shafting and thrust bearing required for the operating range between maximum and minimum system resistance curves.

1117. The pump shall be able to operate on any point along its head-capacity curve without the power draw exceeding 95% of the pump's motor capability.

1118. The motors shall have grease lubricated bearings with a minimum L10 bearing life of 50,000 hours.

1119. Accessories. A lifting ring shall be provided on the pump's top casing for ease of lifting and installation. All specified accessories and any other standard accessories required for correct and safe operation of the pump shall be furnished with the pumps.

Table 83: Materials of Construction

Component	Material
Casing1	Ni-Hard Cast Iron: ASTMA-532, 550 BHN
Impeller1	Ni-Hard Cast Iron: ASTMA-532, 550 BHN
Shafts	Stainless Steel: AISI 416
Wear Rings	Ni-Hard Cast Iron: ASTMA-532, 550 BHN
Note:Hydraulic passages of these components shall be coated to enhance pump efficiency, after conducting performance testing.	

1120. Cooling water and lubricating water pumps. The Contractor shall work out the pump parameters for the above pumps. Pump capacity shall be at least 10% more than the calculated figure.

1121. For raw water cooling and lubricating pumps, the Second Stage requirement shall also be considered and the Contractor shall provide the pumps and associated piping accordingly, including making arrangements for extending the piping for the pumps to be installed under first Stage.

1122. The pumps shall be end-suction top-discharge horizontal back pull out type. The motor rating shall be more than the maximum power required by the pump from shut off to run out.
At least one pump shall be provided as standby for each category. The drawings and information to be provided by the Contractor are as follows:

Pump data sheets and performance curves (manufacturer's literature)
Cross sectional drawings with materials of construction
Pump set outline dimensional drawing indicating pump parameters

1123. Inspection Requirements of Pumps. All pumps shall be assembled in the shop to ensure correct fitting of all parts and shall be match marked before shipment.

1124. Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.

1125. Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head, whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.

1126. Raw water pumps and clear water pumps shall undergo witnessed performance tests as per BS 5316 Part 2 Class B / ISO 3555 at the rated speed at the pump manufacturer's Works. Other pump testing shall be as per ISO 2548 / IS 9137. All pumps shall be tested for performance without internal coating and with electric motor being supplied under the Contract.

1127. Standard running test shall be conducted at manufacturer's works to measure the capacity, total head, efficiency and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pumps shall be tested over a range comprising shut off head to maximum flow. Minimum seven readings approximately equidistant shall be taken for plotting the performance curve. The following formula shall be taken for computing the pump efficiency:

1128. **For horizontal pumps:**
Pump efficiency %: Q x H / 367.2 x N
where, Q = Discharge in cum/hr
H = Total head in mwc
N = Power in put to motor * motor efficiency.

1129. (ii) For vertical turbine pumps:
Pump bowl efficiency %: Q x H / 367.2 x N
where, Q = Discharge in cum/hr
H = Bowl head in mwc (Total head + loss in discharge elbow + loss in column pipe)
N = Power in put to motor * motor efficiency – (Thrust Bearing and transmission losses)

1130. If the vibration and/or noise level readings taken during performance test are higher than that permitted, the Contractor and manufacturer shall guarantee that the permitted values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.

1131. If the tested pump efficiency is not within the acceptable negative tolerance limit, as set forth in the referenced Codes, the Contractor shall make such changes, modifications and/or additions as may be necessary at his own cost and expense to achieve the efficiency within the allowable tolerance. If, after such corrective measures, the pump is still unable to achieve the efficiency within the allowable negative tolerance, the Employer's Representative shall reject the pump.

1132. Any other tests, including NDT (as applicable), as specified in the data sheets/ drawings/ specifications/ applicable standards and codes.

1133. EOT Crane. The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures and shall conform to IS 3177 Mechanism Class M6.

1134. The crane shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing is required along the full span length of the bridge girder. Steel shall be tested quality conforming to IS 2062 .The bridge shall be designed to carry safely the loads specified in IS 807. All anti-friction bearings for bridge and trolley track wheels, gearboxes and bottom sheaves shall be lubricated manually by hand operated grease pump through respective grease nipples.

1135. Wheel and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and to prevent skew ness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads. The crane rails shall be manufactured from wear resistant steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall

be at least 500 mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

1136. All exposed couplings, shafts, gears, wheels, pinions and chain drives, etc., shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 10,000 hours. Electro-magnetic and hydraulic thruster brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

1137. Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball/thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 3815/5749 and shall have a safety latch to prevent rope coming off the hook.

1138. Hoist rope shall be extra flexible, improved plough un-galvanized steel rope with well lubricated hemp core and having six strands of 36 or 37 wires per stand with minimum ultimate tensile strength of 1600000 kN/m2 of Right Hand Ordinary (RHO) laid construction. Rope drums shall be grooved and shall be either cast steel or welded steel conforming to IS 3177.

1139. 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 conform to IS 4460.

1140. A capacity plate not less than 150mm height showing year of manufacture and rated capacity of hoist in figures shall be placed on each side of the crane girder.The maximum deflection under full load shall not exceed 1/900 of the span.

1141. All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc., necessary for the safe and satisfactory operation of the crane shall be provided.

1142. Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:

`Start' and `Stop'.
Long travel - `Right' and `Left'.
Cross travel - `To' and `Fro'.
Hook - `Hoist' and `Lower'.
Red indicating lamp for supply `ON' indication.

1143. Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

For `Up' and `Down' motions of the hook.
Long travel motion
Cross travel motion

1144. Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

1145. Drawings and information to be provided by Contractor shall include the following:

Drawings showing general arrangement, clearance requirement, assembly, and materials of construction for:
EOT Crane
Crane rail fixing arrangement
Run way conductor system details
Trolley arrangement
Drive and transmission details for bridge travel, trolley travel and main hoist.
Design calculations for the following:
Rope drum, wire rope, gearboxes, motor ratings, brake selection wheels, etc.
Characteristics and other data for each drive motor.

1146. **Intake pumping station.** The Contractor shall provide a 10 ton or more EOT crane as required and for settled water pumping station a 5 ton or more EOT crane as required.

1147. **Clear water pumping station.** The Contractor shall provide a 10 ton or more EOT crane as required.

1148. **Inspection requirements.** The cranes shall be completely assembled in the Contractor's or manufacturer's works and shall be subjected to the tests as specified in IS 807/IS 3177 or relevant internationally approved standard. The Contractor shall provide the test results for approval of the Employer's Representative.

1149. **Delivery and suction pipes.** The design considerations are to be decided by Contractor conforming to pump machinery IS codes, Pump manual.

1150. For suction and delivery piping, the minimum thickness of the MS pipes shall be as per subsection 4. Buried portions of delivery piping and main header are to be coated externally.

1151. **Ventilation and cooling of Pump House**. Fresh air circulation system is to be provided for the pump house for circulation of fresh air to limit increase in temperature and also avoid stale air presence. The complete system along with all associated required air supply fans, exhaust fans, ducts, grills, galvanized bird screens, hoods and all necessary accessories shall be provided. Suitable arrangements to prevent ingress of rain water into building shall also be provided. The system shall be designed with required air changes and the Contractor shall provide detailed calculations to determine the air capacity, static pressure etc. and relevant technical details for the approval of Employers representative.

1152. All duct work shall be of high quality approved galvanized sheet steel guaranteed not to crack or peel on bending of fabrication of ducts.

1153. The ducts shall be fabricated from galvanized plain steel sheets conforming to IS: 277-2003. All duct work, sheet metal thickness and fabrication, unless otherwise directed, shall strictly meet requirements as described in IS: 655.

1154. All joints shall be tight and shall be made in the direction of air flow. The ducts shall be reinforced where necessary and must be secured in place so as to avoid vibrations of the duct and its supports.

1155. Volume control dampers shall be of an approved type, lever operated and complete with locking devices which will permit the dampers to be adjusted and locked in any position.

1156. Exhaust fans of appropriate rating shall be provided for pumping stations. The Contractor shall submit the fan selection details for approval.

1157. For axial flow fans / propeller fans, speed limitation shall be as follows:

For impeller diameter of up-to 450 mm – maximum speed shall be 1500 rpm.

For impeller diameter above 450 mm – maximum speed shall be 1000 rpm.

1158. Suitable designed guards shall be fitted to the inlet and the outlet sides to prevent accidental contacts. No inflammable material shall be used in the construction of fans.

1159. Drive motors shall be rated at least 15% higher than the power requirement at duty point or 10% higher than the maximum power requirements at the selected speed, whichever is higher. Motor shall be conforming to TEFC, IP 54 protection.

1160. **Noise and vibration**. Noise level produced by any rotating equipment individually or collectively shall not exceed 85 dB (A) measured at a distance of 1.5 meters from source in any direction. The overall vibration level shall be as per zones A and B of ISO 10816-1. Balance quality requirements shall be G 6.3 conforming to ISO 1940/1

1161. **Air washer.** For the clear water pumping station, 2 nos (both working) of rigid media pad type air washer system with all accessories shall be provided for supplying air to the pump room, along with all associated ducts, grilles, etc. Air ducts shall be fabricated as per IS: 655.

1162. Make-up with float valve and quick-fill connections with isolating valve, drain with isolating valve and overflow connection, marine light and inspection door, etc., shall be provided.

1163. The Contractor shall provide detailed calculations to determine the air washer system capacity considering Second Stage requirements. The maximum permissible inside temperature shall not exceed 37 deg. C.

1164. The Contractor shall submit relevant technical details for approval.

1165. **Exhaust fans.** In general, exhaust fans of appropriate rating shall be provided for pump houses and switchgear rooms, at floor level for the raw water pumping station and settled water pumping station, and for electrical rooms for the clear water pumping station. Contractor shall submit the fan selection details for approval.

a. Operating conditions

1	Fan designation	Exhaust duty
2	No. of fans and design capacity	To be selected based on acceptable air changes per hour or maximum temperature rise (5 deg. C), whichever is higher.
3	Type	Wall Mounted, Centrifugal / Propeller

b. Features of construction

1	Impeller	Mild steel or Cast Aluminium
2	Hub	Cast Iron/Die Cast Aluminium
3	Casing	Mild Steel
4	Wall cowl	Galvanized Iron Sheet - 20 gauge
5	Bird screen	14 gauge Galvanized Iron with 12 mm square bird screen.
6	Motor	TEFC IP 54,with speed below 1000 rpm synchronous

1166. **Air conditioner**. Air-cooled package A.C. / ductable split type AC units, two numbers of 50% capacity each, shall be provided for the SCADA/ PLC room.

Operating Conditions

1	Location	SCADA/PLC Room
2	Room size	As per approved drawing
3	Outside temperature	Ambient 45 deg. C
4	Inside temperature requirement	24° C + or – 1.1 deg. C, RH 60 % + or – 5 %

1167. Contractor shall submit cooling load estimation, equipment selection and layout drawings for approval.

1168. **Pipe fittings.** Pipe fittings of size 50 NB and below shall be forged conforming to A 105. Fittings above 50 NB up to 200 NB shall be welded/seamless conforming to ASTM A-234 Gr. WP and dimensional standard ANSI B.16.9. Fittings and specials of size 250 NB and above can be fabricated from MS pipes fabricated as per specifications detailed in Subsection 4, Mild Steel Pipe and Coating Works.

1169. All specials such as bends, tees, tapers, etc., shall be fabricated from MS pipes made as per specifications given in Subsection 3. Before fabrication the detailed drawings of fabrication of each special must be got approved from the Employer's Representative. All specials must be brought to site after inner and outer coating as specified in Subsection 5.

1170. **Expansion bellows.** The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Stainless steel AISI 304 expansion bellows which can take radial and axial misalignment of minimum 1 percent of valve nominal size with tie rods shall be included in the suction and delivery pipe work of all pumps as well as on delivery header for easy dismantling. All loose flanges shall be secured to fixed flanges by suitable tie-bolts. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange or other suitable sealing device. The final outlet connection of the pipe work shall match the connecting point of the transmission main.

1171. **Nuts, bolts studs and washers**. Except as may be elsewhere specified, all nuts and bolts shall be of the best quality bright steel, machined on the shank and under the head and nut. Studs, bolts and nuts shall be galvanized. Nuts and bolts shall conform to IS 1363 and IS 1367. Washers, locking devices and anti-vibration arrangements shall be provided where necessary.

1172. Where there is a risk of corrosion, bolts, nuts and studs shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions. All bolts, studs, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of SS 410.

1173. The Contractor shall supply all holding down an alignment leveling bolts, complete with anchorages, nuts washers and packing required to fix the plant to its foundations, bed plates, frames and other structural parts

1174. The Contractor shall procure and keep at site reasonable excess quantities to cover wastage of those materials which will be normally subject to waste during erection, commissioning and setting to work.

1175. **Gaskets.** Gaskets shall be of Nitrile rubber and readymade matching with respective flanges. Gaskets cut out from rubber sheet are not acceptable.

1176. **Support for pipe work and valves.** All necessary supports, saddles, fixing bolts and foundation bolts shall be supplied to support the pipe work. Valves and other devices mounted in the pipe work shall be supported independent of the pipes to which they connect. Wherever necessary RCC supports shall also be provided.

1177. **Galvanizing.** Wherever galvanizing has been specified the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below:

Fabricated steel

Thickness less than 2 mm but not less than 1.2 mm	340 gm/sq. m.
Thickness 2 mm and above	460 gm/ sq. m.

Fasteners

Up to nominal size M10	270 gm/ sq. m.
Over M10	300 gm/ sq. m.

1178. Galvanizing shall be carried out after all drilling, punching, cutting bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts shall be covered well by zinc primer and aluminium paint.

1179. **Painting/coating.** The Contractor, in accordance with provisions in Subsection 3, Civil, Building and Road Works, shall carry out painting of exposed ferrous surface of all items of plant.

1180. After satisfactory testing of pumps and approval from the Employer's Representative, hydraulic passages of suction bell mouth, impeller guide, bowl / casing and impeller (for initial, intermediate and final units) shall be coated with resin to smoothen surface to enhance pump efficiency. The materials used for such coating shall be suitable for use in equipment handling drinking water. The coating shall be highly abrasion resistant. The coating thickness shall be as per resin manufacturer's recommendation. Guarantee for pumps shall also cover the coating provided.

1181. Immediately on arrival at the site all items of plant shall be examined for condition of the primer coat/finish paint applied at the manufacturer's works and unsatisfactory portions shall be cleaned down to the bare metal, all rust being removed, and the surface made good with similar primer / paint.

1182. After erection, such items, which are not finish painted, shall be finish painted. Items finish painted at the manufacturer's works shall be touched up for any damaged paint work.

1183. No painting shall be carried out unless the item has been inspected and accepted by Employer's Representative or the person authorized by him. Employer's Representative shall approve shades of finish painting of equipment.

1184. **Lubrication.** The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept to a minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred.

1185. The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with complete duty specifications, to enable the Employer to arrange procurement in future. The Contractor shall furnish the schedule of quantities for each fill, frequency of filling and annual requirement.

1186. Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month.

1187. Where more than one type of special grease is required, a grease gun for each special type shall be supplied.

1188. All lubricant systems shall be designed so as not to cause a fire or pollution hazard.The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

1189. **Fire Extinguisher** -The Contractor shall provide 22 nos. CO2 fire extinguishers (4.5 kg) for the pumping stations and switchyard and 2 nos. 50-liter capacity mobile foam extinguisher at the locations identified below, after consultation and agreement with the Employer's Representative:

outdoor switchyard (3 nos. CO2 and 1 no. mobile foam extinguisher at each P.S.)
indoor electrical room and battery room (3 nos. at each P.S.)
pump rooms (maintenance bay) and pump house (4 nos. at each P.S.)
control room (1 no. at each P.S.)

1190. **Transformer**- The capacity of the transformers shall be based on 100 % standby or redundancy at Raw water Intake.(i.e. in the event of outage of any one of the transformer, other transformer can supply the complete load of the plant). Transformer system shall have provision such that inter-opera ability with instrumentation controls system.

1191. **Applicable Standards.** The transformers shall conform to the latest applicable standards specified below:

Power Transformer	IS:2026(latest),IS:1180(up to 2500KVA), IEC:60076
Fittings and Accessories	IS:3639
Auxiliary Transformer	IS:1180
Procedure for testing	IS: 1180 / 2026(latest)
Loading of oil immersed transformer	IEC:60076,IS: 2026/IEC:60354
Transformer Oil	IS:335/BS 148/IEC:60296
Bushings for > 1000V, AC	IS:2099/BS:223/IEC:60137
Bushings for ≤ 1000V, AC	IS:7421
Degree of Protection	IS:13947 (Part 1) / IEC:60947-1
Double float type Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS 271/BS:2757/IEC:60085
Climate Proofing	BS:CP1014
Code of Practice for selection, installation and Maintenance of transformers	IS - 10028
Manual on Transformers	CBIP Publication No.295

1192. **Features of Construction.** The transformer tank shall be made from primary-grade sheet steel without any mixing, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint. Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be

galvanized. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

1193. Each tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion the following conditions:

a. Full vacuum of 760 mm of Hg for filling with oil under vacuum
b. Internal gas pressure of 0.35 kg/cm² with oil at operating level

1194. Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings.

1195. Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

1196. The transformer core shall be constructed from primary grade, non-ageing, cold-rolled, grain oriented without mixing of low grade materials, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

1197. Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

1198.The sequence and orientation of HV / LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

1199. Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing with stand capability.

1200. Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. Neutral CT to be provided in case of solid grounding. Transformer having capacity more than 5 MVA shall be provided with Diff. Protection relay.

1201. Winding connections. Windings shall be of HV: Delta & LV: Star, vector group Dyn 11.

1202. Rating. The rating of transformers shall be as per standard ratings shown in IS 2026 , IS 1180 / CBIP Publication.295.

1203. Type of cooling. The transformers shall be oil immersed with natural oil circulation, type ONAN. With the provision for radiator cooling with fans for forced cooling, if required will be added in future. The rating of the transformer with ONAF shall be specified.

1204. Impedance and losses. The percentage impedance, no load & load losses shall be as per IS 2026 latest for transformer above 2500kVA for 2500kVA and below as mentioned in IS 1180 chart table for losses value for transformer.

Performance requirements

1205. The transformers shall be suitable for operation without danger on to any particular tapping at the rated KVA provided that the voltage does not vary by more than ± 10 % of the voltage corresponding to the tapping.

1206. The transformers shall be suitable for continuous operation with a frequency variation of ± 5 % of rated frequency, combined voltage and frequency variation should not exceed 10 %.
1207. All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.

1208. The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.
1209. The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.

1210. The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium.

Top oil (measured by thermometer) : 35° C
Winding (measured by resistance) : 45° C
Noise level of transformers shall be less than 80 dB.

1211. **Tap Changer.** For transformer of rating less than or equal to 500 kVA, tap changing shall be carried out by means of an off circuit externally operated self-positioning switch when the transformer is in de energized condition. Tapings shall be provided on the higher voltage winding for variation of HV voltage from plus +7.5% to minus -7.5% in steps of 2.5%. For transformer of rating greater than 500 kVA. On load tap changer may be provided on HV side for variation HV voltage from plus 5% to minus 15% in steps of 1.25% with Electronic type Remote Tap Changing Controller (RTCC), Automatic Voltage Regulator (AVR) etc.

1212. On Load Tap Changing Gear for Transformer (above 750 KVA)
The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e., 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
1213. When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.
1214. Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge and Magnetic oil level gauge.
1215. Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.
1216. Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handles.
1217. OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP 55 protection which shall include:
a.Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
b.Motor starting contactor with thermal overload relays, isolating switch/MCB/MPCB/ HRC fuses.
c.Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
d.Control switch: Raise/off/lower (spring return to normal type).
e.Remote/local selector switch (maintained contact type).
f.Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
g.Limit switches to prevent motor over-travel in either direction or final mechanical stops.
h.Brake or clutches to permit only one tap change at a time on manual operation.
i.Emergency manual operating device (hand crank or hand wheel).

j.A five digit operation counter.
k.Electrically interlocked reversing contactors (preferably also mechanically interlocked).240V, 50 Hz. AC space heater with MCB.
l.Interior lighting fixture with lamp door switch and MCB.
m.Gasketed and hinged door with locking arrangement.
n.Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
o.Necessary digital protection relays, contactors, current transformers etc.

1218. Control Requirements for OLTC. The following electrical control features shall be provided:

1219. Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
1220. Only one taps change from each tap change impulse even if the control switches or push button is maintained in the operated position
1221. Cut-off of electrical control when manual control is resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

1222. **Automatic Control of OLTC shall include the following items:**

Voltage setting device
Voltage sensing and voltage regulating devices.
Line drop compensator with adjustable R and X elements.
Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
Adjustable dead band for voltage variation

1223. **OLTC Panel (Remote Tap Changing Controller) (RTCC):**

The OLTC remote control equipment shall be suitable for 110V DC supply and shall be housed in an indoor sheet steel cubicle to be located in a remote control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP 54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade ( ) of IS-5 respectively.
Earthing bus shall be of 25 x 6 mm copper.
Control switch : Raise / Off / Lower

(Spring return to normal type)
Auto / manual selector switch (maintained contact type)
Tap position indicator
Fascia type alarm annunciations with “accept” and “lamp test” facilities.
A.C. supply failure
Drive motor auto tripped
Tap change delayed
Necessary auxiliary relays
Lamp indications for :
Tap change in progress
Lower limit reached
Upper limit reached
Double compression Cable glands for power and control cables
240 V rated panel space heater with thermostat and ON-OFF MCB
Fluorescent type Energy efficient (lumen per Watt shall be specified) interior lighting fixture with 18 W lamp and door switch

MCB / HRC fuses, Terminal blocks, Internal wiring, Earthing terminal, etc. as required.

1224. **Fittings and accessories**. The following fittings and accessories shall be provided with transformer:

Name plate, rating plate and diagram plate.
Two earthing terminals on opposite ends of the transformer tank.
Inspection manhole in the cover.
Lifting lugs for the transformer, core assembly and tank core.
Conservator, complete with filling plug, sump and drain valve, and a shut-off valve on the pipe connection between transformer tank and conservator, to permit removal of the conservator. The conservator shall be designed to maintain an oil seal through a temperature range of 100 Deg C.
Oil level indicator with minimum marking.
1225. Weather proof dehydrating breather with Clear polycarbonate desiccant container weight of the desiccant shall meet 400 charge life days. Desiccant type shall be self indicating bread silica gel as the dehydrating agent.
1226. Plain Oil level Gauge for all transformers up to 500 kVA. Above 500 kVA, Magnetic type oil level gauge with low oil level alarm contact, mounted on the conservators with waterproof and dustproof terminal box and shall be wired to marshalling box.
1227. Gas detector relays with separate alarm and trip contacts complete with shut-off valves shall be wired to marshalling box.
Separate drain valve, oil sampling valve with plug and top filter valve shall be provided on the tank and shall be leak proof after commissioning.
1228. Explosion vent with diaphragm for relieving pressure inside the transformer. The device shall be rain proof after operation. For transformers of 500 KVA and above Pressure Relief Valve (PRV) and shall be wired to marshaling box. An equalizer pipe connecting the pressure relief device to the conservator shall be supplied.
1229. Separately mounted, water proof and dustproof marshaling box housing the buck holz relay wiring, MOG oil level low wiring, oil temperature indicator, winding temperature indicator with alarm and trip contacts and PRV with trip contacts to marshaling facilities for electrical devices mounted on transformer including load management signal shall be provided to give an information about the over loading condition of the transformer and all signals shall be wire able to alarm annunciation. (The signal shall not give indication for momentary over loading). The marshaling box shall be in accordance with IS 2147. The degree of protection shall be IP55 with space heaters etc.
1230. For transformers rated 500 KVA and above. Adequate number of air vents for relieving trapped air during oil filling / during maintenance and shall be leak proof after commissioning.
Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.
Four jacking pads for lifting the transformer with jacks.
Pulling eyes and skids for the movement of the transformer.
Bidirectional wheels for movement of the transformers.
1231. Accessories for clamping the wheel mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2g.
Transformer shall be supplied complete with insulating oil required for first filling plus 10% excess oil in non returnable drums.(With gas analysis report)

1232. **Cable terminations/cabling requirement.** Cable termination boxes for transformers shall be suitable for dry termination of HV and LV cables. Non-magnetic gland plates shall be provided for the termination of cables. Maximum size of the cable and number of cables that can be terminated shall be indicated.

1233. It shall be possible to remove the cable boxes without dismantling the cable glanding or draining the oil.

1234. Disconnecting links shall be provided to facilitate testing of the cable. All transformers shall be provided with lockable emergency Push Button station near the transformer to trip the transformer as per IER. Wired to marshaling box of transformer and Alarm Annunciation of transformer feeder. All transformers shall be provided with alarm annunciation on transformer breaker control panel.

1235. **Tolerance on losses.** The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. The values of load-losses and No-load losses shall be within the values given in latest edition of IS 1180 for transformers up to 2500KVA.

1236. Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

1237. **Rejection.** The BUDIP Bhagalpur or BUDIP's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026. For Auxiliary supply Transformer shall be of Energy Efficient as per BEE star rating. The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

1238. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the BUDIP's Representative reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

1239. **Drawings and data.** All Drawings, data, Guaranteed Technical Particulars, Temperature rise calculations, detailed literature, catalogues, Type test certificates of typical transformer etc shall be submitted along with the bid / after award of contract.

33 / 0.433 kV Metal Enclosed Switchboards & Switchgears

1240. 33 / 0.433 kV metal enclosed Switchboards and Switchgear system shall have provision such that inter-opera ability with instrumentation control system.

1241. The switchgear and its components shall conform to the latest applicable standards specified below:

Table 84: Applicable Standards for Switchgear

Circuit Breakers	IS : 13118 / BS : 5311 / IEC : 60056,60694, IEC 62271-100
Metal Enclosed switchgear	IS : 3427 / BSEN:60298 / IEC: 60298, IEC: 62271-200
Current Transformers	IS : 2705 / BS : 7626
Voltage Transformers	IS : 3156 / BS : 7625 / IEC : 60186
Arrangement for Switchgear Bus bars, Main Connections and Auxiliary wiring	IS : 5578, 11353
Busbar Support insulators	IS : 2544 / BS : 3297 / IEC :60 273
Degree of Protection	IS : 13947 (Part 1) / IEC : 60947-1 / BSEN : 60529
Electrical Relays for Power system protection	IS : 3231, 3842 / BS : 142 /IEC : 60255
Electrical Indicating Instruments	IS : 1248 / BS : 89 / IEC :60051
High Voltage Fuses	IS : 9385 / BS : 2692 / IEC : 60282
AC Electricity Meters	IS : 722, 8530 / BS : 5685 / IEC : 60145,60211
Specification for copper rods and bars for electrical purposes	IS : 613
Code of practice for phosphate iron and steel	IS : 6005 / BS : 3189

Alternating current Switches for voltages above 1000 V	IS : 9920 / IEC : 60129, 60265 & 60298
Low voltage fuses	IS : 13703 / BS 1362 / IEC 60269
Toggle switches	IS : 3452 / BS : 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS : 10118
Control switches	IS:6875 / BSEN 60947 / IEC : 60947
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS 5572, IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements Fault level calculation	IEC 60079; IS: 2026

1242. **Constructional Features.** Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices. The adjacent panels shall be completely separated by steel sheets except in bus bar sheet compartments where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits. Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle. Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X and the relay and meter compartments shall have a degree of Protection not less than IP 52. All removable covers shall be gasketed all around with neoprene or superior gaskets.

1243. Instruments, relays, metering and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields. All transformers shall be provided with alarm annunciation on breaker control panel.

1244. The Electrical grade Aluminium bus bar shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher as per fault withstanding time without exceeding maximum allowable temperature rise. The Electrical grade Aluminium bus shall be properly supported to withstand stresses induced by the rated momentary short circuit current with tested support insulators. Necessary shrouding shall be provided where ever required. Adequate cross section shall be considered at joints and 'T' Joints, which shall be higher than the nominal cross section of bus bar.

1245. Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

1246. The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover up the fixed high voltage contacts on bus bars when the circuit breaker carriage is moved to' test' and 'isolated' positions.

1247. One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

1248. **Circuit breaker.** Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder. Circuit Breakers shall be re strike free, stored energy operated and trip free type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another. Anti-pumping relay and trip coil suspension relay shall be provided.

1249. There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.

1250. Electrical tripping shall be performed by shunt trip coils. "Local / Remote" selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service" and "Test" positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of "Service" and "Test" positions are not available on the cubicle door.

1251. Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

1252. 10% spare feeders with at least one for each type of highest rating shall be provided in each switch gear.

1253. Surge arrestors shall be provided for all motors / transformer feeders and shall be metal oxide gapped or gapless type generally in accordance with IEC 60099-1and suitable for indoor only.

1254. Core balance CTs (CBCT) shall be provided on outgoing motor and transformer feeders having CT Ratio 50 / 1A or more. These CBCTs shall be mounted inside the switch gear panel.

Operating Mechanism Control

1255.Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
Operating mechanism shall normally be operated from the breaker cubicle itself.
1256. The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
1257. Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
1258. The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.
1259. Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
1260. Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

Safety Interlocks and Features

1261. Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.
1262. All circuit breaker shall have lockable local / remote selector switch, for closing the breaker from local shall be possible only in TEST position. Whereas as closing from remote shall be possible in either SERVICE and TEST position. For opening breaker from local shall be possible only when local remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.
1263. All Motors and Service Transformers feeder breaker shall have lockable emergency push button (open able only with key) near motor and service transformer, hard wired to respective circuit breaker panel.
1264. Operation of a circuit breaker shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.
1265. Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.
1266. The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.

Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are 1267. likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

1268. **Earthing.** Electrical grade Aluminium earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

1269. Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

1270. Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

1271. Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

1272. All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green Colour ed, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

1273. Circuit/busbarearthing facility. It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker. The earthing facilities proposed to be provided by the Contractor shall be clearly detailed in the Bid and shall be subject to BUDIP Bhagalpur’s approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

1274. **Annunciations**. Annunciation shall be of fascia type with translucent plastic window for each alarm point. Annunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light is lighted. Each annunciation window shall be provided with two LED Lights to provide redundancy against LED light failure. Lamps shall be of clustered LED type.

1275. All fascia annunciated points shall be suitable to accept external contacts of either ‘NO’ or ‘NC’ self or hand reset type for initiating the annunciation sequence. Annunciations shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.
1276. For static annunciation schemes, special precaution shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciated wiring and switching disturbances from the neighboring circuits within the panels / desks.

1277. A “Lamp Test” push button shall be provided for each individual panel’s group of annunciations to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics dual tone alarm circuits of annunciations is desirable for alarm and trip. The Contractor shall give the details of the offered scheme.

1278. Annunciation shall have following features:
Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.
Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
"Alarm Supply Failure” Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply
Alarm annunciates having provision to integrate all alarm / trip signals to PLC / SCADA through RS 485.
Alarm annunciation shall be provided for transformers, DC & DCDB, Chlorination system and surge vessel system where ever discrete local automation is envisaged.
Duel tone Hooter to indicate alarm and trip signals separately.

1279. **Indicating instruments and meters (digital type).** The instruments shall be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters. Metering instruments (digital type) shall be as follows:
Multifunction Meter with the facility to measure KW, KWH, KVAr, PF, KWh, Hz with communication port.
Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.
MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.
Ammeter shall be digital ammeter with built in selector switch with / without CT.
Voltmeter shall be digital type with built in selector switch with / without PT.

1280. The instruments can be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

1281. **Control and selector switches.** Control and instrument switches shall be heavy duty rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

1282. The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in ‘normal after close’ and ‘normal after trip’ position. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch. Local / Remote selector switch shall be stay put 2 / 3 position with lockable provision.

1283. Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.

1284. Indicating lights/pilot lights. Indicating light shall be rated for operation at either 230 V AC or at the 110V DC system voltage as applicable. Lights shall be provided with translucent light covers.

1285. Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073. Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

1286. The basis of colours shall be as follows:

Red	:	Flow of energy.
Green	:	No flow of energy.
White	:	Supervision of power available, relay coil healthy, etc.
Amber:		For all alarm conditions such as pressure low, overload, Disagreement with original condition 'abnormal' condition or'sequence–on' condition also for service and test position.
Blue	:	For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.
Yellow	:	For R, Y, B indication light, yellow as one of the light.

1287. **Push buttons.**Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

1288. Normal stop push button shall be mushroom type latch able in red colour, after pressing and it is latched and latch can be removed by clockwise rotation. (Motor stops automatically after pre-determined conditions such as delivery valve close in case of pumps.) This may replace stop push button.

1289. Emergency stop push button red in colour shall be lockable by pressing the push button and can be opened only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required) Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.

1290. Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting.

1291. All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

1292. All push button shall have additional NO / NC potential free for hard wiring to instrumentation control panel.

1293. **Space heaters**. Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle / marshalling box, bus ducts and Motors above 7.5 kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a RTD thermostat to cut off the heaters at 35o C.

1294. **Cubicle lighting/receptacle.**Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) CFL, fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply. A 240 V, 1 phase, AC 5/6 A, 2/3 pin receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

1295. **Power and control cable termination.**Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of bi-metallic lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper confirming to IS 8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of termination provide on the equipment.

1296. Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multi core cables shall be provided and shall confirm to BS: 6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide water tight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

1297. Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

1298. Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations. Suitable flange type glands Nickel coated shall be provided at cable entry to panel.

1299. Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

1300. Wiring for control and protective circuits.All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

1301. All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wire ways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.

1302. Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

1303. **Termination and Ferrules.** Engraved core identification ferrules, indicating starting panel, TB, No: / ending panel, TB, No: Vise versa to be marked to correspond with the

wiring diagram, shall be fitted to each wire and each core of multi core cables terminated on the panels.

1304. Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.

1305. All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

1306. **Control Wiring Terminal Blocks**. Terminal blocks shall be of 1100 V grade, 10A and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

1307. Terminals shall be numbered for identification, grouped according to function. Engraved 'black on-white' labels shall be provided on the terminal blocks describing the function of the circuit.

1308. Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled. Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility for earthing the secondary.

1309. Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

1310. At least 20 % cores shall be kept spare in multi core control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

1311. **Bus Bars.** The Bus bars shall be of electrical grade, high conductivity, Aluminium and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear. All bus bars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

1312. Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Bus bars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint. Adequate cross section shall be considered at joints and 'T' Joints, which shall be higher than the nominal cross section of bus bar.

1313. Direct access to, or accidental contact with bus bars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of bus bars due to insertion of maintenance tools.

1314. Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

1315. End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

1316. **Current and voltage transformers**. Current transformers shall be of cast resin, bar-primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound-primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high grade silicon steel. Where multi-ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios. These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

1317. Magnetization characteristics, calculated performance and protective settings shall be provided by the Contractor. All Voltage Transformers shall be of Single Phase type. The bus VT's shall be housed in a separate panel in a truck so as to be fully with draw able. All Voltage transformers shall have HRC fuses on Primary and Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

1318. Relays will have the following specifications:

All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity and shall be tested as per IEC 60947.
All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement including voltage, current, power (active / reactive) and energy parameters.
All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.
All numerical relays and timers shall be rated for 110V DC supply voltage shall be capable of satisfactory continuous operation between 70 % to 110 % of the rated voltage. Making, Carrying and Breaking Current ratings of the relay Contacts shall be adequate for the circuits in which they are used.
The numerical relays shall have communication, Metering and Monitoring Facility. The communication facility shall have two Ports local front port for laptop communication and the second port, an IEC 61850 port, for LAN Communication with LAN.
The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided.
Numerical Relays shall have diagnostic feature with self check for power failure, Programmable routines, memory and main CPU Failures etc. for upstream and downstream protection as per IEC 60255.

The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110 V DC Control Voltage.
The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1 A / 5 A selectable at Site.
Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.
Timer function shall be programmable for ON/OFF delays.
Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.
All relays shall withstand minimum test voltage of 2 KV AC RMS for one minute.
Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

1319. Energy monitoring and power supply management.Necessary Provisions & features shall be incorporated to enable energy monitoring / energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the Contractor through instrumentation control system, without any manipulation.

1320. In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter is not required.

1321. Necessary provision & features shall be incorporated to under voltage monitoring / relay for incomer feeder, bus bar chamber and control supply.

1322. **Testing.** The following routine tests shall be carried out on the assembled switchboard / panel during inspection at the manufacturer's works in addition to other tests as per applicable standards.
1323. Primary injection tests to ensure correct ratios and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
1324. Balance earth fault stability test by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.
1325. Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.
1326. Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.
Functionality tests to check the interfacing status contacts and instrumentation.
Testing of the differential protection relays.
One minute power-frequency voltage dry withstand tests on the main circuits
One minute power-frequency voltage dry withstand tests on auxiliary circuits
Insulation resistance tests

1327. All circuit breakers shall be subject to the following tests:

Routine tests including a HV pressure test, mill volt drop test and mechanical tests.
Testing to ensure the operation of the DC closing coil and the satisfactory closing of the circuit breaker with the voltage of the coil down to 80% of its rated voltage, and that mal-functioning does not occur with the voltage on the coil at 120% of its rated voltage.

Verifying the interchangeability of removable identically equipped circuit breakers, and checking of all mechanical and electrical interlocks.

1328. Type test figures for heat test runs performed on identical panel types shall be made available.

1329. I/O Signal for instrumentation, control and automation system from electrical panels. I / O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers will not enter in to power panel, which are not familiar with them.

1330. Necessary provisions shall be incorporated to meet the requirements indicated in:
I / O Schedules
Data Transfer Schedule
Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System.

1331. Drawings and data. All Drawings, data, Guaranteed Technical Particulars, Temperature rise calculations, detailed literature, catalogues, Type test certificates of typical type of Panel, test certificates for digital instruments etc shall be submitted along with the bid / after award of contract.

415 V Metal Enclosed Switchgears (PCC / MCC)

1332. 415 V Metal Enclosed Switch gear (PCC / MCC) system shall have provision such that inter-opera ability with instrumentation controls system.

1333. **Applicable standards**.The switchgear and components shall conform to the latest applicable standards specified below.

Table 85: Standards for Switchgear and Components

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages up to and including 1000 V AC & 1200 V DC	IS:8623/BS:5486/IEC:60439
Air Break Switches	IS:13947-P3 /BSEN60947 / IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2/ BS EN 60947-2
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947-4/ IEC:60292-1TO 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626
Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530/BS:5685 / IEC 60145,60 211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphateing iron and steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021

Classification of Hazardous areas having Flammable gases and vapors for Electrical Installation	IS 5572
Guide for Selection of Electrical Equipment for Hazardous areas	IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC 60079

1334. The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features.

1335. Total height of switchgear shall not exceed 2300 mm. Height of Switches, Push buttons shall not exceed 1800 mm and shall not be less than 700 mm.
Shall be single front execution and fixed type
Shall have designation labels both on front and rear sides
Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.
Degree of Protection shall be IP54 for indoor & IP55 for Outdoor.
Thickness of CRCA Sheet is 2.5 mm for frames and 2 mm for doors and sides.
Shall follow IS 5572 / IEC 60079, standard specification and standard practice for installation in Hazardous area.

1336. Switchgear shall be divided into distinct vertical sections each comprising:

A completely enclosed bus bar compartment running horizontally
Enclosed vertical bus bars serving all modules in vertical section
A separate horizontal enclosure for all auxiliary power and control buses if required.
Vertical cable alley of 250 mm wide covering entire height.

Operating devices shall be incorporated only in the front of switchgear
Each shipping section shall have metal sheets at both ends
Cable alley shall be provided with suitable hinged doors
Electrical grade Aluminium Earth bus of suitable size shall be provided at the bottom.
Rear of Single Front Switchgear shall be provided with removable panels with screws.
All doors shall be with concealed type hinges and captive screws
Each vertical section shall be equipped with 240 V, 1 Phase, 50 Hz space heater controlled by thermostat
A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps
Interchangeability

1337. All identical equipment and corresponding parts be fully interchangeable without any modifications.
1338. Main and Auxiliary Buses

1339. Switchgear bus bars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn Aluminium conductor.
Busbar shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints and shall be adequately supported to withstand stresses developed due to short circuits. Supports shall be of glass reinforced phenolic material or cast resin.
1340. Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and belleville washers and nuts.

1341. Adequate cross section shall be considered at joints and 'T' Joints, which shall be higher than the nominal cross section of bus bar.

Air Circuit Breaker (ACB)

1342. Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
1343. The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
1344. The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.
Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.
1345. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.
1346. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 - 110 % the rated control voltage.
1347. The Breaker shall be provided with Microprocessor based releases for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.
1348. The breaker service Short Circuit breaking capacity (I CS) shall be equal to ultimate Short Circuit capacity (I CU)and shall be equal to short time withstand current of Breaker (ICW).

Moulded Case Circuit Breaker. (MCCB) / Motor Protection Circuit Breaker (MPCB) Panel

1349. MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing. MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified. MCCBs shall have a service short circuit breaking capacity (ICS) equal to the ultimate short-circuit capacity (I CU).

1350. Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

1351. The MCCBs shall be provided with the following features.

Common trip bar for simultaneous tripping of all poles Shrouded terminals with extended copper /Aluminium bar.
Time for clearing short circuit current of 30 msec.
NO + 2 NC auxiliary contacts
Extended rotary handle with pad lock arrangement.
Extended copper terminal from MCCB.
Shall be provided with adjustable O/C, E/F, S/C.

1352. MPCB shall be provided for Motor up to 7.5 kW for DOL starting from panel / Local DOL.
Comprehensive MPCB for Motors up to 30 kW for Automatic star / delta starting in LV.

Switches and Fuses

1353. 415 V air-break switched shall be of the load break, fault make, group operated type. (MCCB's are preferable 100A & above and MCB up to 63A, switches can be avoided, unless the system requires the same.)
For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire.
For use on single phase system, the MCB type switches shall be of the two pole type.
1354. Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided on the switches.
1355. Switches for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.
1356. All DC circuit fuses shall be on both poles and 415 V switches and fuses shall be provided with the following interlocks so that :
1357. The fuses are not advisable unless the system requires the same.
1358. It is not possible to close the switch when the cover is open, but an authorized person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch is left in the 'ON' position.
1359. Fuse less system shall be provided, in case fuses required, fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.
1360. Earthing and neutral lines in main supply circuits shall be of solid Aluminium and be of the bolted pattern.
1361. Fuses and links functionally associated with the same circuit shall be mounted side by side.

Miniature Circuit Breaker (MCB) and ELCB / RCCB

1362. MCB shall be hand operated, air break, quick make, quick break type. Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

1363. Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load.

Where this is not specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

1364. ELCB / RCCB shall be provided for all Lighting and Plug and socket points.

Contactors

1365. The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

1366. Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70 % of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All TPN contactor shall all be provided with single phasing preventer (SPP).

1367. Motor starters shall be complete with auxiliary energy meters, protective relays, timers and necessary indications such that inter-opera ability with the instrumentation system.

1368. **Current Transformers / CBCT**

1369. Current Transformers shall be Cast Resin type.
Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.
Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the 1370. Technical Specification.
CT core laminations shall be of high grade silicon steel.
Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

1371. **Voltage Transformers**

Voltage Transformers shall be Cast Resin type.
Secondary and tertiary windings of voltage transformers shall be rated for a three phase line to line voltage of 110 V.
It shall be possible to replace voltage transformer fuses easily without having to de energizer the main bus-bars.

Indicating Instruments & Meters

1372. All indication instruments and watt hour meters shall be of the digital type and shall have an accuracy of Class 1.0. Digital type ammeters, voltmeters, multifunction and energy meters shall have communication facility.

Indicating Lights

1373. Indicating lights shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be rated for operation at either 240 V AC or at the 110V DC voltage as applicable. LED shall be provided with translucent lamp covers.

Push Buttons

1374. "Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head without key or Emergency push button lockable in OFF position and open able only with key.

Space Heaters

1375. Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control RTD thermostat to cut off the heaters at 35 Deg. C.

Safety Arrangements

1376. Terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened. Components within the cubicles shall be labeled to facilitate testing.

Earthing of Switchboards / Panels

1377. Each switchboard, control panel, etc. shall be provided with Aluminium earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

1378. Bus bars shall be of Aluminium and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

1379. Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

1380. All instrument and relay cases shall be connected to earth bus bar by means of 1100 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

Internal Wiring

1381. I/O for Instrumentation, control and automation system from electrical panels. I / O signals from instruments shall be wired to marshalling box of MCC / Switch gear such that instrumentation engineers will not enter into power system panel that are not familiar with them. Necessary provisions shall be incorporated to meet the requirements indicated in (a)I/O schedules; (b) data transfer schedule; and (c) alarm schedule of particular requirement of instrumentation, control &automation system.

Drawing and Data

1382. All Drawings, data, Guaranteed technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical type MV panel etc shall be submitted along with the bid / after award of contract.

415 V APFC Power capacitor and control panel

1383. Applicable standards.The capacitor and control panel shall conform to the latest applicable standards as specified below. In case of conflict between standards and this specification, this specification shall govern.

Reference standards	IS: 13585 (Part I) 1994
Shunt capacitors for power systems	IS : 13340
Internal fuses and internal overpressure disconnections for shunt capacitors	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298/ IEC : 60298
Code of practice for phosphate iron and steel	IS : 6005/BS : 3189
Specification for copper rods and bars for electrical purpose HRC cartridge type Load break switch (LBS) shall be three times the rated capacitor current.	IS : 613 IEC 60269

Design Features

1384. The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
1385. The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
1386. The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.
1387. The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free standing type.
1388. All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stove shall be applied.
1389. The assembly of the banks along with harmonic filter reactors shall be such that it provides adequate heat dissipation without ventilation for each unit.
All MV APFC Relay shall be provided with Thyrister switched Micro APFC Passive filter panel.
1390. Each capacitor unit / bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS : 2834.

1391. Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnate shall be non PCB (poly chlorinated biphenyl) oil.
1392. Each unit shall satisfactorily operate at 130% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10% above the rated voltage, excluding transients.
1393. **Unit Protection:**Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.
1394. The Inputs to the APFC system is Voltage input from two phases and current input from the third phase. Out of two phases of voltage one phase voltage is taken as Reference 0 and other phase voltage as 440 V. APFC need to be installed CT (Current Transformer) on the third phase at main incomer ACB after transformer, which will give signal to the APFC Relay. Based on this inputs the ASIC (Application Specific Integrated Circuit) OR Call it as Microprocessor internal to the APFC Relay will give output signal to relay outputs which will energize coil of the contactor so that the contactor come in line connecting the capacitor bank in circuit. However this is step correction means PF is corrected in steps. The Voltage rise due to connection of capacitor banks is marginal. There will be no frequency correction with APFC System. Power factor correction up to 0.96 min. (overall) and min 0.99 (LT) considering worst conditions.
The capacitor units shall be subjected to the following tests:
1395. **Load test** - At 110% rated voltage at an ambient temperature of 45o to 50o C for a period of 8 hours or more;
1396. **Leakage test** - Initially after impregnation and total sealing, each capacitor shall be heated up to 80o C to 110o C for a few minutes; and
After the load test each capacitor unit shall be carefully inspected for leakage.

APFC Power Capacitor and Control Panel

1397. Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.
The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of :
Bus bars shall be of Aluminium conductor of hard drawn (HD) and high conductivity
Isolating switch shall be three times the rated capacitor.
Capacitor Duty Contactor shall be three times the rated capacitor current.
Overload element to match the rated capacitor.
APFC Relays responsive to current / voltage / KVAR / PF as specified for automatic switching shall be of microprocessor based suitable for both for state board Electricity and DG set with reduced power factor.
Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
Auto-manual selector switches
Push button for opening and closing the power circuit.
Red and green cluster LED lights for capacitors ON/OFF indication
Protective numerical relays to protect the healthy capacitor units when one unit fails in a series connection
Space heater and cubicle lighting as per the requirements.

Earthing of individual capacitors as required in panel.
All MV APFC Relay shall be provided with Thyrister switched Micro APFC Passive filter panel.

Load Brake / Disconnect Switches and Fuses for MV motor capacitor panels

1398. Disconnect switches shall be of the load break, fault make, grouping operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral connection. The capacity of LBS shall be rated three times the capacitor rating. Making capacity of LBS shall be supported with type test certificate of similar unit.

1399. The disconnect switches shall be of the heavy duty, quick make and quick break type. It shall be electrically and manually operated. Their contacts shall be silver plated, and contact springs shall be of stainless steel. Their handles shall have provision for locking in both fully open and fully closed positions. Mechanical 'ON-OFF' indication shall be provided and visible from front panel door.

1400. For combination units of disconnect switches and fuses, the following interlocks shall be incorporated:

The fuses shall not be accessible unless the disconnect switch is in the fully open position.
It shall not be possible to close the disconnect switch when the fuse cover is open, but an authorized person may override the interlock and operate the disconnect switch. After such an operation, the cover shall be prevented from closing if the disconnect switch is left in the "ON" position.
Fuse failure indicator connected to VCB and LBS trip circuit.
CBCT for the cable with relay to trip the VCB and LBS.
LBS shall be provided with 2 NO 2NC Aux contact.
Ready ness / Door inter lock with Main VCB panel for motor.

1401. All fuses shall be of the HRC cartridge type mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated. Current vs. time characteristics of all types of fuses shall be furnished to the BUDIP's Representative as a part of the design submittal.

1402. Fuses-links functionally associated with the same circuit shall be mounted side by side.

1403. An adequate number of spare fuse cartridges of each rating shall be supplied and fitted in clips inside the panel.

1404. **Drawings and data.** All Drawings, data, Guaranteed technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical type of APFC Panel etc shall be submitted along with the bid / after award of contract.

Battery, Battery Charger and D.C Distribution Board.

1405. Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.

1406. **Requirements**. Following items shall be covered in the Contract:
One no. 110 V Nickel Cadmium type Battery (Minimum capacity of Battery –150AH)

One no. Float-cum-boost charger for 110 V batteries
DC distribution board with LED indication.
DC Earth leak sensor.
Digital dual tone alarm Annunciation with RS 485 output.
Digital AC / DC Voltmeter / Ammeter.
Battery charging current digital Ammeter.
All indication lamps with LED

1407. All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

1408. **Nickel–Cadmium Battery Design Features.** Battery offered shall be Nickel Cadmium (Ni-Cd) Type. The battery shall conform to the latest applicable standards specified below: Specification for Nickel Cadmium Batteries: IS : 10918

1409. Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. Aqueous solution of battery grade Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically change during charging/ discharging.

1410. The containers shall be transparent and preferably be made of toughened glass or plastic polypropylene material and provided with electrolyte level indicator. The Containers shall be robust, heat resistant, leak proof, nonabsorbent and free from crack, blisters, pin hole etc.

1411. The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have maximum recharge time of 8 hours. The batteries shall be sized for an operational period of 24 hours, in case of power failure. The ampere-hour capacity shall be selected to cater to all the emergency loads, operation of control gear, indication lamps, annunciation panels, emergency lighting, incoming breaker(s) spring charging currents, short time loads etc. A margin of about 25% shall be taken to cater to the contingencies.

1412. Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead covered. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.
Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

1413. Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

1414. **Battery racks**
Porcelain insulators, rubber pads, etc.
Set of inter-cell, inter-tier and inter-bank nickel coated Aluminium connectors as required for the complete installation.

1415. 1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
ii.	One	-	Filler hole float fitted with plug and cap and having specific gravity correction scale.
iii.	Three	-	Digital portable Pocket thermometers
iv	Two	-	Cell lifting straps
v	One set Each	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors, spare vent plugs, spare nuts and bolts suitable set of spanners.

1416. Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

1417. It shall be the responsibility of the Contractor to provide batteries of adequate capacity For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell at the end of the loading cycle. The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages.

The following information shall be legibly marked on outside each cell.

- Manufacturer's Name & Trade Mark
- Country & Year of Manufacture
- AH Capacity at 5 hour discharge rate
- Type Designation & Sl.No

1418. Drawing. All Drawings, data, Guaranteed technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical type battery charger etc shall be submitted along with the bid / after award of contract.

1419. Battery charger and DC Distribution Board. The battery charger and D.C. distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability : IS: 9000
Tests for components for electronic and
Electrical equipment
Environmental tests for electronic and : IS: 9000
Electrical equipment
Metal clad base material for printed : IS: 5921
circuits for use in electronic and
Telecommunication equipment
Transformers and inductors (power, : IS: 6297
Audio, pulse and switching) for
Electronic equipment
Printed wiring boards : IS: 7405
Environmental requirements for semi- : IS: 6553
Conductor devices and integrated circuits
Terminals for electronic equipment : IS: 4007
Factory built assemblies of switchgear and
control gear for voltages up to and
including 1000 V AC and 1200 V D : IS: 8623/BS: 5486 / IEC: 60439
Air break switches : IS: 13947 (Part –3); BSEN 60947
Miniature circuit breakers : IS: 8828/BSEN: 60898
HRC cartridge fuses : IS: 9224/BS: 88

Contactors : IS: 13947 (Part – 3) /BS:775 / IEC: 60158-1
Control switches/push buttons : IS: 6875
Indicating instruments : IS: 1248/BC:89/ EC:51
Degree of Protection : IS:13947-(Part1)/IEC:60947-1
Climate-proofing of electrical equipment : BSCP: 1014
Code of practice for phosphate iron and steel : IS: 6005/BS:3189
Semi-conductor converters : IEC: 60146
Semi-conductor rectifier equipment safety : IS: 6619
Code Specification for copper rods and bars for : IS: 613
Electrical purposes

Battery Charger.

1420. Battery charger shall be combined float-cum-boost type.
The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.
The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The Contractor shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.
The float charger shall be designed for supplying :
The D.C continuous load and short-time overload.
The trickle charging current of the battery.
The boost charger shall be designed for supplying the boost charging current of the battery.
If the battery and charger are to be supplied by separate Contractors, the charger Contractor shall coordinate with the battery Contractor regarding float /trickle boost charging current & voltages required for the battery.
Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. Contractor regarding the float/trickle and boost charging current and voltages required by the battery,
The D.C System shall be unearthed. Sensitive earth fault detectors shall be provided in DC system to annunciate earth fault.
Performance

Boost Charger

1421. Applicable For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.
In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. Manual control shall be used if auto-mode fails.
During boost charging following emergency measures shall be provided:
If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.

Charger Panel and D.C. Distribution Board.

1422. Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.
Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.
The components shall be liberally rated and housed in a well-ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.
1423. Busbars shall be of Electrolytic Aluminium Grade conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints
All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.
1424. All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
1425. All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.
1426. All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm2 and for power wiring shall be 2.5 mm2, 0.650 / 110v grade.
Ground terminals with isolating links shall be provided.
Cable glands shall be provided to suit the incoming and outgoing cables.
DC DB shall meet the emergency lighting requirement also.

1427. **Components and accessories**. The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON / OFF switches, sticker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.

One (1) Set - Three phase full wave half controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The diodes / SCRs shall be individually protected by fuses with fuse fail indication.
One (1) Double wound, dry type, three phases suitably rated mains transformer.
One (1) Set of suitably rated control transformers for electronic controller.
One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilization of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.
The electronic controller shall be provided with following features.
Boost current stabilization of ±2% with AC input variation of voltage and frequency variation of ±10% and ±5% respectively.
Boost charge current limiter with potentiometer to adjust the setting.
Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.

One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.
One (1) Front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
One (1) Front panel mounted potentiometer for manual adjustment of voltage in manual mode.
One (1) TP AC ON/OFF switch for float charger incoming.
One (1) set of HRC / MCB fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.
One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.
One (1) Digital Voltmeter, ammeter and frequency meter for Mains.
One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.
One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
One (1) Digital DC ammeter, with shunt, suitable range to read the float charger output current.
One (1) Digital DC ammeter, with shunt, suitable range to read the charging and discharging current for battery.
One (1) Double pole DC ON/OFF MCB switch for float charger output.
One (1) LED indicating lamp to indicate float charger DC 'ON' condition.
Duel tone alarm Annunciation System with RS 485 output with following.
AC Supply Failure.
Rectifier Fuse Failure.
Surge Circuit Fuse Failure.
Filter Fuse Failure.
Load Limiter Operated.
Charger Trip.
Battery on Float.
Battery on Boost.
DC Earth leakage.

Power Electronic Components

1428. Diode and thyristors shall be of mono crystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
1429. If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.
1430. Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
1431. Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
1432. The diodes or thyristor banks shall be natural air cooled.
1433. The diodes or thyristors shall be protected against over voltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of bus bars and as near as possible identical contact resistance in each current path.

1434. **Drawings and data.** All Drawings, data, guaranteed technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical Battery charger etc shall be submitted along with the bid / after award of contract.

LV Motors

1435. All motors shall comply with the following International standards, including standards referred to therein.
IEC 60034
IEC 60072
IS 325
IS 4029
IS 4691
IS 6362
IS 12065
IS 12075
IS 9283 (2013)

1436. The motors shall be as manufactured by BHEL, Siemens, ABB, Alstom, CGL, Kirloskar, Jothi or equivalent as approved by BUDIP Bhagalpur.

1437. **Performance features.**The LV motors shall be of the totally enclosed fan cooled type, with degree of protection for enclosure of IP 55 and shall be suitable for continuous operation and direct-on-line starting, unless otherwise specified.

1438. Motors shall be suitable in all respects for service in extreme climatic conditions. Main conductor and slot insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.

1439. Motors shall be capable of operating continuously at rated output at any frequency between 49 and 51 Hz and at any voltage within + 10% of the nominal value. Motors shall be designed to be operated for a period of not less than five minutes at a voltage of 20% below the nominal value and at normal frequency without injurious overheating.

1440. The starting current at rated voltage when started direct-on-line shall not exceed 6 times the rated full load current. When started with soft starter it should be 2.5 to 3 times the rated full load current. The motor characteristics shall be co-ordinated with soft starter manufacturer by Contractor.

1441. All bearings shall be fitted with oil or grease lubricators. Vertical shaft motors shall have thrust bearings.

1442. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.

1443. All terminal boxes shall be fitted with an approved sealing chamber, conduit entry or adapter plate, as required, together with the necessary fittings to suit the type of cable specified.

The power rating of the motors shall be of the following:

115% of the power input to the piece of equipment at duty point at a speed corresponding to a frequency of 50 hz.

The maximum power input while operating with maximum and minimum system resistance considering pumps or other equipment operating in parallel at a speed corresponding to a frequency of 50 hz.
In the case of pumps, they shall be able to operate at any point along their Q-H performance curve without overloading the motor.

1444. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage.

1445. Motors shall be capable of satisfactory operation at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.

1446. The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by at least two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motor, which is inclusive of 20% tolerance.

1447. Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding at least two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

1448. In case of motors started by soft starters, the three phases shall be segregated by metal barriers within both line and neutral side terminal boxes. The two (2) terminal boxes shall be on opposite sides.

1449. The earthing pad shall be of non-corrodible metal, welded / brazed at two locations on opposite sides. The pad size shall be 75 x 65 x 25 mm with two (2) holes drilled at 40 mm centers, tapped and provided with suitable bolts and washers for connecting the earthing strip.

1450. Motors shall have space heaters suitable for 230 V, single phase 50 Hz AC supply. These shall be placed in easily accessible positions in the lower part of motor frame.

1451. Provision / pocket shall be made, where specified or directed, to measure temperature of bearing by inserting hand held temperature measuring device. (One number portable instrument shall be provided along with the equipment) The same instrument shall also be used to measure the pump bearing temperature or RTD temperature probe shall be inserted to measure the temperature along with winding temperature. All wired up to terminal box and details to be furnished to instrumentation.

1452. Vibration sensors shall be embedded in the motor winding to avoid damage of windings due to stress due to electrical power. All wired up to terminal box and details to be furnished to instrumentation.

1453. Motors shall have drain plugs so located that they will drain water, resulting from condensation or other causes from all pockets in the motor casing.

1454. **Insulation**. Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the

motor in extreme climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

1455. The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.

1456. **Features of construction.** The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

1457. Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

1458. The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.

1459. At least six (6) numbers of simplex resistance type temperature detectors (RTDs) each having a DC resistance of 100 ohms at 35 degree Celsius, shall be embedded in the stator winding at locations where highest temperatures may be expected and at motor bearings. The material of RTDs shall be platinum.

1460. At least three (3) numbers of accelerometer vibration sensors shall be embedded on the end-phase winding for early detection of vibration is key in preventing forced outages.

1461. **Terminal box.** Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry of dust and water, gaskets of neoprene, Buna N or approved equivalent shall be provided at cover joints and between box and motor frame. The terminal box shall be suitable for bottom entry of cables. It shall be suitable of being rotated through 36o in steps of 90o.

1462. The terminals shall be of stud type with necessary plain washers, spring washers and check nuts. They shall be designed for rated current carrying capacity and shall ensure ample phase to phase and phase to earth clearances. Suitable cable glands and lugs shall be supplied to match specified cables.

1463. Separate terminal box or plug and socket connectors shall be provided for termination of cables for RTDs.

1464. Separate terminal box or plug and socket connectors shall be provided for termination of cables for vibration sensors.

1465. **Accessories.** Two (2) independent earthing points shall be provided on opposite sides of the motor for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

1466. Testing. Motors shall be subject to routine tests which shall also include the following:

Insulation resistance test
Measurement of winding resistance
High voltage test
No load / full load tests to determine efficiency, power-factor and slip
Momentary overload test
Test for noise levels of motor
Test for vibration severity of motor

Over speed test
Locked rotor readings of voltage, current and power input at a reduced voltage.
Heat run test (on motors above 0.433 kW rating only)

1467. Test certificates for test runs performed on identical motors (below 0.433 kW rating) shall be made available. Whenever two (2) or more identical motors (0.433 kW rating and above) are being offered, type tests on one (1) of them shall be carried out, including heat run test.

DOL Starter feeder shall be provided for all induction motors up to 7.5 KW, with Motor Protection Circuit breaker.
Fully Automatic Star Delta starter shall be provided for motors from 9 KW up to 22 KW with MCCB, Contactor, O/L relay etc.
Wherever regulated flow / control are required a VFD shall be provided.
Soft Start starter shall be provided for motors above 22 KW with MCCB, CMPR etc.
All Motors 250 KW and above shall be with 0.433 KV starting with Neutral soft starters, VCB, and Capacitor etc with RTD's and Vibration sensors.
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1468. All De-watering pump shall have local ON / OFF starter Control panel arrangement and protection against IP 65, under voltage, over voltage, single phasing, over Load with time delay to prevent nuisance tripping.
1469. All submersible pumps shall have Control Cubicle with suitable starter arrangement and protection against under voltage, over voltage, single phasing, wrong phase sequence, low water level, moisture entry, over temperature with time delay to prevent nuisance tripping, 0.415kV,6-P, TEFC squirrel cage induction motor 1000 RPM conforming to IS:9283-2013 latest having continuous rating suitable for submersible operation at 440 volts +/- 10% ,3-phase, 50Hz,+/-,5% with 'F' class insulation temperature rise limited to class B insulation. motor shall be suitable for driving pump as specified in mechanical section. Each Motor feeder shall be provided with necessary motor protections such as thermal overload, single phase protection, Undervoltage, overcurrent, etc. with relay or protection as applicable.
1470. All Motor Operated Valves shall have Actuator panel with suitable Forward / Reverse starter with all protections to control the valve from all its positions linearly to the selected reference position from remote PLC panel.
1471. All motors from 9 kW up to 75 kW shall be provided with large motor terminal box greater than the standard type.
1472. All motors above 75 kW shall be provided with double terminal box, one for motor power connection and one for neutral soft start connection.

Soft Starters for Motors

1473. The soft starters shall comply with the requirements of the following International Standards including those standards referred to therein.

IEC 60034,
IEC 60947
IS 325

1474. Reactance type soft starters shall be as manufactured by Innovative Technomics, Jayashree, or equivalent as approved by BUDIP Bhagalpur.

1475. Electronic type soft starters shall be as manufactured by Alstom, ABB, Siemens, Allen Bradley, Danfoss, or equivalent as approved by the BUDIP Bhagalpur.

1476. **Construction and Performance Features**

1477. Motor soft starters shall be switched reactance type or flux compensated type or electronic type.

1478. Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for:

Control, metering and current transformers for differential protection
Shorting (bypass) arrangement
Bus bars
Power cable terminations
Push buttons with indicating lamps
Interlocking with motor VCB.

1479. Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment. Starting current shall be limited to 3 to 3.5 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose. Separate removable gland plates shall be provided for power and control cables. Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels. A detailed wiring diagram shall be provided showing the starting interlock, trip circuit, starting and running mode signals. It shall be possible to manually start the motor locally from the starter panel or in 'Auto' mode through the PLC.

1480. **Main bus bars**. Bus bars shall be fully insulated by encapsulation in epoxy resin, with moulded caps protecting all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be of hard drawn Aluminium conductor and of high conductivity, Electrical grade Aluminium .

1481. **Earthing**. A Aluminium earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted / welded to the framework. All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid copper conductor.

1482. Panel accessories and wiring. Panels shall be supplied completely wired internally up to equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided. All auxiliary wiring shall be carried out with 1100 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm. Terminal blocks shall be of stud type, 10 A rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks. Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, with a 240 o scale for flush mounting with only flanges projecting. Push buttons shall be provided with inscription plates engraved with their functions.

1483. Indicating lamps shall be of clustered LED type. Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230 V, 1 ph, 50 Hz supply. They shall be complete with MCB and thermostat. Each panel shall be provided with 230 Volts, 1 phase, 50 Hz, 5 A, 3 pin receptacle with MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided. The DC and AC auxiliary supply shall be distributed inside the panel with

necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

1484. **Testing.** Each soft starter unit shall be tested at the manufacturer's work. Test result must satisfy all of the characteristics during starting and acceleration against their quoted values listed in the design submittals.

Cables: HV, LV Power and Control

1485. **Applicable standards.** The cables shall conform to the latest applicable standards specified below.

PVC insulated cables (for voltage up to 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Cross linked polyethylene XLPE insulated PVC sheathed cables	:	IS: 7098/II/85
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 60189-1 & IEC: 60189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and sheath of electric cables.	:	BS: 6746

1486. Features of the construction are as follows:

HV Power Cables:

XLPE Insulated HV all aluminium stranded Power Cables :

1487. The Cables shall be 36 kV unearthed grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded Semiconducting compound, insulation screening through Combination of semi conducting compound and non magnetic tape (Copper tape), inner sheath over laid up cores, galvanized steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2. Core Identification shall be by printed numerals.

LT Power Cables

PVC Insulated Cables:

1488. The Cables shall be 1.1 KV Grade , heavy duty, Stranded Aluminium above 6 sq mm / Copper Conductor 6 sq mm and below , PVC Compound type A insulated , inner sheathed, galvanized steel wire /strip armoured ,black PVC compound type ST1 outer sheathed.

XLPE Insulated Cables:

1489. The Cable shall be 1.1 KV Grade , heavy duty, stranded aluminium above 6 sq mm / Copper Conductor 6 mm and below, XLPE insulated , inner sheathed, galvanized steel wire / strip armoured ,extruded black PVC Compound type ST2 outer sheathed.

Control Cables: (4 sq mm and below with copper conductor)

1490. The Cables shall be 1.1 KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanized steel wire/ strip armoured extruded PVC type ST1 outer sheathed.
The tests carried out on every cable length and / or drum at manufacturer's premises shall include following tests as applicable but not be limited to:
High voltage DC insulation pressure test, between cores,each core to earth, metallic sheath or armor as applicable
Insulation resistance test;
Core continuity test and identification
Conductor resistance test
Elongation test
Smoke density test
HCl gas generation test
Anti-rodent test (presence of lead)

1491. **Cable rating**. The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use. In assessing the rating of any cable or wire, the following factors shall be taken into account:

1492. Supply voltage and frequencyMaximum voltage drop permissible
Type and magnitude of load
Fault level and duration of 1sec min
Circuit over current protection
Route length and disposition of cables
Ambient temperature
Operating temperature
Method of installation and all applicable derating factors pertaining to worst condition .i.e low efficiency, poor power factor, under voltage, etc.

1493. All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 450C. The design current of any circuit shall exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to no more than 3 %.Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energized. HV and LV cables shall be sized for a fault clearance time of 1 second to withstand fault at particular load.

1494. All power cables shall be sized based on continuous current capacity, permissible voltage drop and short circuit current rating. The voltage drop shall be limited to 2.5 % at rated equipment current rating.

1495. **Cable colours.** All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

1496. The colour coding should be as follows:

3 Phase	:	Red, Yellow and Blue.
1 Phase	:	Red and Black.
Earth	:	Green / Yellow.
Control	:	Blue (dc) and Red (ac).

1497. **Cable conductors.** Copper conductors shall be used for cables of sizes up to 4 Sq mm. Aluminium conductors shall be used for cables of size 6 Sq mm and above. Cores of cross-sectional area greater than 1.5 mm2 shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm2. Power cables shall be of a minimum cross-section of 2.5 Sq. mm. Internal wiring of control panels shall be of a minimum cross-section of 1.0 Sq.mm flexible and stranded. Control cables shall be of a minimum cross-section 1.5 Sq.mm for external use and 1.0 Sq.mm for internal use.

1498. **Cable numbering.** All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit number.

HV Power	HV-P_____
LV Power	P_____
Conrol	C_____
Insrumentation	I_____
Protection	PR_____

1499. **Cable drums.** Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

1500. The Contractor shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. However, before winding the cables on drums.Contractor shall obtain BUDIP's approval for the drum lengths.

1501. Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size and number of cores, length, result and date of tests as required in the BUDIP's Requirements. Cables manufactured more than 12 months before delivery will not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

Cable Installation

1502. **General.** Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

1503. Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

1504. Cable fire sealing shall be provided such that fire proof cable penetration seals rated for two hours shall be provided. The FPS system shall comply in all respects with the requirements of the codes and standards described in IEC 331 and IEC 332. Type tests shall be conducted on different fire-stop test specimens described above in accordance with standard IEEE 634.

1505. Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table 86: Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/Protection
HV Power	N/A	300	500
LV Power	300	N/A	300
C&I/Protection	500	300	N/A

1506. These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

1507. In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

1508. Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.

1509. Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.

1510. Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. Plastic or GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

1511. Cables laid direct on ground. Buried cable up to 1100 V shall have a minimum cover of 500 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

1512. Cables of greater than 650/1 100 V shall be buried with a minimum cover of 1 m. The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked `Danger -Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm. Warning tape shall be laid a minimum of 200 mm above the protective covers. Cables are to be installed without tees or through joints unless otherwise approved by the Employers representative. Single core cables shall be run in trefoil formation.

1513. Cables laid on underground ducts. Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 500 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 m deep and

encased on all sides by 150 mm of concrete. The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

1514. Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Employers representative. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

1515. Cables installed in conduit. Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized. A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection. Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

1516. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

1517. Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

1518. Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Employers representative. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

1519. Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.

1520. Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

1521. **Surface installation.** Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be

marked out for approval by the Employers representative before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Employers representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Employers representative before carrying out the work.

1522. Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

1523. **Concealed installation.** Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to brick work, etc. Building nails will not be accepted.

1524. At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

1525. Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

1526. The conduit installation shall be inspected by the Employers representative before the building operation conceals the work.

1527. Cables installed in flexible conduit. Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

1528. Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

1529. Cables installed in cable trunking–metal. Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size. Segregation of cables shall be carried out if required using continuous sheet steel barriers

with the bottom edge welded to the trunking. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

1530. Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire. Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes. Trunking shall be supported at intervals not greater than 2 m horizontally or 2.5 m vertically.

1531. Crossings over expansion joints shall be made in flexible conduit. Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

1532. Cable and conduit / trunking runs shall be determined by the Contractor and agreed by the Employers representative before any work is started. The run shall be at least 150 mm clear of plumbing and mechanical services. Conduit / trunking systems erected outside a building shall be weatherproof.

1533. Cable installed on cable tray. Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1 mm for trays up to 100 mm width, not less than 1.25 mm for trays from 100 mm to 150 mm width and not less than 1.5 mm for trays from 150 mm to 300 mm width. Cable tray shall be hot dipped galvanized. Cable tray for use in areas where chlorine gas may be present shall construct from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.

1534. All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.

1535. Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer’s instructions.

1536. Cable tray supports supplied by a manufacturer or made up on Site shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid-span.

1537. Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, then for galvanized trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

1538. All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Employers representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid-span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

1539. Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray.

1540. The sizing of the cable tray shall provide a minimum of 25% spare capacity. The tray shall be run at least 150 mm clear of plumbing and mechanical services.

1541. Cables installed on ladder rack systems. Ladder racking either light or heavy weight shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed. Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed. The sizing of the cable rack system shall provide a minimum of 25% spare capacity. The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

1542. Cable clipped direct. All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed.

1543. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

1544. Cable installed in internal floor trench. In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner. Here the trench is shared by other services, cables shall be installed on the walls of the trench in an approved manner.

1545. All other trenches including walk through service ducts Cabling shall be installed to the walls of the trench in an approved manner. Where other services are present the cables shall be segregated from them and wherever possible kept above `cold' wet services. Cables should not be run if at all possible above or in close proximity to `hot' services. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation.

Cable Terminations and Joints.

1546. Power cable terminations. Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

1547. Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

1548. Adequate provision shall be made to bond the cable armoring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.

1549. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.Where terminations of multi core type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken

into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

1550. Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

1551. **Power cable joints.** Through joints shall only be allowed with the approval of the Employers representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Employers representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

1552. In case of HT cable end termination and straight through joints shall be approved heat shrinkable type. High voltage test shall be conducted and test reports and meager values shall be submitted after test along with calibration certificates of the instrument used for measuring.

1553. **Multicore or control cable terminations**. A sufficient number of terminals shall be provided to terminate all cable cores including 10% spare cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

1554. Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

1555. Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.

1556. Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

1557. **Cable fixings.** Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.

1558. Large single cables shall be secured with cable clamps or cable cleats.

1559. **Cable identification.** At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Employers representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

1560. **Cable glands.** Glands shall generally be of the mechanical double compression hexagon type. Earth continuity of brass glands shall confirm to BS: 6121/ EN 50262 : 1999 . This may be achieved by the rigid clamping of the armor within the gland and the intimate contact between the threaded components of the gland and the equipment. Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to

the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armor wires of the cable where applicable.

1561. Glands for single core cables shall be constructed from non-magnetic materials. Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped.

1562. Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

1563. For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weather proof type, gland shrouds shall be used and entry shall be sealed.

1564. For dry indoor situations, standard industrial glands with shrouds are acceptable.

1565. For hazardous areas, glands conforming to EExd standard shall be used with double seal and shroud.

1566. Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the glanded device in order that a true earth loop value may be measured when carrying out tests on the installation. Cable Glands shall be suitable for indoor and outdoor use, appropriate for single wire armored, plastic or rubber sheathed cable. Which provides grip to the cable with outer and inner seals suitable for all climatic conditions. Weatherproof and waterproof.

1567. **Marking locations of underground cables.** The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall. In addition concrete route marker posts shall be installed at intervals of not more than 50 m at all junctions and changes of direction along the cable route and cable joint markers shall be provided where ever undergrounding cable joint exists. Such marker posts shall be not less than 200 mm high and of substantial construction. A drawing or sample of a typical marker post shall be submitted for the approval of the Employers representative.

1568. The markers shall be marked `electric cable' / ‘cable Joint’ in English and the vernacular.

1569. **Drawings and data**. All Drawings, data, guaranteed technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical type of cable etc. shall be submitted along with the bid / after award of contract.

Cable Carrier System

1570. The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.
Applicable Standards

Steel for general structural purposes	:	IS: 2062
Dimensions for hot rolled steel beam, column channel and angle sections	:	IS: 808

Code of practice for use of metal arc welding for general construction in mild steel	:	IS: 816
Hot deep galvanizing of iron & steel	:	IS: 2629
Methods of testing uniformity of coating of zinc coated articles	:	IS: 2633
Hot dip zinc coatings on structural steel and other allied products	:	IS: 4759

Cable Racks, Trays and their support structure

1571. Typical cable tray arrangement/trench arrangement/directly buried cable arrangement etc. shall be shown in , Typical Drawings.
Cable racks/trays shall be fabricated from standard structural steel members.
All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanized.

1572. **Galvanizing.** Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

Fabricated steel	
Thickness 1.2 mm up to 2 mm	340 grams / Sqmm
Thickness 2 mm up to 5 mm	460 grams / Sqmm
Thickness 5 mm and above	610 grams / Sqmm
Fasteners	
Up to Nominal size M 10	270 grams / Sqmm
Over M 10	300 grams / Sqmm

1573. Galvanizing shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts such welded joints, fabricated cable trays and supports should be covered well by zinc rich primer and aluminium paint.

1574. **Drawings and data**. All Drawings, data, guaranteed technical particulars, calculations, detailed literature, catalogues, similar test certificates etc shall be submitted along with the bid/ after award of contract.

Lighting System

1575. **General requirements**. Lighting fixtures complete with Lamps and accessories lumen per watt shall be indicated. Lighting system equipment shall have ISI make. Light control switches, receptacle units with control Switch units, lighting wires, conduits and other similar items necessary to complete lighting system shall be provided. Lighting fixture supports, street lighting poles and flood Lighting, Main Lighting distribution board, lighting panels, Multi core cables for street, boundary and flood lighting shall be ISI make. DC Emergency Lighting shall be provided for Substation room, SCADA room and Switchgear room. Load balancing of lighting system shall be made.

1576. The illumination levels for various areas shall be as follows:

Area	Illumination level (lux)(lumen / Sq.mm.)

Pump Houses/Equipment Rooms	:	250
Office/Conference Rooms	:	300
Electrical/Switchboard Rooms	:	250
All Other Indoor Areas	:	150
Outdoor Switchyard Area	:	50
Outdoor Plant Areas and Roads	:	25

1577. The following values of 'light loss factor' shall be considered for design:

Indoor air-conditioned area	:	0.8
Other indoor areas	:	0.7
Outdoor area	:	0.6

1578. The Contractor shall furnish detailed design calculations, uniformity factors, ratios of maximum to minimum illumination levels, ratios of average to minimum illumination levels, glare values, etc. for approval by the BUDIP's Representative. Detailed characteristics of various types of fixtures including photometric curves and tables shall also be furnished for review.

1579. The size of the wiringto be furnished shall be such as to limit the voltage drop to a maximum within 3 %.of the service voltage. Theminimum area of conductor shall be as follows:

Table 87: Minimum area of Conductor

Service	Current Rating	Min Copper Conductor Area	Loading
Lighting Fixtures	All	1.5 mm2	per the lamp
Receptacles	6A	2.5 mm2	100 watts
Receptacles	16A	4.0 mm2	500 watts
Indl. Recipticle	20A, 3Ø	6.0 mm2	5000 watts
Lighting load	20A, 1Ø	4.0 mm2	3000 watts

1580. **Applicable standards**. All light fittings shall be energy efficient type with lumen per watt shall be specified. The design, manufacture and performance of equipment shall conform to the latest standards specified below.

1. Lighting Fixtures & Accessories:

Electrical lighting fittings general and safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665
Calculation of co-efficient of utilization	:	IS: 3646 (Part - III)
Industrial lighting fittings with metal	:	IS: 1777

2. Reflectors:

Decorative lighting outfits	:	IS: 5077
Dust proof electric lighting fittings	:	IS: 4012
Dust tight electric lighting fittings	:	IS: 4013
Flood lights	:	IS: 10322/BS: 4533
Luminaires for street lighting	:	IS: 10322 Part 5
Water tight electric lighting fittings	:	IS: 3553/ BS: 4533, 5225(I)
Bayonet lamp holders	:	IS: 1258/BSEN 61184 IEC:60061

Edision screw lamp holders	:	IS: 10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS: 3323
Starters for fluorescent lamp holders	:	IS: 2215/BSEN 60155
for starters for tubular		
Fluorescent lamps.	:	IS: 3324/ BSEN 60400
Ballast for use in fluorescent lighting fittings	:	IS:1534(Part1)/BSEN 60920& 60921
Transistorized ballast for fluorescent lamps	:	IS: 7027
Ballast for HP mercury vapour lamp	:	IS: 6616
Capacitors for use in fluorescent	:	IS: 1569/ BSEN 61048
HPMV & LP sodium vapour discharge circuits		& 61049 /IEC: 60586
Vitreous enamel reflector for tungsten	:	IS: 8017
filament lamp		
Tubular fluorescent lamps	:	IS:2418 (Part 1)/ BSEN 60081
IEC: 60081		
High pressure mercury vapour lamps	:	IS: 9900/BS: 3677/ IEC: 60188
Tungsten filament general electric lamps	:	IS: 418/IEC: 60432
Cast acrylic sheets for use in Luminaires	:	IS: 7569
Screw less terminal and electrical	:	IS: 10322
connections for lighting fittings		
High pressure sodium vapour lamps	:	IS: 9974
Emergency lighting units	:	IS: 9583
Ignition proof enclosures, dust-tight for	:	IS: 11005
elect. Equipment Luminare	:	IS: 10322 (Part I to V)

1581. Applicable Lighting System Equipment

Arrangement for bus bars, main connections	:	IS: 5578/ 11353/BS: 159
and auxiliary wiring and marking		
Enclosed distribution fuse boards and	:	IS: 2675/ BSEN 60439
Cutouts for voltages not exceeding 1000V		
General requirements for switchgear and	:	IS: 13947
Control gear for voltages not exceeding		
1000 V		
Code of practice - installation and	:	IS: 10118/BS: 6423
Maintenance of switchgear		BS: 6626, BS 6867
Factory built assemblies of switchgear	:	IS:8623/BS-5486/IEC: 60439
and control gear for voltages up to and		
Including 1000 V AC and 1200 V DC		
Miniature air break circuit breakers for	:	IS: 8828/ BSEN 60898
AC circuits		
HRC cartridge fuse links up to 650 V	:	IS: 9224/BS: 88/ IEC: 60269
Current transformers	:	IS: 2705/BS: 7626/ IEC: 60185
Voltage transformers	:	IS: 3156/BS: 7625/ IEC: 60186
Direct acting electrical indicating Instruments	:	IS: 1248/BS: 89/ IEC: 60051
A.C. electricity meters	:	IS: 722/BS 5685
Electrical relays for power system protection	:	IS: 3231/BS: 142/ IEC: 60255
Switches for domestic and similar purposes	:	IS: 3854/BS: 3676
Three pin plugs and socket outlets	:	IS: 1293/BS: 546
Boxes for enclosure of electrical accessories	:	IS: 5133(1)
Rigid steel conduits for electrical wiring	:	IS: 9537/BS: 31
Accessories for rigid steel conduits for wiring	:	IS: 3837/BS-31
Flexible steel conduits for electrical wiring	:	IS: 3480

Rigid non-metallic conduits - electrical installations	:	IS: 9537/BS: 4607(2)
Fittings for rigid non-metallic conduits	:	IS: 3419/BS: 4607(2)
PVC insulated cables for working voltages Up to and including 1100 V	:	IS: 694
Tubular / Octagonal steel poles	:	IS: 2713 / BS:5649partVI 1982.
Specification for copper rods and bars for electrical purposes	:	IS: 613
Code of practice for phosphate iron and steel	:	IS: 6005/ BS: 3189
Fittings for rigid steel conduits for wiring	:	IS: 2667

Lighting Fixtures (Luminaires)

1582. Luminaires shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.
1583. The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
Connections between different components shall be made in such a way that they will not work loose by small vibration.
1584. For each type of Luminaires the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
1585. All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.
1586. The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
1587. LED Luminaires shall be complete with accessories like lamps, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaire housing only. If these cannot be accommodated integral with the Luminaires then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box.
1588. Each luminaire shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminium conductor wires up to 4 sq.mm in size. In outdoor areas the termination at the luminaire shall be suitable for 1100 V, PVC insulated, copper/aluminium conductor, armoured cables of sizes up to 6 sq.mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of standard copper wire of minimum 1 sq.mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.
1589. Mounting facility and conduit knock-outs for the luminaries shall be provided.
The fixtures provided shall be energy efficient and shall be consuming less power.

Earthing

1590. Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
1591. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.
1592. All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

Painting/Finish

1593. All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
1594. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
1595. The luminaire housing shall be stove-enameled/epoxy stove-enamelled-vitreous enameled or anodized as indicated under various types of fittings.
The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 1/2" dia. mandrel.
1596. The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.
1597. External control gear box provided for housing accessories shall be painted or galvanized.

Decorative Luminaires.

LED Luminaires:

1598. These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enameled.
1599. Decorative LED type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers.
1600. Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.
1601. Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This is mainly to reduce reflection of the light source from TV/monitor screens.
Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

Industrial Luminaires.

LED Luminaires.

1602. The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enameled.
1603. Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.
1604. The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.
1605. The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used.

LED lamps luminaires.

Bulk Head Luminaire.

1606. The luminaire shall be of robust construction, with cast aluminium/vitreous enameled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets

for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enameled finish shall be provided.
1607. The luminaire shall be suitable for LED up to 15 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

High, Medium and Low Bay Luminaires.

1608. High and medium bay luminaires shall be with cast aluminium housing, anodized aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.
1609. The luminaire shall be suitable for LED lamps. The control gear accessories shall be mounted integral with the luminaire.
1610. High bay luminaires shall be used when the mounting height is above 8 meters while medium bay luminaires shall be used when the mounting height is around 6 to 8 meters.

Flood Light Luminaire.

General purpose flood light luminaire

1611. Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodized aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
1612. The housing shall be supported on a cast iron base and capable of being swiveled in both horizontal and vertical directions and locked in any desired position.
1613. For focusing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
1614. The Luminaires shall be suitable for single or multiple lamps. The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.
It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
It shall be possible to replace the lamp from the canopy without opening the front glass.

Outdoor Lantern Luminaires.

Post top Lantern.

1615. Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.
1616. The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.
Sub-station Lantern.

1617. Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.
1618. The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodized aluminium reflector to give light distribution at an angle 20 to 40 degrees, above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

Street Lighting Luminaires.

Fluorescent Luminaires.

1619. Street lighting LED luminaire shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.
1620. The luminaire shall be of semi-cut off or non-cut off type, with CRCA sheet steel housing, vitreous enameled, plain or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, side pipe entry or top suspension type.
1621. The luminaire shall be suitable for 1 x 40 watts or 2 x 40 watts LED tubes and for mounting heights up to 4 meters .

LED luminaires.

1622. Street light LED luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.
1623. The luminaire shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

Portable Emergency Light Luminaire.

1624. Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.
1625. The luminaire shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.
1626. The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.
The luminaire shall be suitable for incandescent lamp up to fluorescent lamp up to 20 W.

Accessories for Luminaires.

Reflectors:

1627. The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaires.
1628. The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enameled finish. Aluminium used for reflectors shall be anodized/epoxy stove enameled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.
1629. Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.
1630. Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

Lamp holders / Starter Holders:

1631. Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.
1632. Lamp holders for the LED lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamps holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.
1633. The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

Lamps:

1634. Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/electrodes shall not break under such circumstances.
LED lamps:
1635. LED shall be rated for 230/250 volts, Single phase A.C.
Lamps may be with Edison Screw type metal lamp caps to prevent pilferage.
Lamps shall be milky white for diffused, soft, glare free lighting and rated up to 100 watts.

Lighting System Equipment.

Main Lighting Distribution Board and Lighting Panels (AC Phase segregated & DC).

Constructional Features:

1636. Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 55. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.
1637. All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the MCB arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with the door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted Bakelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the Bakelite sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with TPN MCB with ELCB.
1638. All accessible live connections/metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.
1639. For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.
1640. Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required.

Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.
1641. Two earthing terminals shall be provided to suit the earthing conductor.
1642. All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognized phosphate process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enameled finish paint of specified colour.

Bus bars:

1643. Bus bars shall be of Aluminium conductor of hard drawn (HD) and high conductivity. Bus bars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.
Bus bars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.
1644. Bus bars shall be adequately sized for the continuous current rating such that the maximum temperature of the bus bars, busbar risers/droppers and contacts does not exceed 85° C under site reference ambient temperature.
1645. The bus bars, busbar connections and busbar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.
1646. Busbar supports shall be made from suitable insulating material such as Hylam sheets, glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the bus bars. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.
1647. The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase bus bars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase bus bars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

Panels/Boards' Component Equipment:

Miniature Circuit Breakers (MCB) / ELCB / RCCB

1648. MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.
1649. The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 6 kA r.m.s. at 415 V/110 V D.C.
Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with tag on facility.
1650. The incomer shall be MCCB for ≥ 100 A and shall be MCB TPN for < 100A connections shall be phase segregated shall be insulated and all live connections shall be shrouded. RCCB with suitable rating shall be provided for incomer 100mA and power receptacle feeder 30mA. One digital type energy meter shall be provided on each lighting MCB DB.

Fuses for DC / Thyristor fuses:

1651. Fuse less system is preferable however some special case fuses can be used. Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80 kA at 440 V. Fuses upto 63A for distribution systems of medium short circuit levels may be of HRC link type, having a certified rupturing capacity of not less than 46 kA at 440 V and 16 kA at 250 V D.C.

Fuses shall be provided with visible indication to show that they have operated.
Insulated fuse pulling handle shall be provided for each size of fuse for eachswitchboard.
All thristors shall be protected with fuses and fuse fail indicators.

Indicating Instruments and Meters (Digital):

1652. Whenever required, digital instruments and meters shall be of the flush mounting type. They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

Instruments such as voltmeter and ammeter shall be of digital instruments.
Watt-hour meters shall be of direct reading of digital multifunction meter.

Instrument Transformers:

1653. Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.

Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.
Voltage transformers shall be provided with suitably rated primary and secondary fuses.

Indicating Lights:

Indicating lights shall be of the clustered LED type with translucent covers.

Internal Wiring:

1654. Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V grade, PVC insulated, stranded aluminium /copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.

1655. Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

1656. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.

Terminals for circuits with voltage exceeding 125 V shall be shrouded.
Terminals shall be numbered and provided with identification strip for identification of the circuit.
Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

Labels & Diagram Plate:

1657. All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.

Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved PVC
Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

Light Control box and switches:

1658. Applicable Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be Modular suitable for use on 240 V, 1 Ph, 50 Hz supply.
Switches shall be of flush type for mounting behind an insulated modular plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The modular switch box / enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.
1659. Applicable The size of enclosure modular boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanized. The enclosure plates / boxes shall be fabricated out of quality tested raw material such as metal, PVC, power coated metal. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

Receptacle Units:

1660. Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch (5/6A) or MCB (15/16A) shall be flush mounted within galvanized 18 gauge steel / modular enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.
1661. The receptacle units shall be suitable for 240 V, 1 ph - N, 50 Hz, 5/6A / 415 V, 3 Ph - N, 50 Hz, 15/16A supply as required.
1662. Single phase receptacles 15/16A shall be associated with ELCB / RCCB and MCB of same current rating and the receptacle shall become live only when the associated ELCB / RCCB and MCB is in “ON” position.
1663. Three phase receptacles shall be metal clad associated with a TPN MCB housed in the same enclosure. The receptacle shall become live only when the associated MCB switch is in “ON” position.
1664. The plugs shall be provided along with three phase receptacle with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

Lighting Wires:

1665. The wires for wiring in lighting system shall be 1100 volt grade ISI make, 1/C, PVC insulated, un-armoured with stranded copper conductors.
1666. The minimum area of conductors shall be 1.5 sq.mm. for light fittings and 5/6A Receptacles and 2.5 sq.mm for receptacles rated 15/16 A and above.
1667. The wires shall be coded white for phase/positive of D.C. and black for neutral/negative of D.C.

Conduits:

1668. Rigid non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.
1669. Nonmetallic conduits shall be supplied in standard lengths of 5 m of 2.5 mm thickness and shall confirm IS 2509.
1670. Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work inclusive of all the consumables such as adhesive tape / paste, rawal plug, screws etc.

Junction Boxes:

1671. Square or rectangular type modular Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for indoor / outdoor areas, 3 phase receptacles etc.
1672. The junction boxes shall be dust and vermin proof and shall be fabricated from quality tested raw material such as metal, PVC and powder coated metal and shall be complete with removable cover plate with gaskets. Boxes shall be additionally weather proof with earthing terminals.
1673. The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, earthing terminals as required.
1674. The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanized nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.
1675. The boxes shall be aesthetic look and weather proof for outdoor unit with MCB for branching lighting circuit.

Lighting Poles and Flood Light Pole Mounting:

1676. Lighting poles for street lights and flood lights shall be of stepped tubular / octagonal steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint / GI on the inside as well as embedded outside surface. Exposed outside surface shall be painted with one coat of red lead oxide primer. After completion of installation two coats of aluminium paint shall be applied.
1677. Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. A steel ladder shall be provided. The length of each step of the ladder shall be at least 300 mm and spacing between two adjacent steps not more than 300 mm.
The supply of poles shall be complete with fixing bracket/necessary pipe reducer for fixing the fitting and also include the necessary associated pole mounted junction boxes. The required sizes of poles and the junction box shall be as indicated in the drawings.

1678. Drawings and data. All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates, etc. shall be submitted along with the bid / after award of contract.

bb. Earthing and Lightning Protection System.

1679. The scope of work shall consist of designing the earthing and lightning protection systems in accordance with the applicable standards and specific design criteria listed below:

(i) The design shall be based upon the average value of soil resistivity as measured for different electrode spacing at the Project Site. Measurements shall be taken from 2 to 100 meters or more in steps of 5 and 10 meters. At least 2 sets of 20 readings each shall be taken over the project area, each set in a different direction.
(ii) Permissible values of step and touch potentials shall be based on the weight of a human being as 70 kg and an earth fault current of 40 kA for 1 second.
(iii) Gravel where used shall have a surface resistivity taken as 3,000 ohm-m

(iv) The depth of burial of earth conductors shall be 600 mm below ground level
(v) Ground resistance with only electrodes of maximum of 1 ohm.
(vi) Ground resistance of earthing grid of maximum of 1 ohm
(vii) Provide a corrosion allowance of at least 20%
(viii) The earthing conductor material shall be GS pipe electrode shall be of a minimum of40 mm diameter and 3,000 mm long.

1680. Earthing system design and calculations shall be subject to the approval of the BUDIP's Representative.

1681. The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories. Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system; Crane rails, tracks, metal pipes and conduits also shall be earthed at two points. Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic sheaths/ screens and armour of multi core cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only. Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post. Each Continuous laid length of cable tray shall be earthed at minimum two places by GS Flats to earthing system, the distance between the earthing points shall not exceed 30 m.

1682. Lightning Protection System shall compromise vertical / horizontal air terminations, down conductors, test limits and earth electrodes. Air terminations, down conductors and test links shall be of galvanized steel conductors and earth connection below the ground level shall be of mild steel.

1683. While sizing the buried earth conductors, a corrosion allowance of at least 20% shall be taken. Plant earthing system shall be designed such that the overall earthing grid resistance is the maximum one (1) ohm.

1684. Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level. Earthing and lightning protection system conductors run along walls, columns, etc. shall be cleated at an interval not to exceed 750 mm.

1685. Every down conductor shall be provided with a 'test link' mounted on a wall or column at about 1,000 mm above ground level, housed in a 16 SWG GS enclosure. The test joint shall be directly connected to the earth electrode.

1686. **Appicable standards.** The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS: 3043
Code of Practice for the Protection of Building and allied structure against lightning	:	IS: 2309
Hot dip galvanizing	:	IS: 2629, 2633, 4759
Structural steel	:	IS: 2062 & 808
Welding	:	IS: 816

1687. **Earthing conductor.** The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor. The material used for the earthing conductor shall be as follows:

(a) Conductors above ground shall be galvanised steel flat;
(b) Conductor buried in the ground or embedded in concrete shall be galvanised steel, rod /flat. Allowance shall be made for reduction in the cross section of the steel over the design life of the earthing system;

1688. The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.

1689. Earth electrodes where used shall be of heavy duty galvanised mild steel pipe of not less than 40 mm NB and 3000 mm long. Where multiple electrodes are used they shall be separated by a distance of not less than the driven length.

1690. Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked `Electrical Earth'.
All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the BUDIP's Representative.

1691. Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

1692. After the earth installation has been completed the Contractor shall demonstrate to the BUDIP's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

1693. Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.

1694. The lightning protection shall be provided by the Contractor as per code of practice for lightning protection – IS: 2309.

1695. **Main equal potential bonding conductor.** Main equal potential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

1696. Equal potential bonding conductors shall have the following minimum sizes.

a)	Main Equal potential Conductors	
	- Main Earth Conductor buried in earth	40 mm dia MS rod/50x10 mmGS flat
-	Transformers, main switchboard and standby generator installation.	50 x 10 mm flat
-	interconnection to lightning protection system	50 x 10 mm flat
-	interconnection to MCC s	50 x 10 mm /50 x6mm flat
b)	Equal potential Conductors	
-	interconnection to CP s	25 x 3 mm flat
-	power factor correction capacitor panel	25 x 3 mm flat

-	local push buttons	14 SWG	wire
-	lighting distribution board	4 SWG	wire
-	lighting and receptacle system	12 SWG	wire
-	outdoor street lighting	8 SWG	wire
-	ladder rack and cable tray at suitable points	25 x 3 mm	flat
-	hand rails and metallic structures	25 x 3 mm	flat
-	building reinforcement	25 x 3 mm	flat
-	incoming and outgoing process services	25 x 3 mm	flat
-	steel structures comprising storage tanks, mezzanine platform, crane rails, air handling ductwork systems etc.	25 x 3 mm	flat
-	LV Motors		
-	up to 10 kW	8 SWG	wire
-	10 to 20 kW	4 SWG	wire
-	20 to 50 kW	25 x 3 mm	flat
-	Earth electrode	40 mm dia 3000 mm long heavy Duty G.I. pipe electrode	

Notes:

1 Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor as per IER 1986 Act.

2 Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

1697. **Circuit protective conductors.** An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

a. A separate core within a multi core cable;
b. A separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor;
c. The metal sheath of an armored cable. The sheath shall be bonded to the metalworkof the apparatus and to the apparatus earth bar if any;
d. The copper sheath of a mineral insulated copper sheathed cable;
e. An independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.

1698. Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multi core cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

1699. The armoring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

1700. Where the cable armoring or sheath is used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armor to any piece of apparatus fitted with

a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

1701. **Instrumentation Earth.** An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument plate type earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radials from the same plate type earth point.

1702. The earth pit for instrumentation system shall be separate. Instrumentation earthing System conductors shall not be connected to other earthing conductors above the ground level. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated. Connection between instrument earth bar and instrument plate type earth pit shall be insulated copper wire such that earth pit resistance is less than 1 Ohm at panel.

1703. SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

1704. **Galvanizing.** Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

(a)	Fabricated steel		
	1.	Thickness 1.2 mm up to 2 mm	340 grams / Sqmm
	2.	Thickness 2 mm up to 5 mm	460 grams / Sqmm
	3.	Thickness 5 mm and above	610 grams / Sqmm
(b)	Fasteners		
	1.	Up to Nominal size M 10	270 grams / Sqmm
	2.	Over M 10	300 grams / Sqmm

1705. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminum paint.

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cc. Reference Inter-opera ability Architecture DetailsBetween Electrical System and Instrumentation control System

1706. All sub-systems such as Compressor system, Chlorination system, Chemical dosing system, APFC, Transformer protection system, DG set and Motor control system, shall be complete in all respects and shall be user friendly to SCADA; Electrical power requirement such as motor capacity, maximum cable size that can be terminated in the motor shall be indicated.

Table 89: MV Motors (K0.433V Motor with Line / Neutral Soft Start with capacitor)

A.	**Signals from PLC to HT Panel**		
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
1	Motor Start (Normal start)	Command from PLC	Digital signal
2	Motor Stop (Normal Stop)	Command from PLC	Digital signal
B.	**Signals from MV Panel to PLC**		
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
3	Motor Running	Feed back to PLC	Digital signal
4	E. Stop Applied LPBS / Panel	Feed back to PLC	Digital signal
5	Availability	Feed back to PLC	Digital signal
6	Local Selected	Feed back to PLC	Digital signal
7	Motor tripped from CMPR	Feed back to PLC	Digital signal
8	Motor winding / Bearing RTD	FB from Temp. Scanner	Analog Signal
9	Multi Function Meter	Feed back to PLC	Analog Signal
10	Motor / Pump Vibration sensors	FB from Vibration Switch	Analog Signal

Table 90: LT Motors (Pumping Application)

C.	**Signals from PLC to LT Panel**		
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
1	Motor Start (Normal start)	Command from PLC	Digital signal
2	Motor Stop (Normal Stop)	Command from PLC	Digital signal
D.	**Signals from LT Panel to PLC**		
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
3	Motor Running	Feed back to PLC	Digital signal
4	E. Stop Applied LPBS / Panel	Feed back to PLC	Digital signal
5	Availability	Feed back to PLC	Digital signal
6	Local Selected	Feed back to PLC	Digital signal
7	Motor tripped from MPR	Feed back to PLC	Digital signal
8	Multi Function Meter	Feed Back to PLC	Analog signal (read & write)

Table 91: Motor Operated Valves (Outdoor unit from butterfly valves)

E. Signals from PLC to Actuator Control Panel			
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
1	MOV Open	Command from PLC	Digital signal
2	MOV Close	Command from PLC	Digital signal
F. Signals from Actuator Control Panel to PLC			
Sl. No.	**Signal Description**	**Command / Feed back**	**Type of signal**
3	Position Indicator	Feed back to PLC	Analog signal
4	Limit Switch - Open / Opening	Feed back to PLC	Digital signal
5	Limit Switch – Close / Closing	Feed back to PLC	Digital signal
6	Local Selected	Feed back to PLC	Digital signal
7	Torque Switch - Open	Feed back to PLC	Digital signal
8	Torque Switch - Close	Feed back to PLC	Digital signal
9	Motor Availability	Feed back to PLC	Digital signal

PARTICULAR ELECTRICAL PLANT REQUIREMENTS

(To be read in conjunction with Technical Specification)

1707. The specific design and performance requirements for all electrical equipment are given in this part of the Specifications. The requirement specified shall be fully met with by the Contractor. In case of any deviations, the Contractor shall bring out the same in "Schedule of Deviations from Particular Requirement" failing which it will be considered that the Contractor fully complies with these requirements.

1708. **Primary power source for Bhagalpur Water Supply Porject.** The Electrical power supply for the intake as well as WTP site shall be obtained from 33 kV, 3 phase, 50 Hz substations of Bihar Power Distribution Company Ltd. From 33 kV Overhead line required ACSR conductors shall be terminated at WTP through DP structure, laying 33 kV underground cable from the Double / four Pole structure (i/e. Metering Units one at Intake site and another at WTP site) from the step down Sub Station. This work will be executed by Power Supply Company up to DP structure at site WTP and Intake; the provisional sum, which is required to execute the work, will be paid directly to Bihar State Electricity Board. Power supply from Bihar Electricity Board shall be obtained from 33 kV Overhead line from nearby substation having capacity to cater our Pump house and WTP load to our 33/0.433 kV Substation.

1709. Necessary double pole structure with vertical poles, cross arms, string / pin insulators, lightning arrestors, 33 kV Isolators, CT's, PT's, interconnecting cable from double pole structure to metering unit and the metering unit along with SF6CB / VCB will be provided by the successful Contractor as per Bihar State Electricity Board Norms / Specification.

1710. The Contractor's scope includes laisoning with Bihar State Electricity Board for getting permanent power supply, and making new power supply agreement between Bihar State Electricity Board and BUDIP, Bhagalpur for the proposed project and getting final

clearance from CEIG for all Electrical system at intake and WTP, which include submission and approval of Electrical drawings to CEIG. Arranging inspection for CEIG and obtaining safety certificate for switching ON the system from Bihar State Electricity Board.

1711. **Scope of works.** The scope of works for above project in Bhagalpur includes Design, testing at works, supply and delivery at site, unloading and storing the equipment at site , installation, FAT (Factory Acceptance Test) SAT (Site Acceptance test), testing and commissioning of the following equipment at site:-

1712. The Contractor's scope starts from the Express feeder incoming 33 kV overhead line adjoining to intake and WTP sites and providing of 33 kV CT, PT, GOD, DOF, metering unit SF6CB/ VCB as per Bihar State Electricity Board/IER 1956 Act norms and subsequently to all equipment/items as given below.

33 kV/ 0.433 kV transformers, 33 kV/ 0.433 kV transformers, 33 kV Metal enclosed Switchboards, 0.433 kV Metal enclosed Switchboards, 0.433 kV Metal enclosed switchboards, 0.433 kV capacitor banks with APFC panel, 0.433 kV capacitor banks with APFC panel, 110V DC Battery, Battery charger with DC Distribution board, 0.433 kV Motors, 0.433 kV capacitors for Motors, 0.433 kV Neutral Side Soft starters , Main Lighting system MCCB DB, Main Power MCCB DB, Actuator MPCB DB, Ventilation system, Aux. Load MCB DB, Power & control cables, H.T cables, L.T cables, Cable carrier system, Earthing& Lightning protection system, etc.

1713. . Various equipment / items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

1714. **Power supply arrangement**. The power supply arrangement for the above project in Bhagalpur shown in Single line diagrams, for reference Contractor shall design the system as per site requirements considering statutory requirements.

1715. **Design criteria for the project.** All electrical equipment will be rated for 45°C designed ambient temperature. The installation will generally conform to Indian Standards / IEC.

Table 92: 33 & 0.433 kV System

Nominal voltage Number of phases Frequency	33 & 0.433 kV 3 50 Hz
Connection	3 Wire
Maximum Fault Level	To be decided by the Contractor as per system requirements

L V System

(a) General Supply

- Voltage:	0.433 kV V nominal
- Frequency:	50 Hz
- Connection	4 wire
- No load transformer voltage	433 V
- System earthing	Solidly earthed

- Maximum fault level	To be decided by the Contractor as per system requirements

1716. All Plant shall, unless otherwise specified, be capable of continuous operation at a voltage level in the range of 90% to 110% of the relevant nominal voltage and a frequency variation of plus 3% minus 3%.

(b) AC Control , Lighting and Space Heating

- Voltage:	240 V
- Phases:	1
- Frequency	50 Hz
- Connection	2 wire (Phase & Neutral)

(c) DC Control , Protection and Alarm

- Voltage:	110 V
- Phases:	1
-Connection	2 wire (unearthed)

1717. **33 kV and 0.433 kV indoor switchboard.** 33 kV& 0.433 kV Switchboard shall be indoor, floor standing, sheet metal enclosed with IP4X degree of protection, with draw out type vacuum circuit breakers for incoming & outgoing feeders, control & protection .The switchboard shall be rated for a fault current not less than 26.25 kA. All protective relays shall be numerical type as per IEC 60255.

1718. **Power and distribution transformers.** Water treatment Plant and Clear Water Pump House will have 2 nos 33 kV / 0.433 kV Transformers, at Raw Water Intake 2 nos 33 kV / 0.433kV Transformers which will be feeding the connected loads. The transformers shall be sized considering 20% Contingency of total working load while arriving at the final capacity of transformers. Two no of transformers shall be provided for 0.433 kV CWPS and 0.433 kV WTP and RWPS such that under normal condition, each transformer will be loaded up to 50% and in case of failure of any one transformer, the healthy transformer shall have capacity to take entire load so as to have 100% standby. The transformer shall be designed such that at any point of time maximum loading on any single transformer shall not exceed 80% of full load capacity.

1719. The transformer kVA rating selected shall meet the following criteria during last largest motor starting period.

- Transient transformer loading shall not exceed 1.5 times i.e. 50% overloading
- Under minimum supply voltage conditions, the voltage at the motor terminals shall not be lower than 85% of the motor rated voltage
- The voltage drop at the point of supply shall not be greater than 10% of the rated voltage

1720. Transformer sizing calculations shall be submitted for approval by the Contractor.

1721. The transformers (Primary and Secondary), and the cables emanating from the secondary, shall be rated to accommodate the entire load for Phase 1 requirement. Suitable provision shall be made in the 3.45 and 0.433 kV switchboards, under the present Contract, to cater to this future connection of Phase 2. Also, spaces for the future HV switchboard

extension, future transformer, etc. shall be provided under this contract for extension of Phase 2. Necessary metering, protection and indication/ annunciation shall be provided on all the switchboards.

1722. **Electrical systems for RWPS.** The distance between Sub-station and RWPS may be approx. 250 m. However, the Contractor shall ensure about the length at the time of bidding.The cables to the 0.433 kV switchboard are to be suitable for outdoor application. The cables emanating from the secondary shall be rated to cater to the entire load for Phase 2 requirement. In future, an additional set of electric power supply system will be installed at the power substation constructed under the present projectby a separate Contract.

1723. The 33 kV indoor switchboard in RWPS, receiving power from the 33 kV feeder from Bihar State Electricity Board Sub-station, shall consist of one incomer VCBs (with line VTs), two outgoing VCBs with VT. The switchboard shall vacuum contactor panels for RWPS motors.

1724. 0.433 kV Switchboards shall receive power also from the 2 nos 0.433 kV feeders in the substation to supply power to the LV auxiliary loads of RWPS, which includes loads such as electrical valve actuators, battery charger, control and instrumentation panels, EOT crane, LV auxiliary motors and indoor and outdoor lighting load etc.

1725. **Electrical system for Settled Water Pumping Station, WTP and CWPS.** The 33/0.433 kV transformers shall feed the 0.433 kV indoor switchboards in CWPS in WTP complex. The cables to the 0.433 kV switchboard are to be suitable for outdoor application. The cables emanating from the secondary shall be rated to cater to the entire load including the future loads i.e. phase 2 requirements.

1726. The 0.433 kV indoor switchboards in CWPS in WTP, receiving power from the 0.433 kV feeders in the substation also, shall consist of two incomer VCBs (with line VTs), a bus coupler VCB and VTs on both the bus sections. The switchboard shall also vacuum contactor panels for CWPS motors. The cables emanating from the secondary shall be rated to cater to the entire load of Phase 2 requirement.In future, an additional set of electric power supply system will be installed at the power substation constructed under the present projectby a separate Contract.

1727. 0.433kV switchboards at the substation in WTP campus shall receive power from the auxiliary 33/0.433 kV transformers to feed the individual auxiliary loads in WTP. Appropriate electric power distribution system shall be planned and designed by the Contractor to feed loads for various facilities and equipment in WTP complex taking risk distribution of entire power distribution system and convenient operation and maintenance into account.

1728. **Unit of measurement.** Metric units of measurement (System International) shall be used in all Contract documentation. Angular measurement shall be in degrees with 90 degrees comprising one right angle.

1729. **Reference standards.** All equipment / systems supplied under this Contract shall conform to the latest editions of the International Electro-technical Commission (IEC) Standards or equivalent Indian Standards or other International Standards, provided they promise to confirm equal or superior performance.

1730. If standards other than IEC are referred, then the Contractor shall enclose English version of the standard with the bid.

1731. **Pollution level and creepage distance.** The installation is classified as Very Heavy Pollution Level (level IV of IEC 60815). However, creepage distance shall be 31 mm/kV for outdoor equipment such as bushings and insulators and 25 mm/kV for indoor equipment, the voltage being highest system phase to phase voltage.

1732. **Spare parts, tools and appliances.** The Contractor shall supply essential spares as specified in these specifications. In addition, the Contractor shall state in the relevant schedules the spares, special tools and / or appliances which are recommended for satisfactory operation and maintenance for 2 years required in the Bid Documents.

1733. All spares shall be interchangeable with the original parts and Contractor should submit interchangeable certificate. They shall be treated and packed for long term storage under the climatic conditions of site.

1734. All cases, containers, or other packages are liable to be opened for inspection and checking on site.

1735. **System protection.** A microprocessor / Digital based protection system for various parts of the power supply system are proposed with communicable port. The Contractor shall carryout a comprehensive protection co-ordination design study for the different types of faults occurring at different points in the system under maximum and minimum fault conditions. The proposed relay characteristics shall be shown on the grading diagram. The following protection systems shall be used:

(a) 33 kV Incomer Feeder
- Instantaneous phase over current relay;
- Instantaneous earth fault relay;
- Inverse definite minimum time phase over current relay;
- Potential transformer fuse failure relay;
- Under voltage relay.

(b) 33 kV Transformer Feeder
- Inverse definite minimum time over current with instantaneous over current element;
- Instantaneous earth fault relay
- Standby earth fault.
- Winding temperature high, alarm trip.
- Oil temperature high, alarm trip.
- Buchholz relay with alarm and trip contacts.
- Magnetic oil level gauge with alarm contacts.
- Restricted Earth Fault relay to be provided for Transformer rating more than 2MVA.
- Differential Protection to be provided for Transformer rating more than 5MVA.

(c) 0.433 kV Incomer Feeder
- Instantaneous phase over current relay;
- Instantaneous earth fault relay;
- Inverse definite minimum time phase over current relay;
- Potential transformer fuse failure relay;
- Under voltage relay.

(d) 0.433 kV Motor Feeder
- Comprehensive Motor protection relay for motor above 900 kW;
- Motor winding / bearing temperature monitor and protection relay;
- Vibration monitoring and protection relay;

- Motor locked protection;
- Phase sequence;
- Overload, short circuit etc.

(e) 0.433 kV V Incomer Feeder
- Overload, Earth fault and short circuit protection;
- Under voltage relay.

(f) LV Motors

Motors less than 7.5 kW
- overload protection by three phase thermal (bimetal) relay.
- Single phasing preventer.

Motors 7.5 kW up to 75 kW
- Electronic motor protection relay providing the following protection for
- Overload;
- Earth fault;
- phase currents out of balance.
- Single phasing preventer.

Motors 132 kW and above
- Comprehensive motor protection relay providing the following protection for
- Overload;
- locked rotor;
- Over current;
- Earth fault;
- phase currents out of balance.
- Over voltage & under voltage;
- phase loss/reversal;
- Negative sequence;
- Protection for repeated and prolonged starts;
- restart inhibition;
- No load running;
- Single phasing preventer.

Switchgear Equipment / Instruments

(a) 33 kV Feeders (Incomer and Transformer feeders)
- Digital Ammeter with built in selector switch;
- Digital Voltmeter with built in selector switch;
- KW meter;
- KWh meter;
- KVArh meter;
- Frequency meter;
- Power factor meter.

(b) 0.433 kV Feeders (Incomer)
- Digital Ammeter with built in selector switch;
- Digital Voltmeter with built in selector switch;
- KW meter;
- KWh meter;
- KVArh meter;
- Frequency meter;
- Power factor meter.

(c) 0.433 kV Incomer Feeders
- Digital Ammeter with built in selector switch;
- Digital Voltmeter with built in selector switch;

- KW meter;

(d) 0.433 kV Motor Starter Feeders

- KW meters for Motor feeders more than 7.5 kW;
- Multifunction meters with facility to extract historical data.
- DOL Starters for motor feeders less than or equal to 7.5 kW;
- Star-Delta Starters for motor feeders above 7.5 kW and less than or Equal to 22 kW;
- Neutral / Soft Starters for motor feeders 0.433 kV for and above 250 Kw, 415 V, Soft starters formotore above 22 kW.

1736. 0.433 kVMCCB DB shall be floor standing, sheet steel enclosed with Form – IV enclosure as per IS 8623 with Air circuit breakers/MCCB's, Control & Protection. The PCC shall be rated for a fault current not less than 50 KA.

1737. Each motor shall be provided with a press to lock and twist to release type local emergency stop button with mushroom head.

1738. Each Motor starter feeder shall have local start, stop push button with indicating lamp.

1739. **Submersible pumps.** Submersible pumps shall be provided with the following additional protection:

- Run dry protection, moisture entry protection and over temperature protection.

1740. **Positive displacement pumps.** Positive displacement pumps shall be provided with the following additional protection:

- Over pressure protection.

1741. **Blowers.** Blowers shall be provided with the following additional protection:

- Over pressure.

1742. **Rotating arm drives.** Rotating arm drives shall be provided with the following additional protection:

- Motion detectors;
- Over torque detectors.

1743. **Valve actuator drives.** Valve actuator drives shall be provided with the following additional protection:

- Over torque detectors
- Linier valve position indicator.

Dosing pumps

- Suitable for PLC operation.

Sampling pumps

- Suitable for instrumentation.

1744. **Operation logic of switchgears.** Under normal condition, the entire plant shall be fed from the Grid Mains to all the transformers.

1745. **Operation Logic of 0.433 kV Metal enclosed Switchboard at CWPS at WTP Substation**. Under normal condition, Transformer -1, Transformer -2 will be 'On' for bus section 1 and bus section 2 respectively.Each bus section shall be capable of operating 3

motors at a time.In case of failure of Transformer-1, Transformer 1 is made 'Off' and bus coupler made 'On' such that transformer 2 capable of operating 4 motors at a time from bus section 2.In case of failure of Transformer-2, Transformer 2 is made 'Off' and bus coupler made 'On' such that transformer 1 capable of operating 4 motors at a time from bus section 1.

1746. **Operation Logic of 0.433 kV metal Enclosed MCCB DB.**At normal condition, both the incomers shall be in closed position and Bus coupler shall be in open position. If any incomer fails, the faulty incomer will be in open position and the healthy incomer and Bus coupler shall be in closed position.

1747. **MV&LT capacitor bank and power factor correction.** The capacitor banks provided shall be of bus connected type with Automatic Power factor correction, the system shall be designed such that a power factor of not less than 0.98 is maintained.

1748. Automatically controlled multistage power factor correction shall be provided. 2 Nos. 0.433 kV APFC panels providing no less than 4 No PFC stages per panel shall be provided each connected to each bus section of the 0.433 kV distribution board. The PF on each half of the board shall be monitored and corresponding PFC capacitors switched in and out automatically in discrete stages in order to maintain a set point PF value.

1749. Automatically controlled multistage power factor correction shall be provided. 2 Nos. 0.433 kV APFC panels providing no less than 4 to 8 No PFC stages per panel shall be provided each connected to each bus section of the 0.433 kV MCCB DB. The PF on each half of the board shall be monitored and corresponding PFC capacitors switched in and out automatically in discrete stages in order to maintain a set point PF value.

1750. 0.433 kV Motor capacitors of suitable values shall be connected parallel to the MV motors. Design calculations shall be submitted by the Contractor for approval.

1751. **DC power supply.** DC Power supply shall be provided for protection and control in 33 kV, 0.433 kV Switchgears 0.433 kV neutral soft starters, 0.433 kV Motor Capacitors, and for DC emergency lighting.

1752. A Conventional system operating at 110V DC using maintenance free rechargeable Ni-Cd batteries shall be provided and shall be complete with battery, battery charger with boost & trickle charging facilities, necessary controls, indications and emergency lighting. In the DC distribution board with LED indication and MCB for individual feeders.

1753. **HV/MV power cables.** HV cables shall be 3 core, 33 XLPE type with aluminium conductors & GI armoring. Minimum size of cable shall be selected based on the short circuit considerations.

1754. **LV power cables.** LV multi core cables for use on 1.1 kV V and 240 V power supply system shall be XLPE type with aluminium conductors for sizes 6 sqmm and above and Copper Conductors for sizes below 6 sqmm.

1755. **Cable rating.** All power cables shall be sized for continuous current carrying capacity and permissible voltage drop at an ambient temperature of 45 degrees C. Due consideration shall be taken of cable grouping, method of installation and local variations in ambient conditions. Further, for cables controlled by circuit breakers, due consideration shall be given to the fault level.

1756. HV, MV and LV cables shall be sized for a minimum fault clearance time of 1 second for incoming feeders and for outgoing as per fault level at outgoing location.

1757. For all LT Cables, the voltage drop in the cables between the transformer and the switchgear (MCCB DB) or between MCCB DB and Motor terminals for full load current shall be limited to 3%. The total voltage drop transformer secondary to motor terminal shall be limited to 5%.

1758. Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%.

1759. **Ventilation/ceiling fans.** Variable speed ventilation / ceiling fans shall be provided in offices, conference rooms, laboratories, control rooms, control areas and switchgear rooms. One fan shall be provided for each 10 m^2 or part thereof of the area concerned.Where fitted ceiling fans shall be connected to the local lighting circuit.

1760. **Small power outlets.** Switched single phase three pin 5A and 15A receptacles shall be provided throughout. In offices and control rooms they shall be the decorative type and industrial type in all other areas.

1761. Unless required to be provided in greater numbers to power specific Plant items the number of such outlets shall be as follows:

- 5 A type one outlet per 5 m or part thereof of perimeter in offices and laboratories;
- 5 A type one outlet per 20 m or part thereof of perimeter in all other areas;
- 15 A type one outlet per 20 m or part thereof of perimeter in offices and laboratories;
- 15 A type one outlet per 20 m or part thereof of perimeter in all other areas.

1762. **Industrial socket outlet.** 20 A switched three phase and neutral receptacles with plug top shall be provided in plant areas where appropriate i.e. adjacent to areas where flooding is likely (to permit the use of portable sump pumps) or where other portable equipment is likely to be used in the operation of the Pump House. The Contractor shall install ten such outlets at various locations throughout the Water pump House.

1763. Receptacles for outside areas shall have a degree of protection of IP 55.

1764. **System earthing.** An earthing system comprising earth electrodes and conductors shall be established for Water Treatment Plant / Pumping Station.

1765. The earthing system will be designed to give a combined earth resistance value of not greater than 1 ohm. In order to be sure of obtaining suitable final values, soil resistivity shall be measured at the various site locations during the detailed design phase of the work.

1766. In outdoor substation areas the main earth electrode conductors shall be located, to ensure potential gradients occurring at the surface during fault conditions are kept within allowable limits.

1767. Materials used for earth electrodes shall be designed to suit the ground conditions and shall either be plain mild steel or Galvanized steel.

1768. The system shall be designed for the following maximum earth fault currents. These values will be confirmed at the detailed design phase.

- 33 kV 26.25 kA.
- 0.433 kV V system 50 kA.

1769. The Max.fault clearing time shall be taken as 1 second for the 33 kV and 0.433 kV systems.

1770. The maximum temperature allowed for steel welded joints will be taken as 50 degrees C with an ambient of 45^{o} C. Main equipotential bonding conductors shall be galvanized steel.

1771. Circuit protective conductors will comprise either the armoring of the supply cable or, for major loads such as main switchboards and large drives the supply cabling plus an additional suitably sized single core copper cable.

1772. The neutral point of the 33 / 0.433 kV transformer secondary windings shall be solidly earthed. If the Neutral fault current exceeds full load current of the transformer, suitable neutral resistance to be added to limit the current to FLC.

The neutral point of the 33 / 0.433 kV transformer secondary windings shall be solidly earthed.

3. Instrumentation, Automation and Control Systems

a. General

1773. This section of specifications defines the general requirements of the instrumentation elements and the control systems to be installed at the Intake Structure (Raw Water Pump Station), Settled Water Pumping Station, Water Treatment Plant (WTP) & Clear Water Pump Station (CWPS). For selection of field instruments and control systems and associated items, the Contractor shall comply with the specifications contained herein.

1774. Irrespective of the specifications for the instrumentation and control related items, the Contractor shall be required to provide all equipment, accessories, cabling, earthing, necessary transducers/sensors, system hardware/software, programming logic, etc. to achieve the functional requirements described in this document and as shown in the drawings. The civil and electromechanical work associated with the installation of the instrumentation equipment shall be part of the Contractor's scope.

1775. The integrated control systems for the Raw Water Pumping Station (RWPS), Settled Water Pumping Station, Water Treatment Plant (WTP) and Clear Water Pumping Station (CWPS) shall be based on the use of Programmable Logic Controllers (PLCs). The various modes of controls shall be (i) Auto, (ii) Semi-automatic and (iii) Manual. In the event of failure of the automatic sequencing or by operator choice, it shall be possible to revert to manual operation of each item of Plant independent of the PLC functions, based on the hard wiring of essential relays, measurements and control switches as specified in the respective unit's Functional Design Specifications (FDS) for operation and control of the individual units.

1776. The optimal operation of the system shall be achieved by well-coordinated application of:

a. Hydraulic monitoring and control
b. Process monitoring and control
c. Equipment monitoring and control
d. Emergency responses
e. Minimizing energy, chemical and labour costs

1777. There shall a Local PC based supervisory control and data acquisition (SCADA) system with its control center in the Control Room in Administration Building. Remote monitoring and remote operation capabilities shall be provided from this local SCADA system. This local SCADA system shall be configured to interface with a Master SCADA system serving the Employer's entire water supply network in the future for centralized monitoring and limited remote operations of all the water supply works of Bhagalpur City. The Local SCADA systems and the PLCs shall be capable of interfacing and networking with the future Master SCADA system.

1778. **Control systems.** Programmable Logic Controllers (PLCs) should be provided for automatic operation of the following systems/processes, with the local SCADA system having remote supervisory control over local equipment and PLC set point:

- Raw water intake pumping station and transmission pipeline
- Pre-settling basins, and pre-settled raw water pumping station and transmission pipeline
- Pre-treatment systems (flow split, chemical dosing, flash mixing, flocculation, and settling)
- Filtration system, including backwash pumps

- Sludge handling system, including dewatering system
- Clear well pump station, with pump control based on main reservoir water levels

  Note:The PLC software and control system hardware shall be designed to allow an upgrade to fully automatic control in the future, but the control system for Phase 1 shall be configured to allow semi-automatic or manual control only. The automatic control systems referred to in the above paragraphs shall be configured for semi-automatic operation (manual initiation of the automatic sequence) in this project.

1779. Semi-automatic control shall be defined as an automatic control sequence that must be manually initiated to start.

1780. 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 a HV failure as well as the control system power failure (i.e. this requirement refers to a real failure of power to the control system, as would be experienced if the control system UPSs were not functioning).

1781. In the event of a power failure, from the local utility's supply, or a failure of the semi-automatic controls, systems operating in the semi-automatic shall not be restarted automatically, but their failure condition shall be alarmed to signal the need for a manual restart.

1782. The field instrumentation shall also form an integral part of the control system and shall be configured by a system integrator.

1783. **Central monitoring and control requirements.** As stated earlier, the Local SCADA systems and the PLCs shall be capable of interfacing and networking with the future Master SCADA system. It is required that Local SCADA system will provide real-time data acquisition and monitoring of the following, as a minimum, to the central SCADA system after interfacing:

- Raw Water Intake Pumping Station, including the operating status of all pumps (on/off, duty/standby, temperature, etc.), discharge header pressure, valve positions, and raw water flows.
- Clear Well Pumping Station, Settled Water Pumping Station including operating status of pumps (on/off, lead/lag/standby, temperature, etc.), water level in the clear well, valve positions, suction and discharge header pressure, and treated water flows leaving the WTP (going to the main reservoir).
- Treated Water Quality (within or after the clear well), including online measurements of pH, alkalinity, turbidity, and residual chlorine concentrations.
- Water flows at critical locations through the treated water transmission system, including all pipeline branch points that lead to each of the service/distribution reservoirs.
- Water flows arriving at each reservoir.

b. Design Requirements of Instrumentation and Control (I & C) Systems

1784. **Basic design features.** Instrumentation, control, automation human-machine interfaces (HMIs) and SCADA systems shall be designed, manufactured and installed to achieve the following basic requirements:

a. To maintain the highest standards of availability, reliability and accuracy and to give clear warnings of any deterioration in performance
b. To suit the abilities of the staff who will use the systems and service the systems
c. To measure, indicate, process, store and control the relevant parameters, as specified
d. To give clear warnings of dangerous and other abnormal conditions and to initiate plant safety procedures, shutdowns and corrective measures as specified to assure the safety of operations and maintenance (O&M) personnel and plant and to store and collate the data, as required
e. To derive, present and utilize, as required, such additional data as required to facilitate:
   (i) the most efficient operation of the plant;
   (ii) the routine maintenance of the plant.

1785. **General requirements.** The Instrumentation and Control systems shall be designed, manufactured, installed and tested by an experienced system integrator to ensure high standards of operational reliability. Instruments mounted in the field and in panels shall be suitable for continuous operation. All electronic components shall be adequately rated and their circuits shall be designed so that a change in component characteristics shall not affect plant operation.

1786. All I&C equipment shall be new, of proven design, of a reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be specifically designed for the hot humid conditions prevalent in Bhagalpur. The outdoor equipment shall be designed to withstand tropical rain and temperature variation from 0 to50^{o} 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 rooms shall be designed to function at 45^{o}C and the instruments in sheltered places outside the control room shall be rated for 45^{o} C.

1787. Instruments shall have the following basic design attributes:
a. Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., which shall be of proven design.
b. For transmitting instruments, the output signal shall be a 4-20 mA DC linear signal in a two (2) wire system.
c. Unless otherwise stated, overall accuracy of all measurement systemsshall be ±1% of measured value, and repeatability shall be ±0.5%.
d. The performance of all instruments shall be unaffected for a ±10% variation in power supply voltage and a ±5% variation in frequency, occurring simultaneously.
e. After a power failure, when the local utility's power supply resumes, the instruments and associated equipment shall start working automatically.
f. The instruments shall be designed to permit maximum interchange ability of parts and ease of access during inspection and maintenance.

g. Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof protected for ingress to IP 65 standard.
h. The instruments shall be designed to work at the extremes of the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be protected against corrosion.
i. All wetted parts of sensors shall be made out of non-corrosive materials capable of operating with the chlorine content in the fluid being measured at 5 ppm.
j. Lockable enclosures shall be provided for the field mounted instruments.
k. All field instruments and panel-mounted instruments shall have tag plates permanently attached to them.
l. For all instruments (transmitting analogue signals) installed in the field, surge protection devices (SPDs) shall be provided at both ends of the connecting cable for the protection against static discharges, lightning and electromagnetic interference.
m. Pressure transmitters shall be provided with a two (2) valve manifold and a test port, so that in-situ calibration can be performed.
n. Two wire transmitters shall be provided with on-line test terminals.
o. The ranges of all instruments shall be suitable for their specific application in the process, plus an allowance for an additional 25% of scale.
p. Instruments of similar type shall be of same make by a single manufacturer to simplify the inventory of spares, and for the standardization of maintenance and training.
q. The Indian agents of imported equipment shall have established after sales maintenance facilities and shall have the capacity to provide service from inside the country.
r. The Local SCADA system shall be housed in an air conditioned, dust free Control Room.
s. Local manual controls shall be located adjacent to the equipment for which they are associated, to facilitate operation, maintenance and troubleshooting.

1788. All drives essential for the continuous operation of the plant shall be provided with at least one (1) installed standby.

1789. **Erection requirements.** Locally mounted instruments shall be installed on appropriately sized rigid supports, designed to transmit minimum vibrations. The instruments shall be installed away from hot objects.

1790. Instruments shall be protected against physical damage or liquid splashing by providing metallic or fiberglass enclosures or canopies.

1791. All transmitters and transducers shall be installed nearest to the sensing point and at a place convenient to access for maintenance. Field instruments (i.e. the instruments mounted outside of a control panel) shall be mounted at a convenient height of approximately 1.5 m above grade or finished floor level.

1792. While installing an instrument, provision shall be made to carry out in-situ calibration.

1793. Isolation valves and drain valves shall be provided for the field instruments wherever required.

1794. Instrumentation cables shall be separated 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 sealing the cable in field instruments and in the instrument control panel.

1795. A non-corrosive metallic tag number plate shall be provided for each instrument.

c. Reference Standards

1796. 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.

Table 93: Reference Standards

Standard No.	Brief Description
BS 89-2:1990, EN 60051-2:1989, IEC 60051-2:1984	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS 1042 (Various)	Measurement of fluid flow in closed conduits.
BS 1646-1:1979, ISO3511/I-1977	Symbolic representation for process measurement control functions and instrumentation.
BS EN 837-1:1998	Bourdon tube type pressure gauges. Dimensions, metrology, requirements and testing
BS EN 60751:1996, IEC 60751:1983	Industrial platinum resistance thermometer sensors
BS 3680	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analog indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	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	Instrumentation cables
BS EN 60529:1992	Specification for degrees of ingress protection provided by enclosures (IP codes)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying flow meter 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 and 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	Specification for graphical symbols for general engineering.
ISA-5.1-1984 - (R1992)	Instrumentation Symbols and Identification.
ISA-5.4-1991	Instrument Loop Diagrams.
ANSI/ISA-7.0.01-1996	Quality Standard for Instrument Air.
ANSI/ISA-18.1-1979 - (R1992)	Annunciator Sequences and Specifications
ISA-26-1968	Dynamic Response Testing of Process Control Instrumentation.
ISA-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology.

Standard No.	Brief Description
ISA-37.3-1982 - (R1995)	Specifications and Tests for Strain Gage Pressure Transducers.
ANSI/ISA-50.00.01-1975 (R2002)	Compatibility of Analog Signals for Electronic Industrial Process Instruments.
ANSI/ISA-51.1-1979 - (R1993)	Process Instrumentation Terminology.
ISO 9000 and 09004	Quality Systems.
IEEE 60587	Power Supply Surge Protection.
IEC 61131-3	Programming Languages for Programmable Controllers.
IEC 61158-2	Communication Protocols.
ISO 9075 (BS 6964)	Structured Query Language (SQL).
BS 5515	Documentation of Computer Based Systems
BS 7165	Recommendation for Achievement of Quality in Software
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Process measurement control functions - instrumentation symbolic representation.
ISO-OSI	7 Layer Communication Model.
IEEE 472-1974	Surge protection.
IEC-61850	Sub-station automation protocol.
IEC-8705101	Modbus Protocol Conversion.

1797. **Statement of compliance.** The Contractor shall provide a list of the reference standards used and shall provide a compliance/non-compliance statement during the Functional Design Specification (FDS) submission once the Contract has been awarded. The Contractor shall submit the statement above in his Technical Bid. Failure to submit the Statement will be treated as non-responsible bid.

1798. 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 Employer's Representative for his consent before any design utilizing that standard proceeds.

d. Documents to be submiited [refer to Section 2/ITB 11.1 (l)]

1799. The following documentation shall be included with the Contractor'sBid:

a. Provide a block diagram of the proposed system showing all major components and their interconnections and interrelationships. Label each diagram and indicate all external power and communications interfaces.
b. Provide a brief written overview of the proposed SCADA system describing the principal functions and capabilities of the system's PC, PLC's, system communications and general system capabilities.
c. Provide an equipment list of the major equipment and hardware items with descriptive literature.
d. Provide an operating system and software applications list with descriptive literature for the proposed system. Include all major software items and the supplier's name. Indicate that any proposed software is not proprietary and will be turned over to the Employer.

Note: Proprietary software shall not be accepted.

1800. The Contractor shall provide the above required details/documents as qualification criteria during the bid submission. Failure to do so will be treated as a non-responsive bid and lead to technical disqualification.

1801. The following documentation shall be included with the Contractor's Functional Design Specification:

a. Name and version of the proposed PC's operating system.
b. Name and version of the proposed graphical user interface software package (SCADA).
c. Name and version of the PLC on-line/off-line programming software for all controllers.
d. Name and version of any required communications software, firmware, etc.
e. Name and version of the specified report application and operational data management software.
f. Name and version of the specified maintenance application software.
g. Describe how system data points are linked from the system database into various applications such as reporting or maintenance. If via Dynamic Data Exchange (DDE) describe specifically the steps required to import data automatically and on-line into the proposed software applications.
h. Describe the required procedure for configuration and/or programming of the proposed system to add a simple remote PLC and additional I/O's to the system in the future. Describe in detail, specifically how communications will be programmed for a future remote PLC and the necessary changes required at the main controller.
i. Provide a description of any non-resident software required to program, troubleshoot or diagnose any devices in the system.
j. Provide a tentative construction schedule for completion of the project within the specified Contract period. Indicate the following activities with milestones: Mobilization, radio communications licensing, submittal preparation, submittal review, equipment procurement, equipment assembly, system configuration and programming, factory testing, system delivery, system installation, start up, field testing and training, and post acceptance routine service intervals.
k. Describe the system supplier's provisions for service, technical assistance and re-placement parts for the proposed system. Include the system supplier's toll free number, when available. Identify with resumes, all personnel who will be providing technical support services for the project after it is accepted.

e. Qualification Criteria for Instrumentation Vendors and Integrators

1802. The Manufacturers shall be operating under an accredited ISO 9001 or above Quality System. All hardware shall be of the most current technology and versions from the manufacturer.

1803. The instrumentation supplier shall have a minimum 10 years of experience in India in the field of instrument supply and service. They shall have branch locally for service support at Bhagalpur and shall supply only internationally reputed brands.

1804. The SCADA /Automation sub Contractor shall be a reputed system manufacturer or system integrator with a minimum of 10 years of experience in executed instrumentation/control/automation projects and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution. They shall have a local branch for service support at Bhagalpur.

1805. The system supplier shall be an authorized system integrator for the named PLC hardware and SCADA software supplier. Verification certificates shall be submitted directly

from the manufacturer of the PLC hardware and SCADA software supplier. In addition, the system supplier shall submit references for a minimum of five (5) locations where the automation equipment has been successfully installed, including the name, address and telephone number for the appropriate owner's representative to contact.

1806. The system supplier must submit evidence that they employ no less than 15 technical staff to include engineers, programmers, and field technicians. Submit the qualifications for a minimum of five (5) professionals in the direct employ of the system supplier who may be assigned this Project.

1807. All hardware and software proposed shall have been successfully used in a similar water supply application for a period of at least five (5) years and shall be from established and reputable suppliers.

1808. Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost. These shall include all hardware and software necessary to implement the upgrade.

f. System Architecture

1809. The central control room located in the Administration Building shall provide the primary operator interface with the PLC systems and other field instrumentation for real time data acquisition and control functions. The central control room monitors all WTP, intake and reservoir operation and provides a centralized point for the operation of the WTP. It shall provide the following functions:

a. Status information of process equipment, automatic sequencing and primary elements
b. Plant-wide alarm reporting
c. Limited supervisory control of plant processes
d. Printing operational reports and graph
e. Real time trending of process variables

1810. The unit control station consists of a PC with monitor, keyboard & printers. All plant operations are through keyboard & monitor. The PC's server maintains I/O & control database for the system and coordination of all system functions.

1811. **Area control stations.** PLCs shall be installed in and configured to interface with following important areas:

- Raw water intake pumping station and transmission pipeline
- Pre-settling basins, and pre-settled raw water pumping station and transmission pipeline
- Pre-treatment systems (flow split, chemical dosing, flash mixing, flocculation, and settling)
- Filtration system, including backwash pumps
- Sludge handling system, including dewatering system
- Clear well pump station, with pump control based on main reservoir water levels

1812. All field devices shall be connected to their respective PLCs through I/O modules. PLCs shall be interconnected on dual redundant data highway lines.

1813. Real time control of all field devices such as pumps, valves etc. shall be achieved through PLCs for implementation of interlocks, safety startups and shutdown.

1814. Monitoring and control is possible locally through the PLC's panel view in case of SCADA failure.

1815. **Operator workstations.** An operator workstation / terminal shall be provided at each area control station. This terminal shall be connected directly to the PLC liable to only control functions of the concerned area.

1816. **Local control panels.** Local control panel is provided in the form of direct manual operation at the field via conventional push buttons, selector switches, etc. mounted near the ancillaries. The local control is independent of the PLC, even if they share the same control panel, so that plant can be operated manually if the PLC fails.

1817. **Management Information System (MIS).** A separate system shall be provided for information management besides monitoring and control functions. The MIS shall be capable of the following functions.

a. Long term historical storage of process data
b. Trending and graphical plots of historical data
c. Report generation capability
d. Preventive maintenance management
e. Inventory control
f. Plant operation summaries
g. Plant maintenance logs and schedules
h. Personal Management

1818. Three (3) MIS workstations shall be provided: one at the Raw Water Pump Station; one at Control Room of Administration Building; and one at a convenient place to be determined in WTP.

g. Programmable Logic Controller (PLC)

1819. **Codes and standards.** The design material, construction features, manufacture, inspection and testing of Programmable Logic Controllers shall comply with all currently applicable statutes, regulations and safety 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.

1820. **Design and construction requirements.** Programmable systems based on operational logic shall be employed to provide safe and automatic operation of the pumping station and other equipment system specified to operate in an "Auto" or "Semi-automatic" mode. PLC's shall be provided as standalone controllers to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities, at each location.

1821. A PLC shall consist of the necessary processors, Input/output (I/O) modules, communication interface modules and man-machine interfaces (HMIs) required to perform the desired functions.

1822. Each PLC shall have the following attributes as a standalone controller:

a. It shall carry out sequential start/stop logic implementation for operation of the equipment.
b. It shall carry out computations and interfacing for data acquisition, data storage and retrieval.
c. It shall accept downloaded programs from a programmer.
d. It shall have different functional modules to perform the desired functions.
e. It shall scan the inputs in time cycles and update the status of inputs and outputs.
f. To avoid spurious outputs because of failure of an output module, all commands shall be associated with release signals. Release signals shall include information on the condition of the hardware, software and power supply modules.
g. It shall have relays, counters and timer functions, internal registers, alert flags, watch dog timers, set/reset functions, etc.
h. It shall have provision for spare input and output modules.
i. It shall be configured with a hot-standby CPU
j. It shall be dedicated to specific control areas

1823. The PLC system shall be expandable and shall be modular in construction so as to carry out the future expansion without any hardware modifications.

1824. The PLCs shall have analog and digital signal monitoring capability for checking the healthiness of the signals. In case of detection of any unhealthy signal a "PLC Trouble" alarm shall be generated. In case of failure of a PLC, the status of all the outputs of the PLC shall stay put.

1825. Each PLC shall be a 32 bit microprocessor based system with state of the art technology. System components shall be carefully chosen so that the reliability of the PLC shall be as high as possible within the industry. PLCs shall use open standard bus protocols and structures for all communication within and outside the system.

1826. In case of system failure or power supply failure all the outputs shall attain pre-determined fail safe conditions. Spurious signals shall not effect equipment operation. ‘Check back before execution’ features shall be incorporated.

1827. The PLC to be provided shall have a proven record in the type of application concerned and in the prevailing environmental conditions. It shall be possible to perform the simulation operational functions while testing the program by changing the status of contacts and monitoring the output.

1828. The PLC system shall support ‘hot swapping’ of I/O modules (i.e., removal and insertion of I/O modules under a ‘power-on’ condition).

1829. The design of the system configuration and development of the PLC software shall be undertaken by the PLC manufacturer or a System Integrator authorized by the PLC manufacturer. They shall have previous experience in similar applications and shall have a service center at a reasonable distance from the Project Site so as to provide service with a short notice.

1830. **Technical particulars.** Each PLC shall be designed to comply with the following technical parameters:

Table 94: PLC Technical Parameters

Parameter / Item	Particular
Functions	As per the control logic and input/output list
Future Expandability	Provide an additional 50% of installed capacity
Interposing Relays	Shall be provided for all digital outputs (Dos) including spare Dos 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 a viewing glass on the door
CPU and power supply module redundancy	Required (In hot standby mode)
Processor:	
Diagnostic function performance	Required
Minimum 32 bit performance with floating point capability	Required
Memory module	Adequate to store programs, standard software to perform logic functions and diagnostic functions
Inputs and Outputs	Refer to the I/O schedule in the respective subsections of this Volume
System Loading	Max. 60% under the worst loading conditions
Power supply to sensor / transmitters	230v, 1ph, 50hz with a UPS back-up
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 signals as required.
Spare I/O modules	20% of each type, wired to terminal block
Accessories	(i) Laptop computer for programming along with all necessary adapters, carrying kit, cables, connectors and accessories (2 shall be furnished for common usage) (ii) 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 the 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 indicators and totalizers	Required

1831. **Central processing unit (CPU).** The Central Processing Unit shall have a high performance processor with modular configuration suitable for real time process. The features of the CPU shall include: high inherent reliability, self-checking, error-recovery and trouble-shooting.

1832. Communication between the CPU and peripherals shall be by an I/O bus. The individual devices shall be capable of being plugged into the I/O bus.

1833. Each CPU shall have a real time clock capability to accept a time synchronization pulse from an external communication system, with the ability to adjust its internal clock with the pulse.

1834. Each CPU shall have extensive self-diagnostic facilities and watch dog timers to identify faults at card levels.

1835. The CPU word length shall be 32 bit or more. Each CPU shall have at least 50% spare capacity after the commissioning of the application.

1836. Automatic restart of the system on resumption of power shall be provided.

1837. **Memory Unit.** Each Memory Unit shall consist of highly reliable memory chips which are the industry standard, of proven design with fast random access and suitable for operation in process environments. Main memory units shall be modular and a facility shall be provided for upgrading and expansion of memory to meet future demands.

1838. Sufficient program memory and data memory space shall be provided. At least 50% extra memory space shall be provided over the actual requirements. System initialization and application software shall be stored in EEPROM or EPROM with the necessary hardware provided.

1839. Running data shall be stored in a RAM with internal battery back-up. The battery back-up provided shall last for at least 30 days with the life of battery a minimum of 3 years.

1840. Appropriate programs for application software modification shall be provided.

1841. **Input/Output modules.** Standard rack mounted I/O modules with plug-in cards shall be provided. Field wiring shall be terminated in screwed terminal blocks and interconnected to the processor's I/O system with pre-fabricated cables and plug-in card type connectors.

1842. Twenty percent (20%) additional I/Os above the installed capacity for each type shall be provided as spares and shall be wired to the terminal block of the control panel. Provision shall be made for future expansion of extra I/O modules of the installed capacity.

1843. Some of the common features of the I/O modules shall be as follows:

a. All inputs shall be terminated with an input protective network and necessary isolating barriers.
b. Filters for noise rejection shall be provided.
c. Provision for isolation of faulty channels shall be provided.
d. Input /output status shall be indicated by LEDs.
e. Test points and fault indication LEDs shall be provided to carry out module testing.
f. A surge withstand facility shall be provided as per IEEE standards.
g. All of the modules shall be of the addressable type.
h. Protection for continuous overload up to 20% of all input ranges shall be provided.
i. All outputs shall be provided with fuse protection and fuse failure detection. The fuses may be mounted externally from the output module.

j. The I/O modules shall have diagnostic features. In case of the failure of any I/O channel an alarm "PLC Trouble" shall be generated automatically.
k. Internal battery back-up shall be provided.

1844. Analog input modules shall consist of an input isolation unit, signal conditioning unit and an analog to digital converter (ADC). In addition, the following features shall be provided:

a. Cross talk attenuation.
b. Provision for monitoring of the ADC for overflow detection.
c. Gain amplifier with high common mode rejection ratio.
d. Accuracy for analog signals shall be a minimum + 0.5%.
e. Screwed terminals with fuse and LED for indication of 'fuse blown' shall be provided for each analog input.

1845. The following design features shall be provided for digital input modules:

a. Contact bounce protection.
b. Choice of type of contacts.
c. Screwed terminals with fuse and LED for indication of 'fuse blown' shall be provided for each digital input.

1846. The digital output module shall provide a contact closure output by driving relays. The features to be provided are as follows:

a. Contact bounce protection.
b. Relay output to operate motors and motorized valve actuators.
c. Fail safe position in case of output module failure and fault indication.

1847. The digital input and digital output modules shall not have more than 16 channels in each module. The analog input modules shall not have more than 8 channels in each module.

1848. **Default values.** Every operator selectable parameter shall be provided with a default value held in EPROM or EEPROM in the relevant PLC.

1849. The default value shall be used if no other value has been entered at the PLC or 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.

1850. Sensible and logical default values shall be inserted prior to the start of system tests. The default values at the time of commissioning of the plant shall be those found operationally suitable during pre-commissioning testing.

1851. The PLCs shall make available for interrogation by the local SCADA information corresponding to the following PLC faults:

a. Failure of the PLC as indicated by the PLC watchdog relay
b. Failure of each I/O card
c. Failure of the communication link
d. Status of the 24V DC power supply for the I&C system

1852. **Software.** The on-line real time operating system supplied shall be proven in similar applications and shall be able to support all the equipment and peripherals.

1853. PLC programming shall be performed using the latest available industrial standard formats for logic. The PLC programming shall be prepared using the PLC manufacturer's recommended Windows based PLC coding and documentation software. The PLC code shall be structured in the manner of the best and latest industry standard and shall have comprehensive subroutine and rung annotation. Ladder programs shall be used.

1854. The PLC shall be commissioned using RAM memory storage modules which shall be replaced with an erasable programmable read only memory (EPROM) or electrically erasable programmable read only memory (EEPROM) when testing is complete.

1855. **Programming units.** The Contractor shall supply two (2) laptop computers (common for use at the RWPS and WTP) preloaded with the required software. The configuration of each laptop PC shall be latest available at the time of execution of Contract.

1856. The licensed copies of the various software shall be provided which will include software for programming the operating system for the PLC, proprietary PLC programming and documentation, SCADA application, the latest Windows Office software, the latest Antivirus software, the latest Adobe Acrobat Reader and Diagnostics software.

1857. Each laptop computer shall be provided with all necessary adapters, 2 power cords, 2 batteries, a carrying case, cables, connectors and other accessories.

1858. The proprietary PLC programming and documentation software shall have facilities for:

a. Performing program revision management
b. Inserting comprehensive program subroutines and rung comments
c. Search and find and search and replace 'contacts' and 'coils'
d. Simulation functions and testing of the program by changing the status of contacts and monitoring the outputs
e. Preparation of a coil and contact list and their locations and memory maps.
f. Making system backup copies while the system is online
g. Uploading and downloading programs to the PLC while it is on-line
h. Performing on-line monitoring and fault finding on the PLC.

1859. The configuration details for the laptop computers shall be as follows:

Table 95: Laptop Configuration Details

Item / Accessory	Specification / Particulars
CPU Type	C2D @ 2.20 (6600) / Core i3 @ 2.13 (330M)
CPU Speed	2.20 Ghz / 2.13 Ghz
Main Memory	3GB / 4GB
Hard Disk	320 GB
Optical Drive	DVDRW / LS-DVDRW
Graphic	Media Accelerator 4500M / Intel GMS HD
Integrated	56 kbps internal modem, 10/100 Mbps Ethernet LAN Interface Card IEEE 802.3, 16 bit sound card with speaker, 128 bit graphic accelerator, graphics controller with 4X AGP 16 MB RAM, Wireless networking

Item / Accessory	Specification / Particulars
Communication	10/100/1000 Ethernet
Display	15.4''
Power Supply	9 Cell Battery
Interface	Wireless Networking, all standard interfaces namely Bluetooth, Card Reader, Web Cam,
Accessories	Adaptor, power cords, LAN cable, Carry Case etc.

1860. **Operator workstation (OWS).** OWS shall be provided for the PLC system on the front facia of the control panel.

1861. Each OWS shall consist of a panel mounted industrial grade unit with Colour LCD screen and a tactile key pad. It shall be environmentally protected and designed for plant room use with a 'wipe clean' finish.

1862. Each OWS shall provide facilities to:

a. Display the status of Plant in a graphical and tabular format (i.e. running, stopped, fault etc.)
b. Display analog values on the appropriate graphic screen (displays shall change Colour when in fault conditions or when data is suspect);
c. Annunciate alarms associated with the area of the plant concerned including details of the time the alarm occurred
d. Provide facilities for the operator to:

(i) adjust process set points
(ii) select process modes
(iii) select the number of running (duty) units
(iv) provide all other facilities required for operation of the Plant
(v) acknowledge alarms
(vi) view a journal of unacknowledged alarms
(vii) view a journal of the alarms acknowledged
(viii) Display process set points
(ix) Display a total running hours log of equipment motors
(x) Provide real time and historical data
(xi) Any additional features required to assist in the effective and efficient operation of the plant
(xii) Security systems shall be provided to prevent unauthorized adjustment of process set points.

e. Graphic screens shall be provided as follows:

(i) Layered main and subsystem menus
(ii) System overview (i.e. providing details such as No. of units running, total flows, sump or tank level, discharge pressure, control valve position, 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 system equipment status and values
(vi) Running hours log for equipment

(vii) 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.

(viii) 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 the system returned to normal.

1863. **Test for PLCs.** The following tests shall be performed on each PLC:

a. Scanning rate check for analog signals
b. Scanning rate check for digital signals
c. PLC cycle time check
d. Processor redundancy check
e. Power supply redundancy check
f. Processor failure alarm check
g. Power supply failure alarm check
h. Card level failure detection check
i. Failsafe output check on the failure of output modules
j. Sensor failure detection check
k. Status indication check for the condition of each input/output channel and module
l. Status indication check for the power supply for each module
m. Isolation check for each input/output module
n. Input filtering check for noise level
o. Battery back-up check for the processor
p. Controller functioning check for under-voltage and over-voltage
q. Ladder logic program check by simulation of inputs and outputs
r. Functional check of the programming units

1864. **Acceptable PLC manufacturers.** Acceptable manufacturers of the PLC system are Rockwell Automation, Schneider, Siemens, Tata Honeywell, or equivalent as approved by Employer's Representative.

h. PC Based Local SCADA System

1865. The SCADA 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 on a limited basis, provide configuration tools and operate diagnostic facilities from Operator Workstations (OWs) and Engineer Workstations (EWs), after successful log-on with a security password.

1866. The SCADA system shall perform all of the necessary functions for the monitoring, control and operation of the entire system. The SCADA system shall have the ability and functioning to facilitate remote operation of all pieces of major equipment in the Plant. Major equipment shall include all process pumps, mixers, blowers, flocculators, scrapers, thickener mechanisms, motorized valves/gates and chemical feed systems. It does not include EOT cranes, lighting systems and most ventilation equipment including air conditioners. The

ability shall be provided for authorized supervisory staff of the Employer to lockout the remote operation function of any major equipment item.

1867. **SCADA system equipment.** The SCADA system shall have a human-machine interface consisting of a personal computer(PC) based system. The SCADA system shall consist of an industrially rugged PC with a high performance processor with modular configuration suitable for real time process applications. The SCADA system shall consist of following:

a. Widescreen LCD Monitor (32 inch)
   (i) Nominal dimensions: 790 mm wide x 480 mm high x 130 mm deep
   (ii) Minimum resolution: 1366 x 768
   (iii) PC interface: DVI, VGA (HD-15)
   (iv) Technology: TFT active matrix
   (v) HDCP compatible: Yes
   (vi) Sound output: Stereo
   (vii) Accessories: Wall mount kit with a tilt wall plate.

b. Printers
   (i) 1 – 132 column printer shall be provided for on-line printing of alarms and event logging.
      (a) 240 x 288 dpi
      (b) 1,200 lines per minute
      (c) Connects via serial and parallel ports
   (ii) 1 – A3 size Colour graphic laser printer shall be provided for report generation and Colour screen printing.
      (a) 2400 x 600 dpi
      (b) 20 pages per minute minimum in Colour mode
      (c) 2 trays at 500 sheet capacity each
      (d) 1.4 GB RAM
      (e) Connects Via USB 2.0 and fast Ethernet

c. Keyboard and Mouse
   (i) The keyboard and mouse shall be industrially rugged having built in touch pad and 3 keys for the mouse functions.

d. UPS
   (i) A 2 kVA UPS system shall be provided and sized to provide sufficient power to maintain the SCADA system functioning for a minimum period of 2hours, in case of power failure.
   (ii) The 2 hour capacity shall be demonstrated during the factory acceptance test (FAT) and the site acceptance test (SAT).

e. Copier (Desktop)
   (i) A4 size Colour copier
   (ii) 20 copies per minute minimum in Colour mode
   (iii) 600 x 600 dpi
   (iv) Memory: 32 MB
   (v) Zoom: 25% to 400%
   (vi) 1 tray at 500 sheet capacity
   (vii) 4 sets of spare Colour cartridges

1868. **SCADA System Design.** The SCADA system shall be provided with Open system standards, windows based supervisory, control and data acquisition software and shall support industry standard protocols for third party interfacing required in future for connectivity to the master SCADA system. The software package chosen shall be a market leader and have a proven record of use within the water supply industry for similar applications.

1869. The PC based SCADA system shall provide the following facilities and functions:

a. provide Colour graphic screen representation for each plant area and process system
b. provide an overview of each plant area and process system, with a touch screen or equivalent to display a particular chosen area in greater detail
c. display the status of plant in a graphical and tabular format (i.e. running, stopped, fault etc.)
d. display analog values on the appropriate graphic screen (displays shall change Colour when in fault conditions or when data is suspect)
e. display status and values at other downstream Plants as required
f. annunciate alarms associated with the area of the plant concerned including details of the time the alarm occurred and the time it was acknowledged
g. provide facilities for the operator to:
   - display and adjust process set points
   - select process control modes
   - provide all other facilities required for operation of the Plant
   - acknowledge alarms
   - view a journal of unacknowledged alarms
   - view a journal of the last 200 alarms acknowledged and unacknowledged
   - provide real time and historic trending of local analogue values
   - issue commands for start-stop operation of major equipment (where authorization has been given)
   - Issue commands for opening or closing of motorized valves
h. provide data archiving of all local analogue values
i. prepare daily, weekly and monthly reports (providing details of daily, weekly and monthly throughputs against the number of running hours and power usage, chemical consumption, etc.)
j. display a total running hours log of major equipment items
k. Power monitoring using various analog and digital inputs provided from the HV switchgear as noted in the I/O list;
l. Security systems shall be provided to prevent unauthorized adjustment of process set points and unauthorized control of major equipment items.
m. On-line data monitoring and control
n. Provide a database for both real time and historical data management
o. Allow safety tagging and interlocking operations
p. Allow PLC program uploading and downloading
q. Provide interaction with the other packages such as geographic information system (GIS), water demand forecasting, management information system (MIS), etc.

1870. **Graphic display screens.** Graphic screens shall be provided with the following features:

a. main and subsystem menus
b. a pumping system overview (i.e. all pumping stations providing details of No. of pumps running and on standby, total flows, reservoir levels, discharge pressure, power supply status, etc.)
c. a treatment plant overview (i.e. No. of flash mixers in use, No. of plate settlers in use, No. of filters in operation, the No. in backwash, recirculation reservoir level and backwash reservoir level, raw water flow to the treatment plant, flow

of treated water out of the treatment plant and the turbidity, pH and chlorine residual of the raw and clear water, etc.)

d. an overview of power systems
e. an overview of control systems
f. screens to permit viewing of process set points
g. a tabular screen of pumping station statuses and operating values
h. The time and power frequency shall always be displayed in a corner or reserved space on the screen

1871. The graphic display screens shall display data commensurate with their size and the area of and 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.

1872. A comprehensive screen navigation system shall be provided giving access to all screens via a system of menus and short cuts. It shall be possible to follow the process from one screen to another by clicking the mouse cursor on screen 'hotspots' or by 'touchscreen' technology to effect the move from one screen to another.

1873. **Data management.** 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.

1874. The sample rates required for the displaying of trends shall be software settable and adjustable with a predefined access level and shall typically be as follows:

- One sample every 15 seconds for flow values
- One sample every 30 seconds for level measurements

1875. The system shall be capable of storing real time data for one day and historic data for 60 days. The sample rates for archiving shall be the same as for trending. The archives shall be stored in daily files. The system shall provide capacity to store archives for 60 days. A warning alarm shall be provided to the operator to advise that archiving to disk should take place or archived data will be overwritten. It shall be possible to:

- Reintroduce the data derived from archiving to the PC based local SCADA system and the archived data viewed using the trending function
- Display the data using an industry standard spreadsheet or database software in tabular format on a third party machine.

1876. The Contractor shall provide the latest technology (at the time of supply) based industrial magneto-optical (MO) disc drive or DAT drive with the PC based SCADA system in order to download archived data or to upload previously stored archived data onto electronic storage media. The MO or DAT disc drive shall be suitably protected against the environment. It shall be built as an integral part of the industrial PC offered for the local SCADA system.

1877. Design requirements of the data management and archiving system shall take into consideration following criteria:

a. Failsafe design
b. System and replacement parts availability
c. Equipment reliability

d. System expandability
e. User friendly to operate and maintain
f. Fault monitoring and diagnostic capabilities
g. Compatibility for integration with a future centralized Master SCADA system
h. Time Stamping and Synchronization:

    i. Real time clocks shall be provided in all PLCs as well as in the Local SCADA stations.
    ii. The local SCADA system and the PLCs shall be synchronized. An additional facility shall be provided in local SCADA system to synchronize it's time with the Master SCADA system's time (in the future).
    iii. Time synchronization with all PLCs in the WTP shall be done at start-up and periodically. The Contractor shall indicate the corresponding period.
    iv. The maximum time error at any time between PLCs and the local PC based SCADA system shall not exceed 5 milliseconds.
    v. The time stamping of the PLCs shall be made available to the local SCADA system for the data, alarms, events, etc. logged in the database.

1878. **Testing of the Local SCADA System.** The following tests for various items of the Local SCADA system including its power supply system shall be carried out as a part of the FAT in addition to other tests indicated by the Contractor in his submittal the FAT schedule.

1879. **Functional Tests.** All cubicles shall be energized and the power supplies tested on the panel face and the internal lighting configuration examined.

1880. The boards shall be examined to check that there are no 'Status Error' LEDs lit.

1881. The peripherals like printers, etc. shall be energized and the proper operation checked by self-tests by equipment which have VDUs, by connecting them to the system.

1882. The system I/O's shall be simulated and checked for indication on the LOCAL SCADA system database.

1883. The healthiness of all channels shall be checked, with the rated load connected, by varying the different inputs at random and checking to ensure that the correct status reporting is performed at the Local SCADA system.

1884. The following displays shall be functionally checked:

a. Mimic displays: Symbols, Colour s, the correct and approved formats, etc.
b. Control operations: Simulated commands received from the SCADA system without any malfunctioning
c. Status changes: Representation of on-off, open-close and changes in modes of operation
d. Variables: Engineering units, updating their indications as inputs change
e. Events and alarms: Generating alarms, and the indication of events by verifying inputs at random, checking the Colour coding, formatting, and printing
f. Trending: Verify proper selection and presentation under different time scales and check the printing function

g. Reports: Reports shall be checked for correct and approved formats, logging intervals, printing intervals, data accuracy, etc.

1885. **Response time checking.** System response time shall be tested after simulating the full I/O and man-machine interface system.

1886. The time taken from making an object status change to the presentation of the object's status on the display shall be measured.

1887. The time taken to generate and display a single alarm and multiple alarms (up to 50) from the time of the alarm condition shall be measured.

1888. The time taken to display a complex picture, with all variables from the time of calling the display shall be measured.

1889. The accuracy of alarms on the VDU and printer shall be verified.

1890. The time stamping accuracy between the Local SCADA and PLC times shall be measured and the differential accepted or rejected.

1891. **Other tests on local SCADA.** The following tests shall also be performed to verify the reliable operation of the SCADA system, in addition to those listed in the Subsections above:

a. Fail safe operation of the Local SCADA system during total (including battery) backed power failure and restoration.
b. Fail-safe operation during on-line connection and the removal of the hand held maintenance unit, if any is being utilized.
c. Testing the ability to Detect and report failure of any subsystem connected to the network with a VDU status display.
d. Testing the ability of error free data transfer on the communications system along with modems and other communication interfaces.
e. Testing the hard copy unit functions by printing process screens.
f. Testing the maintenance, backup functions (logic/programs, IO database, historical database, system configuration etc.) by connecting them to the system and seeing how they function.

1892. **Acceptable SCADA system manufacturers.** Acceptable manufacturers of the Local SCADA System shall be Rockwell Automation, Schneider, Siemens, GE Fanucand Tata Honeywell or equivalent as approved by Employer's Representative.

i. Instrumentation Control Panels (ICP)

1893. The Instrument Control Panel shall be a computed numerically controlled(CNC) machine prefabricated out of CRCA sheet steel of a thickness of not less than 2.5 mm, shall be modular in construction, properly reinforced, powder epoxy coated and having a rigid frame structure. An internal mounting plate including the gland plate shall be a minimum of 3.0 mm thick. The control panel shall have dimensions as required by the control system. However, the overall height of the control panel with the base frame shall not exceed 2,000 mm.

1894. The exterior corners and edges of the ICP 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.

1895. The Instrument 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 ingress protection as follows:

- Indoor Installations: IP 54
- Outdoor Installations: IP 65

1896. ICPs shall be of the 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, anti-vibration pads and necessary hardware for mounting the control panels. These shall be dispatched in advance so that they may be installed and leveled when the concrete foundations and floors are poured.

1897. 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 an Air-in / Air-out fans. The control panels shall be designed for front and rear access.

1898. Each ICP shall provide separate areas for the PLC, internal power distribution, instrumentation, field cabling terminations and for surge protection devices (SPDs).

1899. **Mounting.** All instrumentation, pushbuttons, switches and other equipment mounted on the front of the panel shall be mounted flush or semi-flush. In case of semi-flush mounting, only flanges or bezels shall be visible from the front.

1900. Equipment shall be mounted such that removal and replacement can be accomplished individually without the 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.

1901. Cut-outs and wiring for free issue items, if any are to be installed shall be in accordance with the corresponding equipment manufacturer's drawing. Cut-outs, if any, provided for future mounting of equipment shall be properly blanked-off.

1902. Panels shall be matched with other adjacent panels in respect to dimensions, Colour , appearance and arrangement of equipment on the front.

1903. **Earthing of instruments.** Each panel shall be equipped with an earth bus securely fixed along the inside base of the panel. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to the instrument earth bus.

1904. Looping of earth connections which would result in a loss of earth connection to other devices when the loop is broken shall not be permitted. Looping of earth connections between equipment to create alternative paths to the earth bus shall be provided.

1905. A separate instrument earth bus shall be created which will be floating and all the cable shields shall be terminated onto this bus. This bus shall be connected to an electronic earth pit.

1906. All metal parts other than those forming a part of an electrical circuit shall be connected to a copper earth bar running 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 shall be provided

at each end of the bar. Connection of the earth bar to the station earthing shall be made by the Contractor.

1907. **Space heaters.** Strip type space heaters of adequate capacity shall be provided inside of the 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 a 230V AC power supply. 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.

1908. **Interior lighting and receptacles.** Each panel shall be provided with a CFL lighting fixture rated for a 20 watt, 230V, 1 phase, 50 hz power supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by a door switch or manual switch. Each panel section shall be provided with separate lighting.

1909. Each panel shall be provided with a 230V, 1 phase, 50 hz, combined 5 amp and 15 amp, 3-pin receptacle with a switch and neon indication. The receptacle with its switch shall be mounted inside the panel at a convenient location. If the panel has front and rear doors then a receptacle for maintenance shall be provided at both locations.

1910. **Voltage level and power supply units.** The incoming power supply to each control panel shall be 230 VAC, 50 hz. The Contractor shall provide the necessary transformers, converters, inverters and other associated hardware required to condition the requisite power supply. Generally, voltage levels for control schemes and the power supply for instruments shall be 24V DC. The 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 a power supply other than 24V DC, the Contractor shall provide the necessary converters.

1911. The power supply to all the instruments shall be without interruption and shall be continued even in case of the failure of the 230 VAC power supply. A battery and battery charger shall be provided for this purpose and the sizing of the same shall be based on the entire load of the instrumentation system.

1912. **Labels.** All of the equipment mounted on the front face of a control panel as well as the equipment mounted inside the panel shall be provided with individual labels, with the equipment designation engraved on them. The labels shall be mounted directly below the respective equipment item. Also the panel shall be provided with a label engraved with the panel designation mounted at the top of the panel face.

1913. **Switched and miniature circuit breakers.**Each control panel shall be provided with the necessary configuration for receiving, distributing, isolating and protecting the DC and AC power supplies for the 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 shall also be protected by MCBs. All such MCBs shall be provided with an auxiliary contact to be used for providing a MCB tripped alarm.

1914. **Internal panel wiring.** Connections within a panel, between panel mounted devices and terminal blocks or between two (2) panel mounted devices shall be made with 660 volt grade, stranded copper conductor insulated with PVC and rated for a minimum conductor temperature of 90^{o} Centigrade. The wires shall be shielded, where necessary in accordance with the IEC and IS Codes.

1915. Panels shall be supplied completely wired internally at the factory to the equipment and terminal blocks, with a Colour coding scheme decided mutually between the Employer's Representative and the Contractor, and shall be ready for external cable connections to be made at the terminal blocks.

1916. Wires within the panel shall be continuous (i.e. without splicing) and shall consist of stranded copper conductors. Internal wiring or wiring between the two assemblies shall be commensurate with mechanical and electrical safety codes. Prefabricated cables with molded multi-pin connectors shall be used.

1917. Wire terminations shall be made with a 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 the panel's 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 the breaker or device shall be distinguished by the addition of a red Colour ed unlettered ferrule.

1918. Relay modules with plug-in type relays having multi-pin connectors shall be used.

1919. **Terminal blocks.** Terminal blocks for power connections shall be 660V grade, 20 amp rated, one-piece molded, furnished complete with stud type terminals, washers, nuts and lock nuts and identification markings. The design of the terminal blocks shall include a white fiber marking strip with a clear plastic, hinged terminal cover. Markings on the terminal strips shall correspond to the wire numbers on the Contractor's approved wiring diagrams. All control output terminals will be of the fused type and all other input signal terminals will be of the clip-on shrouded type.

1920. All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

1921. 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 (2) rows of terminal blocks shall be a minimum of 250 mm.

1922. Panel internal wiring shall not be looped directly from instrument to instrument. The wiring shall be looped through the panel terminal block only.

1923. If accidental short circuiting of certain wires is likely to result in the malfunctioning of equipment, such as the closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

1924. **Cable supports.** All external cables shall present a neat appearance and shall be suitably braced, placed in troughs, clipped or laced to isolate them from the effects of vibration.

1925. **Termial 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.

1926. **Painting of control panels.** The steel sheets of the control panel body shall undergo seven (7) tank treatments prior to powder coating.

1927. All sheet steel work shall be phosphated in accordance with the following procedure:

a. The pre-treatment shall be a hot process with the use of running water for rinsing.
b. Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.
c. Rust and scale shall be removed by trickling with clean water followed by final rinsing with a dilute dichromate solution.

1928. The control panel shall be powder epoxy coated with a minimum coating thickness of 60 microns. A QA test certificate shall be furnished to verify thickness adhesion and hardening of the powder coating.

1929. The Instrument Control Panel shall be subjected to the following dimensional checks:

a. Width
b. Height
c. Depth
d. Cut-out dimension for each panel mounted instrument
e. Spacing between the panel mounted instruments

1930. A high voltage (HV) test shall be performed on the ICP. The HV test of 1 kV AC for one minute duration shall be applied 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 shall not be acceptable.

1931. An insulation test shall be performed on the ICP. The insulation test shall be carried out using a 500V megger as specified below (all instruments shall be disconnected from the wiring):

a. Between adjacent terminals of the terminal block
b. Between individual terminals of the terminal block and ground
c. Between individual wires and ground

1932. **Acceptable ICP manufacturers.** The acceptable indigenous manufacturers for panel enclosures are Rittal, Enclotek, or equivalent as approved by Employer's Representative.

1933. The acceptable control panel manufacturers are Siemens, Sai Technologies, Schneider, Tata Honeywell or equivalent as approved by Employer's Representative.

j. Flow Measuring System

1934. Flow measuring systems shall consist of flow sensors, transducers, flow transmitters, digital flow indicators, integrators and any other items required to complete the system and make it functional.

1935. The components of flow measuring systems shall have the following design features:

a. Flow transducers shall be rugged in construction and shall be suitable for continuous operation. Flow transducers shall have waterproof construction and shall be suitable for installation on underground or above ground pipe lines.
b. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow sensor shall be provided, as required by the flow meter manufacturer and in line with applicable hydraulic standards.

c. The Contractor shall finalize the exact location of flow transducers in consultation with the Employer's Representative.

d. Flow transmitters shall be suitable for field mounting and shall accept an input from the flow transducer. The flow transmitter shall process the input signal and provide a 4-20 mA DC output proportional to the flow rate. Flow transmitters shall have LCD displays to indicate the instantaneous flow rate. The flow range shall be adjustable.

e. For ultrasonic flow meters, an insertion / retraction tool assembly shall be provided so that the flow transducers can be removed or inserted without depressurizing the pipeline. The flow transducers shall be made of anti-corrosive materials.

f. The flow computer shall be microprocessor based and shall have self-diagnosis facilities.

g. The following standards shall be adhered to:
   - BS EN 24185 - Measurement of fluid flow in closed conduits - Weighing method.
   - BS ISO 12765 – Measurement of fluid flow in closed conduits – Methods using transit-time ultrasonic flow meters
   - ISO 8316 – Measurement of fluid flow in closed conduits – Method by collection of the liquid in a volumetric tank
   - BS EN ISO 6817 – Measurement of conductive liquid flow in closed conduits – Method using electromagnetic flow meters
   - BS EN 29104 (ISO 9104) – Measurement of fluid flow in closed conduit – Method of evaluating the performance of electromagnetic flow measuring systems for liquids
   - ISO 9826: Measurement of liquid flow in open channel – Parshall Flume and Saniiri Flumes.

h. The flow meters shall be suitably sized to measure the maximum design flow rates plus 25% excess to accommodate peak conditions.

1936. **Ultrasonic type flow measuring system doe open channels.** Open channel type flow measuring systems shall consist of Parshall flumes,other types of flumes, weirs, ultrasonic level measuring transducers, flow computers, flow transmitters, flow indicators, flow integrators and any other items required to complete the flow measuring system.

1937. The level of the fluid in the flume or above the weir shall be measured by an ultrasonic level transducer. The level measured shall be used along with the physical characteristics of the flume or weir to compute the flow rate.

1938. The design and application of ultrasonic level transducers shall take into account the channel construction, the material, the size and shape, the environment, the process fluid or material being measured, the presence of suspended solids, foam or other foreign matter, etc.

1939. The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with facilities for spurious reflection rejection.

1940. The structure required for supporting the level sensor, platform, railings, etc. shall be furnished by the Contractor in accordance with the flow measuring system manufacturer's recommendations.

1941. The flow computer shall be microprocessor based and shall have features for on-line diagnosis and the entering of data like the type of channel, channel dimensions, engineering units, flow range measuring intervals, etc.

1942. The ultrasonic type flow measuring system shall have the following design characteristics:

Table 96: Design Characteristics of Ultrasonic Type Flow

Details	Description
A. General:	
Type of flow meter	Parshall flume
Overall accuracy of measurement loop	±3 % of full scale with facility for range selection
B. Level Measuring Unit:	
Type	Ultrasonic
Mounting	Above flow channel
Output	4-20 mA or pulsed
Enclosure Material	Die cast aluminium
Enclosure Protection	IP 65 of IS 13947 Part I
Integral cable with sensor	Required
C. Flow Computer and Transmitter	
Type	Microprocessor based
Mounting	Field
Input	From level measuring unit
Output	4-20 mA DC (Isolated)
Enclosure Protection	IP 65 of IS 13947 Part I
Programming facility with programmer	Required
Integration with Local SCADA system	Required
Display	Digital, Seven segment back-lit LCD/LCD display
Unit of display	Flow rate - m^3 / hr Totalized flow – Million Liters
Facility to feed data like the type of channel, channel dimensions, units, dead band, etc.	Required
Enclosure Material	Die cast aluminium
D. Flow Indicator and Integrator	
Specifications will be as given under 'Flow Indicator and Integrator'.	

1943. **Acceptable manufacturers.** The acceptable ultrasonic level measurement equipment manufacturers are Millitronics, Endress-Hauser, Dexelbrooks, or equivalent as approved by Employer's Representative.

i. Ultrasonic Type Flow Measuring System for Pipes

1944. **Flow measuring system of ultrasonic flow meter.** Ultrasonic Transducers shall work on the transit time (time of flight) principle. The design criteria for the transducers shall be as given in the following list:

a. The transducer probe shall be of the wet insertion type with the ability for online insertion and retraction.

b. The flow computer shall be microprocessor based and shall have facilities for on-line diagnosis, entering of the pipe size, engineering units, measuring range, etc.

c. The Contractor shall provide a section of pipe (a flanged pipe spool) having a uniform diameter, for the installation of the flow probes so as to configure the flow meter. The section of pipe shall be installed in the pipeline at the Project Site. The exact inside diameter of the pipe at the location of flow transducer shall be used for the flow computation.

d. The Contractor shall construct a suitable concrete chamber (vault) for installing flow transducers to be mounted on underground pipelines. A concrete enclosure shall be constructed above the chamber for housing the flow transmitter.

e. For aboveground pipelines, a shed or cabin shall be constructed around the pipeline for housing the flow transducer and the flow transmitter. A lockable enclosure shall be provided for the flow transmitter and computing unit.

f. In order to facilitate the removal and reinsertion of the flow transducers when the pipeline is pressurized, the Contractor shall provide an insertion-retraction tool assembly which shall be leakproof at 1.5 times the working pressure.

1945. The ultrasonic type flow measuring system shall have the following design features:

Table 97: Design Features of an Ultrasonic Type Flow Measuring System

Details	Description
A. General:	
Accuracy of flow sensor and transmitter during the FAT	±1% of full scale
Overall accuracy of measurement loop	±1.5% of full scale
Material of pipe	MS
Application	Raw Water and Clear Water transmission mains, Filter Backwash flow
Integration with Local SCADA system	Required
B. Flow Sensor/ Transducer:	
Type	Multipath, Insertion type (Clamp-on type shall not be acceptable)
No. of paths: Up to 1,200 mm line size Above 1,200 mm line size	 Two path (four transducers) Four path (eight transducers)
Measuring principle	Transit time (Time of flight)
Weather Protection Class	IP 68 as per IS 13947 Part I
Surge protection devices (SPD)	Required for protection from lightning surges between each flow sensor and flow computing unit / flow transmitter
Flow probe material	SS type 316
Other wetted parts	SS type 316
Provision for online removal / insertion of flow sensors without depressurization of the line	Required
Accessories	Prefabricated integral cables for connecting sensors and flow computer/transmitter Insertion / Retraction assembly and isolation valve. Sensor mounting nozzles / couplings

Details	Description
	Mounting bracket
	Name plate/ Metal tag
C. Flow Computer and Transmitter:	
Type	Indicating type
Type of display	4 digit, backlit LCD/ LCD,12 mm height for flow rate in m^3/hr. 8 digit, backlit LCD/ LCD,for totalized flow in ML.
Input	From ultrasonic flow sensors
Output	4-20 mA DC (isolated)
Zero and Span Adjustment	Required
Weather Protection Class	IP 65 as per IS 13947 Part I
Battery backup for totalized flow	Required
Facility shall be provided that when any one sensor or path fails the flow meter shall continue to function by automatically discarding the faulty sensor or path from the averaging function.	Required
Facility to display the flow measured by each path	Required
D. Flow indicator and integrator	
Specifications shall be as given under 'Flow Indicator and Integrator'.	

1946. **Calibration of Ultrasonic Flow Meter.** The ultrasonic flow meter shall be calibrated for the accuracy of the velocity measurement wherein the velocities shall correspond to the flow range of the flow meter as per the Contractor's approved design submittal. The calibration shall be carried out for the ultrasonic flow meter under a test consisting of multipath flow sensors, a flow transmitter with computation unit and flow indicator cum integrator unit.

1947. The calibration method shall be either the gravimetric method or volumetric method. The 'test bed' shall be accredited by a national or international certifying authority as per ISO 8316 (Calibration by Volumetric Method) or ISO 4185 (Measurement of fluid flow in closed conduits – weighing method). The Contractor shall produce accreditation certificates for the test facility and the calibration certificate for the flow meter for review by Employer's Representative and shall also demonstrate complete calibration on the test bed in the flow meter laboratory during witnessing of the Factory Acceptance Test. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

1948. **Acceptable manufacturers.** The acceptable ultrasonic flow meter manufacturers are Accusonic, Rittmeyer, Siemens-Danfoss, Krohne, or equivalent as approved by the Employer's Representative.

ii. Electromagnetic Full Bore Type Flow Meter

1949. **Flow measuring system of electromagnetic flow meter.** The full bore type electromagnetic flow meters shall consist of a flow sensor (i.e. flow tube), flow transmitter, flow indicator, integrator and any other item required to complete the system. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flow meter manufacturer and in line with the applicable hydraulic standards. The Contractor shall finalize the exact location of flow meter in consultation with the Employer's Representative.

1950. Flow measurement shall not be affected by physical properties of the water being metered, such as temperature, pressure, etc. within the stated tolerance limits. The Contractor shall provide compensating electronic circuits, if required to dampen interferences.

1951. Flow meters shall be suitable to operate accurately in the water turbidity and suspended solids loadings to be anticipated at the Project Site during the various seasons. The flow tube shall be rugged in construction and shall be suitable for continuous operation. The flow tube shall have waterproof construction and shall be suitable for installation on underground and above ground pipe lines.

1952. The flow computer and transmitter shall be a single unit suitable for field mounting. It shall accept inputs from flow tube process the signals and shall provide an output proportional to the flow rate. The output shall be suitable for transmitting over a long distance via a 4-20 mA signal.

1953. The Contractor shall construct a suitable concrete chamber (vault) for installing flow transducers to be mounted on underground pipelines. A concrete enclosure shall be constructed above the chamber for housing the flow transmitter.

1954. For aboveground pipelines, a shed or cabin shall be constructed around the pipeline for housing the flow transducer and the flow transmitter. A lockable enclosure shall be provided for the flow transmitter and computing unit.

1955. The electromagnetic full bore type flow measuring system shall have the following design features:

Table 98: Design Features of an Electromagnetic Full Bore Type Measuring System

Details	Description
A. General:	
Accuracy of flow measurement during the FAT	± 0.5% of measured value
Overall accuracy of flow measurement loop.	± 1.0 % of measured value
Integration with Local SCADA system	Required
B. Flow Tube:	
Applications	Raw water transmission mains Treated water transmission mains Treated water supply / distribution lines Backwash water Sludge lines Other lines specified
Type	In-line full bore electromagnetic flow tube
Size of flow tube	One standard diameter smaller than pipe size or appropriate size approved
Process connections	Flanged
Weather Protection Class	IP 68 as per IS 13947
Surge protection devices (SPD) between flow tube and flow transmitter	Required for protection from lightning surges
Materials of Construction:	
Electrodes	SS type 316
Coil housing	SS type 316

Details	Description
Flanges	SS type 316 /cast steel
Grounding ring	SS type 316 /cast steel
Flow tube lining	Hard Rubber for potable
C. Flow Transmitter Unit	
Type	Microprocessor based with the ability to configure the ranges.
Type of display	4 digit backlit LCD, or LED for flow rate in m^3/hr. 8 digit backlit LCD, or LED for totalized flow in ML
Units of display	Flow rate - m^3/hr Totalized flow – ML
Input	From flow tube
Output	4-20 mA DC (isolated) proportional to flow rate
Power Supply	24V DC
Zero and Span Adjustment	Required
Weather Protection Class	IP 65 as per IS 13947
Battery backup for totalized flow Type Capacity Backup Time	 Online 2.5 mVA 8 hours.
Facility for on line diagnosis	Required
D. Flow Indicator and Integrator	
Specifications shall be as given under 'Flow Indicator and Integrator'.	

1956. **Acceptalbe manufacturers.** The acceptable manufacturers of the electromagnetic flow meter are Endress-Hauser, Krohne, Siemense-Danfoss or equivalent as approved by the Employer's Representative.

1957. **Calibration of Electromagnetic Flow Meter.** The electromagnetic flow meter shall be calibrated for the full flow range specified as per BS EN 29104 (Methods of evaluation of electromagnetic flow meters).

1958. The calibration method shall be either gravimetric method as per ISO 4185 (Measurement of fluid flow in closed conduits – weighing method) or volumetric method as per ISO 8316 (Calibration by Volumetric Method). The 'test bed' shall be accredited by national /international certifying authority. The Contractor shall produce accreditation certificates for the test facility and calibration certificate for the flow meter for the review by Employer's representative. The Contractor shall also demonstrate complete calibration on the test bed in the flow meter laboratory. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

1959. **Flow Indicator and Integrator.** Flow indicators and integrators shall be modular in design. They shall consist of two (2) separate dedicated displays for flow rate indication and total flow indication. They shall accept a 4-20 mA DC isolated input. The flow integration shall be carried out in the PLC. The flow indicator with flow integrator shall provide a 4-20 mA retransmission output proportional to the flow rate.

1960. The flow indicators and integrators shall have the following design features:

Table 99: Design Features of Flow Indicators and Integrators

Details	Description
Type	Microprocessor based[1]

Details	Description
Mounting	Front facia of control panel
Display	Digital, seven segment back lit LCD or LED display
Digit height	14 mm or greater
No. of Digits for: Flow indicator Flow integrator	 4 Digits 6 Digits
Input	4-20 mA DC (Isolated) from flow transmitter through analog signal multiplier (Refer to Note 2)
Zero and span adjustment	Required
Manual Reset Facility for flow integrator	Required (and shall be password protected)
Integration with Local SCADA system	Required
Engineering units:	
Flow rate indicator Flow integrator	m^3/hr ML
Battery backup for integrator	Required
Retransmitted output	4-20 mA proportional to flow rate
Alarm outputs	1 NO + 1 NC for high and low alarms (adjustable)
Communication port	RS-485 (With Modbus protocol) for interfacing with the PLC
Weather Protection Class	IP 54 of IS 13947 Part I
Accuracy	± 0.25% of span or better.
Notes: 1. The digital flow indicator and flow integrator shall be a combined unit. 2. A facility shall be available in the analog signal multipliers and in the flow indicator and integrator for providing excitation voltage for the flow transmitter for the case of 2-wire flow transmitters	

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1961. **Acceptable manufacturers.** The acceptable manufacturers of flow indicators and integrators are Yokogawa, Lectrotek, Masibus, or equivalent as approved by the Employer's Representative.

1962. **Flow Switches.** Insertion type flapper flow switches shall be provided for clear (treated) water service. The pressure drop caused by the flow switch shall be kept to a minimum. There shall not be any effect on the switch setting because of vibrations.

1963. The flow switch shall have screwed or flanged process connections. The body material shall be suitable for withstanding the maximum working pressure. A standard industrial switch assembly of the micro switch type with an auto reset and an adjustable switch differential shall be provided.

1964. The flow switches shall have the following design features:

Table 100: Design Features of Flow Switches

Details	Description
Type	Flapper type.
Material for flapper and other wetted parts	SS type 316.
Enclosure material	Die cast aluminium .
Weather protection class	IP 65 of IS 13947 Part I.
Mounting	In field on pipe.
Integration with Local SCADA system	Required

Switch type	Microswitch.
Switch differential	Adjustable.
Contacts	2NO+2NC.
Repeatability	±2 % or better.

1965. **Sight Flow Glasses.** Sight flow glasses shall have the following design features:

Table 101: Design Features of Sight Flow Glasses

Details	Description
Type	Flapper type
Body material	Same as the pipe material
Glass	Toughened (tempered)
Process connections	Flanged
Gaskets	PTFE

1966. **Annubar Type Flow Measuring System for Air.** Annubar type flow meters shall be provided for the backwash air (BWA) systems and other air flow measuring applications. Annubar type flow meters shall be insertion type differential pressure (DP) type flow meters that function on the averaging pitot tube (APT) principle. The insertion of the annubar type flow tube shall only require a single pipe penetration.

1967. The annubar tube shall be a single piece which when inserted extends the full pipe diameter into the pipe. The tube shall be teardrop, T-shaped, or other proprietary design shape as patented by a particular manufacturer. The side of the tube facing into the flow stream shall have holes or slots designed to average the flow distribution (velocity profile) across the pipe's cross-section. The Annubar tube shall measure the mean velocity (the weighted average of all flow velocities across the pipe diameter).

1968. The annubar tube in conjunction with the flow transmitter and integrator shall accurate measure the (i) differential pressure, (ii) static pressure and (iii) process fluid temperature to dynamically calculate the fully compensated mass flow. The accuracy of the flow measurement system shall be up to 0.90% of the mass flow rate at a 10:1 turndown rate. The sensor tube shall be sized by the manufacturer for the pipe diameter to be utilized.

1969. The Annubar tube shall be made of type 316 stainless steel. The Annubar flow measuring system shall be as manufactured by Rosemont Model 3095 MFA, Fisher-Porter equivalent, or other equivalent as approved by the Employer's Representative.

1970. **Transmitter.** The transmitter shall be of the mass flow type, rated for a gas (air) temperature range of -40^{o} to 85^{o} C and up to 100% relative humidity. The output shall be a 4-20 mA signal proportion to the flow rate. The power supply shall be 24V DC.

1971. The transmitter may be direct or remote mounted as approved by the Employer's Representative. The transmitter shall have an LCD display showing the flow in m^3/min or m^3/hr to conform to the flow scale of the blower's performance curve. Diagnostics and configuring functions shall be enables via a HART modem.

iii. Level Measuring Systems

1972. The level measurement system shall consist of a level transducer, a level transmitter, a digital level indicator and any other items required to complete the installation of the level measuring system.

1973. To reduce the effects of water turbulence in reservoirs and tanks, an averaging function shall be provided in the transmitter unit for dampening and providing steady readings. A stilling pipe shall be provided for the level electrodes.

1974. The design and application of the level measuring system shall take into account the reservoir or tank construction, the size, shape, environment, the process fluid or medium to be measured, the presence of foam, suspended solids, etc.

1975. For ultrasonic type and radar type level transducers, the design and installation shall avoid any degradation of the instrument performance due to spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. A means shall be provided for the rejection of spurious reflections.

1976. The level transmitters shall be mounted in suitable weatherproof lockable pedestal enclosures near the level sensor and above the high water and overflow levels.

1977. **Radar Type Level measuring system.** The radar type level measuring system shall consist of a radar type level sensor, a level transmitter, prefabricated integral cable connecting the sensor and transmitter, surge protection devices and any other item required to complete the level measurement loop.

1978. The level sensor shall be suitable for flange or bracket mounting as required. The installation shall avoid any degradation of instrument performance due to spurious reflections, absorption and condensation of the radar waves. A means shall be provided for rejection of spurious reflections. The radar type level instrument shall have the facility for dampening and averaging the effect of waves, undulations on the water surface and discriminate the rate of change of levels to provide steady readings. If required, the Contractor shall provide a stilling pipe to ensure the provision of steady readings with the prescribed accuracy.

1979. A lockable enclosure shall be provided for level transmitters mounted in the field. A metal cantilever platform shall be provided for mounting of the level sensor and transmitter.

1980. The radar type level measuring system shall have the following design features:

Table 102: Design Features of a Radar Type Level Measuring System

Details	Description
A. General	
Accuracy	± 5 mm
B. Level Sensor and Level Transmitter	
Type of transmitter	Indicating type having backlit LCD or LED display
Output	4-20 mA, DC (Isolated)
Zero and span adjustment	Required
Prefabricated integral cable between sensor and transmitter	Required
A means for suppressing echoes from interfering structures	Required
Integration with Local SCADA system	Required
Enclosure Material	Die cast aluminium (Non-corrosive)
Process connections flange material	SS type 316

Details	Description
Weather Protection Class for transmitter enclosure	IP 65 of IS 13947 Part I
Lockable mild steel enclosure (epoxy painted) for sensor and transmitter	Required with weather protection class IP 65 of IS 13947 Part I
Accessories	Mounting bracket; Name plate or Metal tag
C. Digital Level Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

1981. **Acceptable manufacturers.** The acceptable manufactures for radar type level measuring systems are Millitronics, Endress-Hauser, Dexelbrooks, or equivalent as approved by the Employer's Representative

1982. **Ultrasonic Type level Measuring System.**Ultrasonic type level measuring devices shall consist of a transducer, a transmitter, a remote level indicator and all other items required to complete the system.

1983. The level sensor and the field-mounted transmitter shall be separate units interconnected by an integral cable of sufficient length. The transducer shall be suitable for flange or bracket mounting as required and shall be environmentally protected as per IP65. It shall have ambient temperature compensation and adjustable datum setting facilities.

1984. The design and application of ultrasonic level meters shall take into account the vessel or channel construction, the material size, shape, environment, process fluid or material being measured, the presence of foam, suspended solids, etc.

1985. The installation shall avoid any degradation of performance from spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For applications where spurious reflections are unavoidable the control unit shall be provided with a means for spurious reflection rejection.

1986. The ultrasonic type level measuring system shall have the following design features:

Table 103: Design Features of an Ultrasonic Type Measuring System

Details	Description
A. General	
Accuracy of measuring loop	± 0.5% of full scale
Temperature compensation	Required
B. Level Sensor and Level Transmitter	
Weather protection	IP 65 of IS 13947 Part I
Type	Indicating type having back-lit LCD or LED display
Output	4-20 mA DC (Isolated)
Mounting	Field
Process connection flange material	SS type 316
Programming facility with programmer	Required
Integration with Local SCADA system	Required
Prefabricated integral cable for connecting sensor and transmitter	Required
C. Digital Level Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

1987. **Acceptable manufacturers.** The acceptable manufactures for ultrasonic type level

measuring systems are Millitronics, Endress-Hauser, Dexelbrooks or equivalent as approved by the Employer's Representative.

1988. **Capacitance/RF Admittance Type Level Measuring System.**The capacitance / radio frequency (RF) Admittance type level measuring system shall consist of a sensing probe, transmitter and a digital indicator. The level-measuring probe shall be installed on a tank and shall be connected to the level transmitter mounted above the high water level.

1989. A guide pipe shall be provided for the probe to maintain in a stable position.

1990. The capacitance / RF Admittance type level measuring system shall have the following design features:

Table 104: Design Features of a Capacitance/RF Admittance Type Level Measuring System

Details	Description
A. General	
Accuracy	±1.5 % of span
B. Level Sensor with Transmitter	
Mounting	On top of the tank
Probe type	Rod
Probe material	SS type 316
Weather Protection Class	IP 65 of IS 13947 Part I
Output	4-20 mA DC (Isolated)
Material of wetted parts	SS type 316
Local indication	Required
Integration with Local SCADA system	Required
Probe insulation material	Teflon
Stilling pipe	SS type 316 with perforations
C. Digital Level Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

1991. **Conductivity Typel Level Switch.** The conductivity probes shall have the following design features:

Table 105: Design Features of Conductivity Type Level Switch

Details	Description
A. Conductivity Probes	
Types	(i) Rigid for lengths of up to 3 meters (ii) Flexible for lengths above 3 meters (Rigid probes preferred)
No. of electrodes	As required per the application
Probe insulation	Teflon (except at the tip of the electrode).
Probe head protection class	IP 65 of IS 13947 Part I
Probe head housing material	Aluminium
Mounting	At the top of the tank or sump
Process connection flange material	SS type 316
Electrode material	SS type 316
Spacers between electrodes	Required for preventing entangling of electrodes.

Details	Description
B. Level Controller	
Protection class	IP-65 of IS 13947 Part I
Switch contact (for each setting)	2 NO + 2 NC
Contact rating	24V DC, 2A
Sensitivity control	Required
Input	From the conductivity probe
Integration with Local SCADA system	Required
Mounting location	Field

1992. **Float type level switch.** The float type level switches shall have the following design features:

Table 106: Design Features of Float Type Level Switch

Details	Description
Mounting	From top of tank / from side as applicable.
Process connection flange material	SS316
Material of float	Polypropylene / SS316
Float installation hardware material	SS316
Switch type	Micro switch (Mercury type not acceptable)
Integration with Local SCADA system	Required
Weather Protection	IP-65 of IS 13947 Part I

1993. **Buoyancy type level switch.** The buoyancy type level switches shall have the following design features:

Table 107: Design Features of Buoyancy Type Level Switch

Details	Description
Sensing Element	Displacer
Mounting	Field, on top of tank or sump
Process connection	Flanged
Weather Protection Class	IP 65 of IS 13947 Part I
Differential	Fixed
Switch Type	Microswitch
No. of contacts	2 SPDT type
Integration with Local SCADA system	Required
Materials of construction:	
Housing	Die cast aluminium
Displacer	SS type 316
Displacer rope / cable	SS type 316
Spring	Spring Steel

Table 108: Pressure Measuring Systems

Accessories	SS type 316 perforated stilling pipe and all mounting hardware

1994. **Pressure transmitters.** Pressure measuring systems shall consist of a pressure transducer, transmitter and digital pressure indicator and any other items required to complete the installation of the pressure measuring system. Pressure transmitters shall be provided with a test port so that in-site calibration can be performed.

1995. Each Pressure transmitter shall be rugged in construction and shall be suitable for continuous operation. Pressure transmitters shall be designed for operation over 130% of full range. They shall be capable of withstanding surge pressures likely to occur in pumped and pressurized systems.

1996. Pressure transmitters shall be suitable for field mounting. They shall provide a 4-20 mA DC output proportional to the pressure being measured. Transmitter output shall be isolated and shall be suitable for transmitting over a long distance. Pressure transmitters shall have a high degree of weatherproof protection as specified in the technical particulars.

1997. Pressure sensors shall be capable of operating in the range of pump's discharge pressure, and be of the diaphragm type. They shall be provided complete with impulse tubing, fittings, two (2) valve manifolds with drain cocks and calibration valves. Local and remote display units shall be provided. Snubbers shall be installed on sensors on all pumped and pressurized lines.

1998. The pressure transmitters shall have the following design features:

Table 109: Design Features of Pressure Transmitters

Details	Description
A. General	
Accuracy of measuring loop	± 0.25% of reading or better
B. Pressure Sensor and Transmitter	
Sensor	Diaphragm type
Material of sensor and other wetted parts	SS 316
Transmitter type	2-wire, Indicating type
Range	Adjustable over full span
Zero and span adjustment	Required
Output signal	4-20mA DC (Isolated)
Integration with Local SCADA system	Required
Enclosure protection	IP 65 of IS 13947 Part I
Accessories	2-valve manifold with drain cock, impulse tubing, snubbers and calibration valve
C. Digital Pressure Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

1999. **Acceptable manufacturers.** The acceptable manufactures for pressure transmitters are ABB, Endress-Hauser, Emerson Process Management or equivalent, as approved by the Employer's Representative.

2000. **Pressure Switch.** The pressure switch shall have a manually adjustable set point and differential switching level. The nominal pressure values at which the pressure switches operate shall be fully adjustable over the whole range of the instrument and the set value shall be clearly indicated by means of a scale and pointer. Pressure switches shall have over range protection.

2001. Pressure switches shall be housed in cast aluminium alloy enclosures providing weather ingress protection to IP 65 standards.

2002. When the process fluid is sludge, oil or a chemical solution, a diaphragm seal shall be used to segregate the switch from the fluid media. In chlorine applications, the diaphragm

shall be made from silver or tantalum. For other fluids an appropriate non-corrosive diaphragm material shall be used.

2003. Each pressure switch shall be provided complete with impulse tubing, a two (2) valve manifold, a drain cock, fittings, etc.

2004. The pressure switches shall have the following design features:

Table 110: Design Features of Pressure Switches

Details	Description
Type	Non-Indicating
Sensing Element	Bellows / Diaphragm
Material of sensor and other wetted parts	SS type 316
Housing	Die cast aluminium
Switch type	Microswitch
Switch differential	Fixed
Set pressure	Adjustable
Repeatability	± 1% of span
Over range protection	125% of maximum pressure
Switch Contacts	2 NO + 2 NC
Integration with Local SCADA system	Required
Switch Rating	Suitable for the control voltage in the panel where the contacts are wired
Accessories	2-valve manifold with drain cock, impulse tubing and diaphragm seals as required

2005. **Pressure Gauges.** Pressure gauges and vacuum gauges shall comply with IS 3624 and BS 1780. A glycerin filled dial shall be provided where the gauge is subjected to pressure pulsation and/or vibrations. The internal parts of each pressure gauge shall be stainless steel.

2006. Pressure gauges shall be provided on the discharge and suction side (except for vertical turbine type) of each pump. Pressure gauges shall be of the bourdon type and calibrated for the required pressure range.

2007. Each gauge shall be supplied complete with impulse tubing, a two (2) valve manifold with a drain cock, fittings, etc. Pulsation dampeners shall be installed on all pump and otherwise pressurized lines.

2008. The minimum diameter for pressure gauges shall be 150 mm. However, where the pressure gauge forms part of a piece of equipment, the equipment manufacturer's standard sizes will be acceptable.

2009. The pressure switches shall have the following design features:

Table 111: Design Features of Pressure Gauges

Details	Description
Accuracy	± 1.5% of full scale
Dial size	150 mm (or 100 mm if approved)
Glass	Shatterproof
Over range protection	125% of maximum pressure
Housing material	Die cast aluminium

Material of sensor and other wetted parts	SS type 316
Accessories	2-valve manifold with drain cock, impulse tubing, snubbers and all installation hardware

2010. **Differential Pressure Measuring System.** Differential pressure measuring systems shall consist of a differential pressure transmitter, a digital differential pressure indicator and any other items required completing the differential pressure measuring system.

2011. Differential pressure transmitter shall be rugged in construction and shall be suitable for continuous operation. Differential pressure transmitters shall be designed for operation over 130% of full range. Differential pressure transmitters shall be suitable for field mounting. They shall provide a 4-20 mA DC output signal proportional to the differential pressure. Transmitter output shall be isolated and shall be suitable for transmitting over a long distance. Differential pressure transmitters shall have a high degree of weatherproof protection as specified in the technical particular.

2012. The differential pressure measuring system shall have the following design features:

Table 112: Design Features of Pressure Measuring System

Details	Description
A. General	
Overall accuracy of measurement loop	± 0.5% of measured value
B. Differential Pressure Sensor and Transmitter	
Sensor	Diaphragm type
Transmitter type	2-wire, Indicating type having back-lit LCD / LED display
Material	Non-corrosive
Mounting	Field
Range	Adjustable over full span.
Zero and span Adjustment	Required
Output	4-20 mA DC (Isolated)
Integration with Local SCADA system	Required
Accessories	Impulse tubing, fittings, valve manifold with drain cock
Enclosure protection	IP 65 of IS 13947 Part I
C. Digital Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

2013. **Acceptable manufacturers.** The acceptable manufactures for differential pressure measuring systems are ABB, Endress-Hauser, Emerson Process Management, or equivalent, as approved by the Employer's Representative.

iv. Temperature Monitoring for Pump Motors

2014. **Permanent Temperature Scanners.** Twelve (12) channel Temperature Scanners shall be provided to measure high winding and bearing temperatures for each pump. The 'high temperature' signal shall be used for annunciation of alarms and the 'very high temperature' signal shall be used for generating tripping (shutdown) signals. The input signals to the temperature scanner shall be provided by industrial type PT100 platinum resistance temperature detectors provided in the windings and bearings.

2015. The temperature scanners shall have the following design features:

Table 113: Design Features of Temperature Scanners

	Description
Service	Motor winding and bearing and pump bearing temperature measurements for each pump motor in the raw water and clear water pumping stations and for the backwash water pumps
Range	0 to 200° C
Type	Microprocessor based
Mounting	On respective Instrument Control Panel
Accuracy	0.2% of range
Resolution	0.1° C
Input Signal	From RTDs for each pump motor
Display	LCD / LED display, 4 digit for data and 2 digit for channel No's.
Scanning rate	Selectable
Communication port for interfacing with PLC system	RS-485 (With Modbus protocol)
Set point	2 set points (high and very high) for each group of channels. A minimum of 3 groups of channels shall be provided. A separate relay shall be required for each set point.
Type of contacts	2 change-over contacts for each set point
No. of channels	12 (6 for pump winding temperatures, 2 for motor bearing temperatures, 2 for pump bearing temperatures and 2 spares).
Programming	Through keyboard mounted on the front facia
Password facility	Required
Integration with Local SCADA system	Required

2016. **Acceptable manufacturers.** The acceptable manufactures for 12 channel temperature scanners are Lectrotek, Yokogawa, Masibus, or equivalent as approved by the Employer's Representative.

2017. **Portable temperature measuring system.** A portable temperature measuring system shall be provided at the raw water pump station and the WTP for measuring the temperature of pump and motor bearings.

2018. The temperature measuring systems shall have the following design features:

Table 114: Design Features of Temperature Measuring Systems

Details	Description
Type	Fixed temperature measuring system
Range	0-200° C
Display	3½ digit LED/ Backlit LCD
Sensor	Thermocouple / PT100
Power supply	Rechargeable battery operated
Memory for previous data storage and processing	The instrument shall be capable of storing records of measurement results
Accuracy	± 0.5° C
Accessories	Attachments for measuring bearing and casing temperatures, a carrying bag, a protective cover,

	batteries (4 sets) and a battery charger.

2019. **Portable Sound Level Meters.** Portable sound level meters shall be provided for raw water pump station and the WTP. The sound level meter shall comply with BS EN 60651, BS EN 747 and ANSI S 1.4 and S1.43.

2020. The portable sound measuring systems shall have the following design features:

Table 115: Design Features of Portable Sound Measuring Systems

Details	Description
Type	Portable
Range	0-150 dB
Display	(i) Backlit LCD to Display (ii) Signal level with a quasi-analog bar (iii) Measuring range (iv) Menus for displaying and editing settings (v) Stored measurement results (vi) Selected parameters with levels
Microphone	Pre-polorized free field microphone
Power supply	Rechargeable battery operated
Memory for previous records	Required
Internal Real time clock for marking measurements with date and time	Required
Data storage and processing	The instrument shall be capable of storing records of measurement results
Accessories	Microphone, shoulder bag, protective cover, batteries (4 sets) and a battery charger

v. Pump Vibration Monitoring System

2021. **Permanent Vibration Monitoring System.** Two (2) vibration switches, one on the pump casing and one on motor casing of each pump, shall be provided for protecting the pumps from costly destructive failure by initiating an alarm or shut-down when excessive vibration of the machinery is detected. Vibration switches can be either Electronic AC or DC powered switches or mechanical switches, the main criteria shall be its durability and reliability.

2022. The Contractor shall offer a complete vibration monitoring system using these vibration switches as the primary sensors in addition to the temperature scanners for monitoring the bearing and winding temperatures of the pumps and motors. A suitable interface shall be provided for transferring the data and alarms to the PLC and Local SCADA system.

2023. **Portable vibration monitoring.** A portable vibration measuring equipment shall also be furnished for measurement of pump and motor vibrations.

2024. The portable vibration measuring systems shall have the following design features:

Table 116: Design Features of Portable Vibration Measuring Systems

Details	Description
Type	Portable vibration meter
Range	Selectable from 0-1 mm/sec, 0-10 mm/sec and 0-100 mm/sec

Frequency range	10hz to 10 khz
Display	LED/ LCD type, displaying instantaneous, true peak, with m/s and mm/s^2 scales
Sensor (Accelerometer)	Piezo-electric type
Mounting Magnet	Required
PTFE Self-adhesive tape	Required
Power supply	Rechargeable battery operated
Memory for previous data storage and processing	The instrument shall be capable of storing records of measurement results
Accessories	Mounting kit, shoulder bag, protective cover, batteries (4 sets) and a battery charger

vi. Online Water Quality Measuring Systems

2025. **On-line pH measuring system.** The pH measuring system shall consist of a pH electrode, a pH transmitter, a digital pH indicator, an electrode holder assembly and any other items required to complete the pH measuring system.

2026. The pH transducer shall be rugged in construction and shall be suitable for continuous operation. The pH transducer shall include a measuring electrode, a reference electrode, and a temperature compensator electrode. All wetted parts of the transducers shall be of non-corrosive material. The pH transmitter output shall be isolated, and shall be suitable for transmitting over long distances.

2027. The electrode holder assembly shall be of such a design that it contains some water even when the sampling pump is shut-off and it shall be provided with a flow regulating device.

2028. A sampling system consisting of a sampling pump with pressure reducing valves, a flow regulator, a rotameter, a filter assembly, etc. shall be provided. The sample water will be connected to a cabinet containing the pH analyzer equipment and the pH transmitter.

2029. The on-line pH measuring systems shall have the following design features:

Table 117: Design Features of Online pH Measuring Systems

Details	Description
A. General	
Overall accuracy of measurement loop	±1% of measured value
Standard pH solutions for on-site calibration	For pH 4,7 and 10 shall be provided (1 liter of each for each system)
Integration with Local SCADA system	Required
B. pH Sensor	
Type	Encapsulated combined electrode
Mounting	On flow through assembly
Automatic temperature compensation	Required
Standard cable for connecting sensor and transmitter	Required
C. pH Transmitter	
Type	Indicating type with backlit LCD / LED display
Mounting	Field
Inputs	From pH electrodes and temperature compensator
Zero and span adjustment	Required

Details	Description
Enclosure material	Non-corrosive
Enclosure Protection	IP 65 of IS 13947 Part I
Output	4 to 20 mA (Isolated) for connecting to pH indicator
Integration with Local SCADA system	Required
D. Digital pH Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

2030. **Acceptable manufactuers.** The acceptable manufacturers of pH measuring systems are HACH, Emerson Process Management, or equivalent as approved by the Employer's Representative.

2031. **Online residual chlorine measuring system.** The Residual chlorine (RCl) measuring system shall consist of a RCl transducer, a RCl transmitter, a digital RCl indicator and any other items required to complete the RCl measuring system. The RCl transmitter output shall be suitable for transmitting over long distance.

2032. Each RCl transducer shall be rugged in construction and shall be suitable for continuous operation. The RCl transducer shall function on the amperometric-Colour imetric principle. The transducer shall also consist of an integral pH sensor for compensating against pH changes and an integral temperature sensor for compensating against temperature changes.

2033. A sampling system consisting of a sampling pump with pressure reducing valves, a flow regulator, a rotameter, a filter assembly, etc. shall be provided. The sample water will be connected to a cabinet containing RCl analyzer equipment and RCl transmitter. The RCl sensor enclosure shall be of such a design that it contains some water even after the sampling pump is shutoff and it shall be provided with flow regulating devices.

2034. The on-line residual chlorine analyzer systems shall have the following design features:

Table 118: Design Features of Online Residual Chlorine Analyzer Systems

Details	Description
A. General	
Overall accuracy of measurement loop	± 5% of measured value
Integration with Local SCADA system	Required
B. Residual Chlorine Sensor	
Type	Membrane covered amperometric three-electrode system
Parameters measured	Free residual or total residual chlorine
Ranges (selectable)	3 ranges: 0.01-2, 0.01-5, and 0.01-10 mg/L ppm
Automatic temperature compensation electrode	Required
Temperature range	0^{o} - 45^{o}C
Automatic pH compensation electrode	Required
Electrode Materials: Working Counter Reference	 Gold cathode Stainless steel anode Silver / silver halide

Details	Description
Sensitivity	0.1 mg/l
Standard cable connecting sensor and Transmitter	Required
C. Residual Chlorine Transmitter	
Type	Indicating type having backlit LCD/LED display
Mounting	Field
Input	From residual chlorine sensor
Output	4-20 mA (Isolated)
Zero and Span Adjustment	Required
Enclosure material	Non-corrosive
Enclosure Protection	IP 65 of IS 13947 Part I
Integration with Local SCADA system	Required
D. Sampling System	
Flow rate	10 to 60 liters/hr
Alarms	Low flow
E. Digital Residual Chlorine Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

2035. **Acceptable meanufacturers.** The acceptable manufacturers of residual chlorine measuring systems are Hach, Emerson Process Management, Chemtrac Systems, or equivalent as approved by the Employer's Representative.

2036. **Online turbidity measuring system.** The on-line turbidity measuring system shall consist of a turbidity detector assembly, a turbidity transmitter, a digital turbidity indicator, and any other items required tocomplete the turbidity measuring system.

2037. The turbidity detector shall operate on the Nephelometric turbidity measurement principle. Each turbidity detector shall have ratio-metric measurement system and shall be suitable for insertion flow through type mounting. It shall be possible to calibrate the turbidity meter at the Project Site, with a formazine standard or a glass cube. The Turbidity detector shall be rugged in construction and shall be suitable for continuous operation. It shall have an integral bubble trap (degassing chamber).

2038. The turbidity transmitter output shall be isolated and shall be suitable for transmitting over long distances.

2039. A sampling system consisting of a sampling pump, pressure reducing valves, a flow regulator, a rotameter, a filter assembly, etc. shall be provided. The sample water will be connected to a cabinet containing the turbidity analyzer equipment and the turbidity transmitter.

2040. The on-line turbidity measuring systems shall have the following design features:

Table 119: Design Features of Online Turbidity Measuring Systems

Details	Description
A. General	
Overall accuracy of measurement loop	± 2%
Integration with Local SCADA system	Required
B. Turbidity Sensor	
Type	Optical sensor
Material For Wetted Parts	Non-corrosive

Details	Description
Cleaning Facility	Required
Bubble Trap / Degassing Chamber	Required
Measuring Principle	Ratio-metric
Lamp life	20,000 hrs minimum
Colour Compensation	Required
Range setting	Selectable (0-100 NTU)
Resolution	0.01 NTU
Repeatability	Better than 1% of reading
Temperature range	0^{o}-50^{o} C
Calibration Standard	Required, Standard Formazine solution or Glass cube.
Accessories	Standard cable for connecting the sensor and transmitter, standard glass cube (3) or formazine solution (2 liters) for calibration
C. Turbidity Transmitter	
Type	Indicating with backlit LCD / LED display
Mounting	Field
Input	From Turbidity sensor
Output	4-20 mA DC (Isolated)
Zero and Span Adjustment	Required
Enclosure material	Non-corrosive
Enclosure Protection	IP 65 of IS 13947 Part I
Integration with Local SCADA system	Required
D. Sampling System	
Flow rate	10 to 60 liters/hr
Alarms	Low flow
E. Digital Turbidity Indicator	
Specifications shall be as given under 'Digital Panel Meters'.	

2041. **Acceptable manufacturers.** The acceptable manufacturers of turbidity measuring systems are HACH, Emerson Process Management, Sigrist, Chemtrac Systems, or equivalent as approved by the Employer's Representative

2042. **Alarm annunciators.** Alarm annunciators shall be microprocessor based and provided for generating audio visual alarms for each abnormal condition as defined in the individual Subsections 6, 9, 10 and 11. Alarms shall be initiated by the opening and closing of volt-free contacts which shall remain unchanged throughout the periods in which the alarm conditions exist. Alarm circuits shall be capable of conversion from open-healthy to open-alarm or vice versa by a simple modification after installation requiring no additional parts or special equipment.

2043. Each alarm shall initiate the operation of both visual and audible devices. The sound intensity of each audible device shall be suitable for the maximum sound level of its environment, and shall be adjustable by the user. The sequence of alarms shall be user selectable by a dip switch.

2044. The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a separate alarm condition occurs. The alarm circuitry shall be arranged so that spurious or transient alarm states persisting for less than 0.5 seconds (adjustable) do not initiate any action.

2045. Isolation facilities shall be provided for the hooter using an MCB. The annunciator shall be of the split architecture type and the facia shall have an LED readout.

2046. Alarm annunciator shall be provided on instrument control panel for annunciation of alarms in control room. The technical particulars of alarm annunciator shall be as follows:

Table 120: Technical Particulars of Alarm Annunciator

Details	Description
Type	Microprocessor based
Mounting	Flush with front panel
Construction	Modular
Inputs	Potential free, NO/NC contacts
Size of windows	50 mm x 35 mm
Operating sequences	First up (user selectable dip switch)
Bulbs per channel	2 (Cluster LEDs)
Push Buttons	For Reset, Accept and Test
Hooter	Electronic type
Power supply status indication	Required
Integration with Local SCADA system	Required
Weather protection	IP 54 of IS 13947

2047. **Surge protection devices.** Two (2) surge protection devices (SPDs) shall be provided for each signal loop and power loop for field instruments located outdoors. One SPD shall be provided in the field near each transmitter and the other shall be mounted in the control panel. The SPDs shall be suitable for withstanding the surge arising out of high energy static discharges and lightning strikes and shall protect the instrument from any damage.

2048. SPDs shall provide three (3) stages of protection through a quick acting semiconductor like tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. The SPDs shall be passive units and shall require no power for operation. During the occurrence of a surge the SPD shall clamp on the allowable voltage and pass the excess voltage to the ground.

2049. The SPDs shall be of self-resetting type to minimize the down time of the measurement loop. The SPDs shall have a weatherproof casing and shall be suitable for field or back of panel mounting. There shall be total isolation between the input, output and ground terminals. Each SPD shall have a minimum surge rating of 10 KA.

2050. **Digital panel meters.** Digital panel meters (DPMs) shall be microprocessor based and modular in design. They shall accept a 4-20 mA DC signals from various transmitters for level, pressure, turbidity, residual chlorine, pH, etc. and display of the readings in engineering units. The DPMs shall have a backlit LCD or LED display.

2051. The technical particulars of the digital panel meters shall be as follows:

Table 121: Technical Particulars of Digital Panel Meters

Details	Description
Type	Microprocessor based
Display	Digital, seven segment backlit LCD / LED display
Digit Height, each	14 mm or higher

Details	Description
No. Of Digits	4
Input	4-20 mA DC (Isolated) from level transmitters, pressure transmitters or valve position transmitters through analog signal multipliers (Refer to Note 1)
Zero and Span Adjustment	Required
Engineering units for display:	
Level indicators	Meters
Pressure indicators	kg/cm^2
Valve position indicators	0% – 100%
Accuracy	± 0.1% of span
Enclosure Material	Non corrosive
Enclosure Protection Class	IP 54 of IS 13947 Part I
Retransmission output	4-20 mA DC (Isolated)
Alarm outputs	2 NO + 2NC for high and low alarms (adjustable)
Integration with Local SCADA system	Required
Note: 1. Facility shall be available in the analog signal multipliers and in the digital indicator for providing excitation voltage for the transmitters in case of 2-wire transmitters.	

2052. **Bar graph indicators.** For level and pressure indications bar graph indicators shall also be allowed as an alternative for the digital panel meters described above. The Contractor and Employer's Representative will determine where to use bar graph indicators.

2053. Bar graph indicators shall be of the single or dual channel type, having 100 segments of red LED bar of 100 mm length, with a 4 digit 7.5 mm high red 7 segment LED display situated above the bar. The seven (7) segment display shall be scalable from –1,999 to 9,999, and suitable for a 4-20 Ma input signal. The LED bar shall have a graduated vertical scale from 0%-100%, graduated every 5%. The input shall be a 4-20 mA DC or a 3 wire RTD (PT100) signal, with an accuracy of ± 0.2%. The power supply shall be 270V AC or 24V DC. An RS 485 port for serial communication shall be furnished. The nominal size shall be 36/72 x 144 x 245 mm.

2054. **Acceptable manufacturers.** The acceptable manufacturers of digital panel meters and bar graph indicators are Yokogawa, Lectrotek, Masibus, or equivalent as approved by the Employer's Representative.

2055. **Analog signal multipliers.** Panel mounted analog signal multipliers shall be provided for multiplication of analog signals for flow, level, pressure, pH, turbidity, residual chlorine, etc. They shall provide loop power with the option to select measurement with power and without. The multiplier shall provide 2 outputs of 4-20mA each: one for the panel mounted indicator and other for connection to the PLC. There shall be total galvanic isolation between the field I/Os and also between the 2 outputs.

2056. **Control Panel Power Supply.** The primary power supply for the control panels shall be derived from the respective LV switchboard at 240V AC. The voltage level for control schemes and power supply for the instrumentation and control system shall be 24V DC. The 24 V DC shall be derived from the 230 V AC supply at the LV switchboard. The 24 V DC power supply systems shall include the following items:

a. Sealed maintenance free (SMF) batteries
b. 24V DC rectifier unit with float boost charger for 24 V DC battery
c. DC distribution board

2057. The batteries shall be sized to provide sufficient power to maintain the instrumentation and control system of the pumping stations or water treatment plant equipment functioning for a period of 1 hour. The battery shall have a maximum recharge time of 8 hours. The control supply voltage for all of the control panels and field instruments shall be derived from the battery. For a detailed technical specification (except the output voltage level) of the batteries and battery charger refer to Subsection 7. The estimated load of the I&C system for each pumping station and for the WTP must be calculated and approved by the Employer's Representative, before procurement of the batteries and battery charger for the respectivepumping station and for the WTP units can be started.

2058. **Uninterrupted Power Supply (UPS).** The Contractor shall provide an on-line Uninterruptible Power Supply (UPS) system with a two (2) hour back-up time at full load for each of the PLC based SCADA systems. The Contractor shall clearly indicate the offered UPS rating and the details of each system in his design submittals.

2059. Each UPS shall be floor mounted, self-contained and metal clad. The UPS shall incorporate a six (6) pulse rectifier and pulse width modulation inverter technology with microprocessor control. It shall incorporate a static bypass switch that shall operate in the event of a UPS failure, overload or manual initiation in order to transfer the output supply to the main utility power supply without disruption in the output supply.

2060. The design of all of the power supply items shall be in accordance with the latest national and international standards such as IS, BS and IEC. The Employer has right to reject the system at any time, if standards are not met by the Contractor. The Contractor shall clearly indicate the standards of design in his design submittals. The power supply scheme and all design calculations for selection of UPS and Battery capacity shall be furnished by the Contractor in his design submittals.

2061. Based on the three phase 415 VAC power supply available at the Project Site all required AC/DC voltages for the SCADA and communication systems, etc. shall be derived from this supply and proper isolation, earthing and safety requirements as per Indian Electricity (IE) Rules shall be complied with by the Contractor. The Contractor shall provide the required and a sufficient number of AC and DC feeders as required for the PC based local SCADA system. At least 2 spare feeders shall be provided in each of the AC and DC systems.

2062. The batteries used for the UPS system shall be rechargeable, of the sealed maintenance free (SMF) lead acid type. The battery supply to the UPS shall be via a fused load break switch disconnect circuit breaker. The battery recharge time to 90% of full charge shall be approximately ten (10) times the discharge time at full load.

2063. The various alarms and status parameters of the UPS system shall be made available to the local SCADA system for monitoring purposes using a RS-232 serial communication port. Software for shutdown of the PC in case the main power supply is not restored shall be provided as a part of the UPS.

2064. Total Harmonic Distortion (THD) of the UPS shall be less than five percent (5%) and any single harmonic distortion shall be less than three percent (3%)

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2065. After a dip or failure of the main power supply, the rectifier controller shall ramp up the DC voltage slowly.

2066. The Uninterruptible Power Supply (UPS) System with SMF lead acid battery shall conform to the minimum following specifications:

Table 122: Minimum Specifications of UPS

Details	Description
A. UPS General Information	
Function	Required for the SCADA and communication systems
Rated Power at PF = 0.7	The Contractor shall design and indicate
Input Voltage	240 VAC single phase to be furnished by the Contractor from 415 VAC ± 10%, 3 phase, 4W, 50 hz ± 5% to be made available at one location at each PLC location.
Integration with Local SCADA system	Required
B. Allowable Variations in Input	
Voltage	± 10%
Frequency	± 5%
Combined voltage and frequency	± 10%
C. Output	
Voltage	230 VAC, single phase
Frequency	50 hz ± 0.5% (free running) and ± 3% (Sync mode)
Regulation	Less than ± 1%
Transient Response	± 5% for 100% load variation, correction in 10 milli-sec or better
Inverter Technology	PWM (IGBT)
Distortion (AC harmonics)	(i) < 5% THD (ii) < 3% for any single harmonic
Short term overload (maximums)	(i) 110% for 30 min (ii) 150% for 10 secs (iii) 200% for 5 cycles
Efficiency	(i) Inverter - 92% or better and (ii) AC to AC - 85% or better
Load Power Factor	0.6 to unity
Static Bypass	Required with a transfer time of less than 5 milli-sec
Manual Bypass Switch	Required
Backup Period	Two hour back-up time at 100% of full load
D. Protections	
Mains Over/Under	Required
DC Over/Under Voltage	Required
Inverter Over/Under Voltage	Required
Inverter Overload	Required
Overheat	Required
Built-in Soft/ Cold start	Required
Snubber circuits for devices	Required
E. LED Indicators	
Mains On	Required
Inverter On	Required
Battery on Charge	Required
Mains Over/Under Voltage	Required
Low Battery Imminent	Required
DC Over/Under Voltage	Required
Inverter Overload	Required
Load On Inverter	Required

Details	Description
Load on Auxiliary Supply	Required
Overheat	Required
F. Digital Metering	
LCD	16 x 2 or better
DC Volts	Required
AC I/P and O/P Volts	Required
DC Current	Required
AC O/P Current	Required
Frequency	Required
% Battery	Required
Audible Alarm	Required
Isolation of UPS output from main power input	Required
Alarm Contacts for Self Diagnostics	Required
Protection Class	IP 54 or better
Operating Temperature	0 to 50 °C
Relative humidity	Up to 95%, non-condensing
G. Batteries	
Type of battery	Sealed maintenance free (SMF) lead acid
Number of cells per unit	Contractor to design and indicate
Nominal cell voltage	Contractor to design and indicate
Final cell voltage	Contractor to design and indicate
Capacity at 100% load	To provide one hour back-up time
Mounting arrangement	Open type multitier
The following Accessories shall be provided but not limited to:	(i) Set of inter-cell, inter-row and inter-bank connectors (ii) Number plates as required for the complete installation (iii) Centre zero voltmeter

2067. **Tests on the UPS systems.** The UPS systems shall be tested at manufacturer's factory and also at Project Site for its functional and operational performance.

2068. The following tests shall be carried out:

a. Voltage regulation at 0%-100% of full load
b. A load test, with verification of the current limiter operation
c. A test of the acceptability of the output voltage variation
d. Ripple and harmonics measurements
e. Efficiency and power factor measurements
f. Megger and HV tests for insulation
g. Heat run tests
h. Functional tests
i. Alarms and self-diagnostics tests
j. A verification of the communication with the Local SCADA system
k. A DC start test for the UPS

2069. If any of the tests results are unacceptable to the Employer's Representative

vii. Control System

2070. **Control system voltages.** The following voltages shall be used for the control system:

Description	Voltage
Instrumentation power supplies	24 V DC
PLC input / output modules	24 V DC
PLC input / output circuits and loops	24 V DC
SCADA System and flow meters	230 V AC (on UPS back-up)

2071. **Control system protection.** All circuits shall be protected against short circuiting by the provision of an adequate number of miniature circuit breakers. For ease of maintenance and system security, the power supply to each instrument loop and each PLC module shall be protected with an individual MCB.

2072. Suitable earthing shall be provided for all of the control panels. The same shall be connected to electrical earthing. Earthing shall be provided for the electronic equipment and shall be connected to an electronic earthing arrangement. The same shall be separate from the electrical earthing.

viii. Cabinets for Field Instruments

2073. Field cabinets shall be provided for enclosing instruments and associated accessories which are mounted outside of the control panel such as transmitters, SPDs, terminal blocks, etc. Field cabinets shall be provided at all measurement locations.

2074. The field instruments shall be mounted at a convenient height of approximately 1.2 meters above the grade platform in lockable field cabinets.

2075. Field Cabinets shall be fabricated from cold rolled steel with a powder epoxy coating applied. The steel sheet shall be of standard gauge and shall be suitable for both wall mounting or pedestal mounting, as required by the site conditions. Each cabinet shall be earthed properly. Suitable arrangements shall be provided in the cabinet for mounting the instrument and accessories.

2076. Enclosures for use outside of buildings or in places where the splashing of water may occur shall have a minimum rating of ingress protection of IP 65 and shall have tops which project outward (overhangs) sufficiently to protect the vertical faces of the enclosure and any components mounted thereon from splashing, inclement weather and direct sunlight.

2077. If enclosures are located with direct exposure to sunlight, the enclosure shall include a sun shield fitted to the top of the enclosure. The sun shield shall prevent direct sunlight from reaching the field cabinet instruments for all days throughout the year, and shall have louvered ventilation.

2078. Fixing arrangements for surface-mounting enclosures shall be external to the enclosure and shall ensure that the rear face of the enclosure is not in contact with the surface to which it is fixed.

2079. Enclosures shall have hinged access doors, fitted with recessed lockable handles. Doors shall be of rigid construction and provided with close-fitting flexible seals in recesses to prevent the ingress of liquids, moisture, dust and vermin. Hinges shall be of the lift-off pattern and one hinge shall engage before the other for the ease of fitting. Wherever

necessary, removable access covers secured by quick-release fasteners shall be provided to ensure ease of maintenance for all installed apparatus.

2080. Mounting plates, brackets and racks shall be provided for all other internal equipment which shall be hinged or otherwise arranged with quick-release fasteners or captive screws to give quick and easy access to equipment, securing screws, terminals and wiring.

2081. Enclosures for two (2) or more devices with electrical circuits shall have gland plates and terminal blocks as specified elsewhere. The incoming cables from the Control Room shall not be directly terminated to the transmitters.

2082. Each enclosure shall be designed for the safe testing and servicing of equipment with the power on. Each part which may be live under any circumstances shall be so covered or shielded as to prevent inadvertent contact.

ix. Instrument Power Supply and Signal Cables

2083. The Contractor shall include in his scope of work the supply and laying of instrumentation signal and power supply cables and the associated civil and mechanical work required for completing the system as required.

2084. Cables shall be capable of satisfactorily withstanding, without damage, transportation to the Project Site, installation at the site, and operation under normal and short circuit conditions of the various systems under the prevailing climatic conditions to which the respective cables are subjected when operating at the site as indicated in this specification. Cables shall be capable of satisfactory performance when laid on trays, in trenches, in conduits, in ducts and when directly buried in the ground.

2085. Cable joints in instrument signal and instrument power supply cables shall not be permitted.

2086. Cables shall be capable of operating satisfactorily under a power supply system voltage variation of ± 15%, and a frequency variation of ± 5.0%, acting simultaneously.

2087. **Acceptable manufacturers.** The acceptable manufacturers of instrument power supply and signal cables are LAPP, Elkay Cables, Telelinks, NICCO, or equivalent as approved by the Employer's Representative.

2088. **Cables for digital signals.** Cables to conduct digital signals shall be 660V or 1100V grade multicore cables, with multi-stranded high conductivity annealed 1.0 mm^2 stranded tinned copper conductor, extruded PVC insulated and screened overall with braided wire or with aluminium mylar tape. An ATC drain wire shall be provided running continuously in contact with the aluminium side of the tape, inner sheathed with extruded PVC, armored with galvanized steel wire and overall sheathed with extruded PVC conforming to IS 1554 and IEC 189 Part II.

2089. **Cables for analog signals and temperature sensor signals.** Cables to conduct analog and temperature sensor signals shall be 660V or 1100V annealed, tinned, high conductivity 1.0 mm^2 stranded copper conductor, extruded PVC insulated, with two or three cores twisted into pairs or triads and laid up collectively. Individual pairs or triads shall be shielded overall with wire braiding or aluminium mylar tape. An ATC drain wire shall be provided running continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armored with galvanized steel wire and overall sheathed with extruded PVC conforming to IS 1554 and IEC 189 Part II.

2090. **Laying of instrument cables.** For the laying of instrument cables the specifications as detailed in Subsection 7 Electrical Equipment shall also be applicable.

2091. A minimum distance of 300 mm shall be maintained between the cables carrying low voltage AC and DC signals and a minimum distance of 600 mm shall be maintained between signal cables and HV cables. In outdoor areas, the cables shall be directly buried. Each instrumentation and power supply cable shall be terminated to an individual panel or terminal box. The identification of each cable shall be by properly placed ferrules at each junction in accordance with the cable schedule to be prepared by the Contractor.

2092. Separate cables shall be used for digital and analog signals.

2093. Cables shall be laid strictly in accordance with the layout drawings and cable schedule, which shall be prepared by the Contractor and submitted for the Employer's Representative's approval.

2094. All cable routes shall be carefully measured and cables cut to the required lengths, leaving a sufficient amount of slack for the final connection of the cable to the terminals on either end. A loop of 1,000 mm shall be left near each field instrument before terminating the cable. Cables shall be laid in complete uncut lengths from one termination end to the other.

2095. All cables shall be identified close to their termination point by cable numbers as per the Contractor's cable interconnection schedules. Identification tags (ferrules) shall be securely fastened to the cables at both ends.

2096. Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.

x. Junction Boxes

2097. 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.

2098. 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 or cast iron and shall provide the degree of ingress protection of IP 65.

2099. Wires and terminals for the digital and analog signals shall be segregated within each junction box. Also wires and terminals for AC and DC signals shall be segregated within the junction boxes.

xi. Video Projector

2100. A portable LCD video projector suitable to project video and computer generated presentations of 23 mm (0.9 inch) thin film transistor (TFT) shall be supplied under this scope of work.

2101. The minimum specifications of the video projector shall be as follows:

a.	Input	Computer video built-in facilities
b.	Video Compatibility	PAL Secam and NTSC
c.	Computer Compatibility	SXGA – (super extended graphics array)
d.	Brightness	2,100 ANSI Lumen (minimum)

e.	Resolution	800 x 600 pixels (SVGA)
f.	Wide Angle	Throughout zoom length
g.	Zoom	Powered and controlled by a remote
h.	Colour	16.7 million Colour
i.	Magnification	Digital through remote control
j.	Supply	Operated on 240V AC
k.	Lamp lamp	Ultra high brightness with 2,500 hrs minimum life

xii. Submittals by the Contractor

2102. The Contractor shall make submittals to the Employers representative of all calculations, design drawings, schedules and complete documentation on spare parts relating to instrumentation and control equipment and systems provided under this Contract. The required number of submittals shall be: 6 hard copies and 2 soft copies of each. No blueprints will be accepted.

2103. These submittals shall include, where relevant, the following:

2104. **Functional design specification.** The Contractor shall submit a complete functional design specification (FDS) for approval by the Employer's Representative within 90 days after the award of the Contract. The Contractor shall take note of the importance of this obligation. This document shall serve as the primary mechanism by which the Employer's Representative may confirm that the Contractor possesses an accurate understanding of the system and its control requirements. The Contractor is encouraged to obtain clarifications and to suggest refinements to the control descriptions contained in this Specification.

2105. The FDS shall comprise an overall description of the plant, its functioning and control, and a detailed description of each section of the control system covering modes of operation, manual overrides, setpoints and parameter selection and adjustment. The detailed description shall include a step-by-step control description which defines the function of each piece of equipment and each control action and interlock, including details of the program for each programmable item.

2106. The FDS shall describe the 'fail-safe' features incorporated into the design for the event of failure of a plant item or system, or loss of an input signal affecting a control loop or process sequence.

2107. The FDS shall describe control actions taken and monitoring functions which remain available during a power failure, and any automatic controls or sequencing which will take place during system start-up and shut-down.

2108. The FDS shall contain the design of the proposed SCADA graphic screen layouts. The format of the program details may be chosen by the Contractor.

2109. The FDS shall be presented in a clear and precise manner and shall include figures or drawings where appropriate.

2110. The Contractor shall submit and obtain approval of the FDS from the Employer's Representative before starting the design of the detailed control system.

2111. **Drawings for I&C and SCADA Systems.**The drawings for the instrumentation and control, SCADA and associated communication and power supply systems covered under

this specification shall be submitted for review of the Employer's Representative after the Award of the Contract The shall include but not be limited to the followings:

Table 123: Specification for I&C and SCADA Systems

Sr. No.	Description
1.0	P&I Diagrams
2.0	Instrument list with tag numbers, range, sizes, makes and model numbers
3.0	Data sheets and catalogs for all instruments, alarm annunciators, instrumentation and control cables
4.0	Control Panels
4.1	Overall dimensional drawings, fabrication details and bill of materials for the instruments mounted on the front facia and inside the control panel
4.2	Front facia layout showing all instruments with cut-outs and bezel dimensions, construction details and interior GA drawings for control panels and consoles
4.3	Wiring diagrams with terminal details for each component and terminal block details
4.4	Power supply distribution schemes with loads of all panel mounted instruments for control panels and consoles
4.5	Bill of materials (quantities) for the instruments mounted on the front facia and inside the control panel
4.6	General arrangement drawings of field-mounted instruments showing installation details
5.0	Loop diagrams for all field mounted instruments. The loop diagrams shall contain tag numbers, terminal numbers, I/O addresses, cable no's. etc.
6.0	List of alarms to be provided on the alarm annunciator
7.0	PLC Systems
7.1	Input / Output list for each PLC indicating the grouping of various signals in each module
7.2	The PLC system configuration indicating interfacing with the Local SCADA system
7.3	A PLC block logic diagram with a descriptive control logic write-up and software program listing
7.4	System hardware details along with a bill of material
7.5	Graphic screens of the Operator Interface Unit
8.0	Installation diagrams and drawings for instruments
9.0	Batteries and Battery Charger
9.1	Front facia layout, overall dimensions, wiring diagrams, indicating terminal details for the battery charger panels
9.2	Bill of materials (quantities)
9.3	Calculation of ampere hour capacity for the battery back-up.
9.4	Catalogs and data sheets of equipment
10.0	I&C system configuration drawing indicating instruments, PLCs and PC based local SCADA system.
11.0	Functional Design Specification containing summary of the Contractor's proposal for the sequence of operation and design intent
12.0	PC based Local SCADA system
12.1	Data sheets and catalogs for PC, peripherals and DAMS software
12.2	Details of communication protocol and data structure
12.3	Graphic screens for the PC based Local SCADA system
13.0	Catalogs, data sheets and sizing calculations for the UPS and battery back-up for the PC based Local SCADA system
14.0	Detailed cable installation layout drawings indicating the route of cables, type of laying, etc.
15.0	Cable Schedules and Interconnection cable schedules

Sr. No.	Description
16.0	Operation and Maintenance manuals for the PLCs, local PC based SCADA system, battery and battery charger panel, the UPS and all instruments
17.0	The SCADA Control Room layout drawing
18.0	Data sheets, catalogs, control wiring drawings with terminal details for motorized valve actuators
19.0	List of spares for the I&C system and PC based Local SCADA system including the power supply systems
20.0	As-built drawings
21.0	Documents for I&C system training
22.0	Any other drawings and documents, required but not covered above

xiii. Inspection Requirements

2112. All tests as required, both at the factory (i.e. the factory acceptance test (FAT) before dispatch, and at the Project Site after installation (i.e. the site acceptance tests (SAT), shall be performed under the direction of the Employer's Representative. Detailed test reports and certificates shall be submitted to the Employer's Representative for his acceptance. Test reports and test certificates for purchased components to be installed shall be submitted to the Employer's Representative for approval. These components shall also be included in the integrated FAT.

2113. The list of tests to be carried for both the FAT and SAT along with the test instruments to be used shall be furnished with the Contractor's design submittal for review by the Employer's Representative. The Contractor shall indicate the location of each FAT and the test facilities available there.

2114. Prior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employer's Representative who will witness the testing, at his discretion. Details of the Contact Person who will coordinate the FAT and the address where the FAT will be performed shall be furnished to the Employer's Representative along with inspection protocol well in advance of the proposed date of testing.

2115. In addition, testing done during manufacturing and assembly in the factory such as a heat run test, component testing, circuit testing, etc. for similar equipment shall have the test results submitted to the Employer's Representative.

2116. **Factory acceptance tests.** To ensure that a well-engineered and contractually compliant system is delivered by the Contractor, factory acceptance tests shall be performed.

2117. Factory Acceptance Tests (Applicable For Inspection Category A, as described in Subsection 12) shall be conducted as follows:

a. A factory acceptance test, which shall be witnessed by Employer's Representative at his discretion, shall be required for each system. No equipment shall be shipped without written confirmation by the Employer's Representative 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 at the point of manufacture. 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 and systems.

c. Factory acceptance Tests shall be conducted according to the Contractor's approved Test Plan which shall contain detailed test procedures. The test plan and procedures shall be submitted by the Contractor for review and shall be subject to approval by the Employer's Representative prior to the commencement of any FAT.

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 Employer's Representative visits the factory for the FAT. The Pre-FAT shall be supervised by the person designated to serve 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 Employer's Representative for review before the Employer's Representative comes to the Manufacturer'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 performed for the factory acceptance test along with the test instruments to be used shall be furnished to the Employer's Representative for review. The Contractor shall indicate the place of inspection and the test facilities available.

g. The testing of all the equipment and accessories shall be carried out in accordance with the latest applicable Indian and International Standards.

h. Prior to testing, all relevant documentation and a sufficient briefing about the testing protocol shall be given to Employer's Representative who will be witnessing the testing.

i. The FAT to be performed in the factory shall include, but not be limited to following:
   (i) Tests to verify the guaranteed technical parameters
   (ii) Integrated functional tests
   (iii) Burn-in tests
   (iv) Hydrostatic tests
   (v) Calibration tests
   (vi) Power supply variation tests
   (vii) Alarm and diagnostic checks

2118. The following are the types of tests to be performed:

a. Type Tests - The Contractor shall submit the test certificates for the 'Type Tests' to the Employer's Representative for approval. The type tests (as applicable) for the instruments shall be as follows:
   (i) 'Burn In' test for electronic components
   (ii) Humidity test for electronic instruments
   (iii) Weather protection testing as per IS 13947
   (iv) Hysteresis test
   (v) High voltage test
   (vi) Short circuit protection test
   (vii) Material test

b. Routine Tests - All instruments shall be subjected to the routine tests (as applicable) mentioned below at the manufacturer's factory to ensure correct functioning.
   (i) Calibration of the instruments - All of the instruments shall be calibrated for accuracies as per the applicable standards. The

calibrations 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 as good or 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 indicators with integrators shall be subjected to the over range protection test.

d. Performance test - All of the instruments shall be tested by connecting them to the specified power supply for the performance test.

e. Power supply variation test - All of the instruments shall work satisfactorily over the range of the specified power supply variations (voltage and frequency). Their 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 test pressure. There shall not be any physical damage to the sensors.

g. Repeatability test - All instruments shall be subjected to a repeatability test over the full range at 0%, 25%, 50%, 75% and 100% of the full range in both the increasing and decreasing directions. Readings for each measurement shall be taken for establishing the repeatability.

h. Dimensional check - The dimensions of all of the instruments shall be checked thoroughly and shall be tabulated in a standard report format.

i. Wherever applicable, the following dimensions shall be checked and noted:
- Total length
- Insertion length
- Diameter
- Mounting head
- Process connection size etc.

(i) For panel mounted instruments and transmitters the following dimensions shall be checked and noted
- Width
- Height
- Depth

(ii) Bezel dimensions and cut-out dimensions for panel mounted instruments, etc.

2119. **Mandatory Spare Parts.** The following mandatory spare parts shall be furnished.

Table 124: Mandatory Spare Parts

Item[1] No.	Description	Unit	Quantity
1	Instrument Control Panels / Consoles		
	Selector switch of installed quantity for each type	%	25
	MCBs of installed quantity for each rating	%	25
	Auxiliary relays of installed quantity for each type	%	25
	Push buttons of installed quantity for each type	%	25
	Recorder ink for 5 years operation	set	1
	Recorder chart paper for 5 years operation	set	1
	Arrestor of each type	sets	5
	Fuse of each type	%	200
	Light bulbs of each type	%	200
	Signals and annunciator lights of each type	sets	2
2	Programmable Logic Controller (PLCs)		
	Input / Output modules of installed quantity	%	25

Item[1] No.	Description	Unit	Quantity
	Power supply module	set	1
	Communication module	set	1
	Empty CDR disk for data collection equipment	sets	50
	PLC equipment of each type	set	1
	Print card in PLC of each type	sets	2
3	PC based SCADA system		
	Power supply unit	set	1
	Card of each type	set	1
	MCB of each type	set	1
4	DC battery & battery charger		
	Diluted potassium for NI-CD type and/or Diluted sulfuric acid for lead-acid type	%	30
	Cells in seal of each type(*)	sets	2
	Diodes of each type(*)	set	1
	Silicon controlled rectifier of each type(*)	set	1
	Indicating lamps and fudes of each type	%	200
5	Pressure Gauge of installed quantity for each range	%	25
6	Temperature sensors of each type	set	1
7	Temperature scanner	set	1
8	Pressure transmitter of installed quantity	%	10
9	Flow switches of installed quantity	%	25
10	Sight flow glass of installed quantity	%	25
11	Pressure switch of installed quantity for each type	%	25
12	Flow transmitter for backwash flow measurement of installed quantity	%	10
13	DP transmitter of installed quantity for each type for filter	%	10
14	Conductivity type level switch	set	1
15	Float type level switch of installed quantity for filter	%	10
16	Level controller for backwash water tank	set	1
17	Ultrasonic type level sensor and transmitter of installed quantity	%	10
18	Rader type level sensor and transmitter of installed quantity	%	10
19	Surge protection device of installed quantity	%	25
20	Flow transmitter of installed quantity for electromagnetic flow meter	%	10

[1] Quantity shown on the above table shall be per total number for each item of equipment supplied except items with asterisk mark.

(*) Quantity of spare parts shall be as per each part of equipment.

SUB-SECTION 6.2

SUBMISSION AND APPROVAL OF DOCUMENTS

1. General Notes

2120. The Employer requires that all goods and materials to be used in the works are new unused, of the most recent or current models and incorporate all recent improvements in design and material.

2121. Only the Employer's Requirements and design brief are specified in the following section. These are not restrictive. The Contractor has to draft, the technical specification and the specification of standards for goods, materials and workmanship with recognized codes and standards.

2. Submittals

2122. The submittals include but is not limited to work required to comply in accordance with general and specified procedures for transmittal of submissions; submission review and subsequent actions; schedule of submissions; resubmission; construction schedule; coordination of drawings; submission of drawings; insert and sleeve location drawings; reproduction of submitted drawings; sample; and construction photocopies. Soft copies of all the documents, drawings, approved drawings, photographs shall be submitted.

3. Design, Drawings, Documents and Data

2123. **General Obligations.** The Contractor shall carry out, and be responsible for, the design of the Works. Design shall be prepared by qualified designers/professionals who comply with the criteria stated in the employer's Requirements. The Contractor undertakes that the designers shall be available to attend discussions with the Employers representativeat all reasonable times during the Contract Period.

2124. **Best Design Parameters.** The bidder is required to study the employer's design criteria, specifications etc., as included in the Bid documents to confirm their correctness in its bid and to assume full responsibility for them.

2125. **Submission of design calculations, drawings and other documents by the Contractor.** After signing the Contract, within 28 days from the date intimated by the EMPLOYER to proceed with the work, the Contractor shall supply to the Employers representative6 (six) hard copies (along with workable soft copies in a CD) each of the design calculations for the process and sizing of all components of the plant including mechanical and electrical equipment, supported by flow diagrams, and general arrangement drawings, reference catalogues /literature of manufacturers, other reference documents used for the design purpose, for approval of the Employers representativeThe Contractor shall incorporate all necessary comments of the Employers representativeEmployers representativein the above design and drawings, if any, and shall re-submit further 6 (six) copies each of the revised design and drawings within 14 (fourteen) days for final approval of the Employers representative The Contractor shall thereafter submit 6 (six) copies each of the approved design and 6 (six) copies each of the approved drawings together with one copy each of the reproducible tracings and workable soft copies of all approved designs, calculations and drawings. The entire cost shall be borne by the Contractor and employer does not hold reliability on this account at any cost and any time.

2126. Design calculations and drawings shall be submitted in sequence as per schedule to be drawn and agreed upon mutually, immediately after submission of the general arrangement drawing. The entire process of submission of all such documents by the Contractor in initial copies and final copies after approval of the Employers representativeshall be completed within 90 days from the date of the work order. These documents shall cover:

- Site Plan.
- Layout Plan and hydraulic flow diagram, process design, P & I diagram
- Architectural Drawings/Renderings, Land scape Plan
- GA drawing of each / individual unit
- Detailed structural design and good for execution drawings pertaining to all components of the plant and other associated works.
- Drawings showing the size, position and other necessary details of all mechanical and electrical equipment and fixtures.
- Wiring diagrams, pressure control, pumps and motor control gear particulars.
- Details of foundations, position of openings, etc., for the pumps, motors, starting cubicles, LT/HT panels, etc.
- Elementary diagram and manufacturers' shop and part drawings for all equipments.
- Services like internal illumination and ventilation, building water supply, sanitation and plumbing, service roads, landscaping, area lighting, etc.

ANY OTHER DESIGN AND DRAWINGS TO FULFILL EMPLOYER' S REQUIREMENT.

2127. **Format of Drawings.** All drawings submitted for approval shall be ISO standard size sheets. Every drawing shall have a title block in the bottom right corner showing:

Owner	:
Contract No.	:
Consultant	:
Contractor	:
Project	:
Drawing Title	:
Drawing Number	:
Revision Number	:
Date	:

2128. Each drawing shall bear the signature of the Project Manager on behalf of the Contractor to the effect that the drawing whether his own or from any other source has been checked by the Contractor before submission to the department.

2129. Each revision shall be properly recorded to show the number, date, specific description of revision(s) carried out, and signature of the Project Manager in the revision block. The Contractor shall be responsible for incorporating all the comments issued by the Employers representative

2130. **Construction documents.** The Contractor shall prepare Construction Documents in sufficient detail to satisfy all regulatory approvals, to provide suppliers and construction personnel sufficient instructions to execute the Works, and to describe the operation of the completed Works. The Employers representativeshall have the right to review and inspect the preparation of Construction Documents, wherever they are being prepared.

2131. Six copies of the Construction Documents shall, when considered ready for use, be submitted to the Employers representativefor pre-construction approval. If the Employers representativenotifies the Contractor that such Construction Document fails to comply with the employer's Requirements, it shall be rectified and submitted and reviewed at the Contractor's cost. Construction shall not commence prior to the approval of the Construction Documents by the Employers representative

2132. If the Contractor wishes to modify any design or document, which has been previously submitted for such pre-construction review, the Contractor shall immediately notify the Employers representativeand shall subsequently submit revised documents. If the Employers representativeinstructs that further Construction Documents are necessary for carrying out the Works, the Contractor shall upon receiving the Employers representative's instructions prepare such Construction Documents. Error, omissions, ambiguities, inconsistencies inadequacies and other defects shall be rectified by the Contractor at his cost.

2133. The design, the Construction Documents, the execution and the completed Works shall comply with the Indian specifications, technical standards, building, construction and environmental regulations, regulations applicable to the product being produced from the Works and the standards specified in the employer's requirements, applicable to the Contractor's Proposal and Schedules or defined by law.

2134. The Contractor shall provide all design, calculations, drawings and all construction documents in six hard copies, soft copies and workable CDs along with 6 sets of all designs and drawings and 3 additional cloth mounted sets of all drawings for the use of Employers representative

2135. **As-built drawings.** The Contractor shall prepare, and keep up-to-date, a complete set of "As Built" records of the execution of the Works, showing the exact "as built" location, sizes and details of the work as executed, with cross references to relevant specifications and data sheets. These records shall be kept on the Site and shall be used exclusively for the purposes of this Sub-clause. Two hard copies shall be submitted to the Employers representativeprior to the Tests on Completion.

2136. In addition, the Contractor shall prepare and submit to the Employers representative"As Built drawings" of the Works, showing all Works as executed. The drawings shall be prepared as the Works proceed, and shall be submitted to the Employers representativefor his inspection. The Contractor shall obtain the consent of the Employers representativeas to their size, the referencing system, and other pertinent details.

2137. Prior to the issue of substantial completion Certificate, the Contractor shall submit to the Employers representativeone soft copy, workable CD, one full-size original copy and six printed cloth mounted copies of the relevant "As Built Drawings", and any further Construction Documents specified in the employer's Requirements. The Works shall not be considered to be completed for issue of substantial completion certificate until such documents have submitted to the Employers representative Failure in submission of "As Built" records shall attribute the delay in completion of the work and issue of substantial completion certificate, on the part of the contractor.

2138. **Coordination drawings.** Coordination drawings shall be prepared and shall comprise composite section drawings showing coordination of mechanical and electrical work to structural work. The composite drawings shall be in sufficient detail to show overall dimensions of ductwork, piping, conduit, and related items and clearance between structural members, lighting and related features for review and approval of relative locations of work

in allocated spaces. The drawings shall indicate any conflicts of clearance problems between various trades. Coordination drawings shall be submitted to Employer's Representative. Coordination drawings will not be submitted for approval but for review only.

2139. **Equipment and interconnection diagram.** Equipment room layout drawings shall be based on actual requirements of equipment furnished and be consolidated for all trades, shall be to scale and shall show all pertinent structural and penetration features and other items, such as electrical cabinets, which affect available space. All mechanical and electrical equipment including electrical conduits, accessories, ductwork and piping shall be shown to scale in plan and also in elevation and / or section and resolve any conflicts or clearance problems. Physical descriptions of the various mechanical and electrical items shown on these drawings shall be submitted concurrently.

2140. **Quality.** Proof of quality of manufacture and reliability in field application. Such proof will normally constitute evidence that the product / equipment has been manufactured by the manufacturer, or fabricator of the quality assured for a unit or item over a period of time and has an established field service record. It shall include installation locations, dates and year of operating service. If there is no experience for an identical unit or item it may relate to a similar unit or item by the same manufacturer.

2141. **Samples.** Samples are defined as those samples required by the contract and as required by the Employer's Representative of any element, item, material or product to be used in the work. Samples shall be furnished without variation to total contract price. They shall be properly marked and tagged with the name of the project, drawing / detail reference number, manufacturer's name and accompanied by a letter of transmittal clearly listing the sample and their intended use and locations in the work s. Prototype of all items including typical details, shall be made by the Contractor for approval by the Employer's Representative.

2142. **Manufacturer’s data.** Manufacturer's data shall include catalog cuts, brochures, circular, specifications, equipment operations and maintenance manuals and other printed information in sufficient detail and scope to verify compliance to the requirements.

2143. **Performance data.** Performance Data shall include certified curves of equipment responses and performance characteristics as required.

2144. **Manufacturer’s colour charts and samples.** Manufacturer's Colour Charts and samples of all applicable materials, products and items of equipment required.

2145. **Parts and special tools list**.

a. Parts lists shall include a complete list of component parts of an item of equipment together with an expanded view or equivalent means to identify the parts.
b. Special Tools lists shall include all tools and devices required for assembly, disassembly, operation and maintenance of the equipment and an indication of the use of each item.
c. The lists shall further identify the sources of manufacture and supply of consumable supplies and those parts, special tools and supplies that are normally furnished with the purchase of the equipment or are specified to be furnished.
d. In additions, a list shall be provided showing items recommended by the manufacturer to support normal maintenance based on the manufacturer's anticipated life cycle of the part for continuous normal operation.

2146. **Certificates of compliance.** Certificate of compliance shall include material or product manufacturer's statement that the supplied items or systems conform to the specifications.

2147. **Test reports.** Test reports shall be provided as required and as follows:

a. Shop tests shall show results of required shop tests of equipments or system certified in writing by the manufacturer or their authorized Representative.
b. Field test reports shall show results of required field test and compliance with approved procedures and shall be certified in writing.

2148. **Maintenance instructions.** Maintenance instructions shall cover finish material including but not limited to hard-surfaced materials. Instructions shall include cleaning, tarnishing, dents and stains from various chemicals.

1. General Procedure for Submittals

2149. Contractor shall make submittals to the employer as follows:

2150. **Identification and Certification of Submissions**.

a. Identify each submission with the name of the project, the Contractor, the subcontractor, supplier or manufacturer, and the date of submission. Provide on each shop drawing and sample of a clear space for the review stamp and comments of reviewer and the Contractor. Where a clear space cannot be provided, attach a tag or sticker to the drawing of sample.
b. Submission shall bear the Contractor's stamp and written certification that they have been coordinated, checked for compliance with the Contract.

2151. **Cost for transmissions.** The Contractor shall be responsible for payment of all cost for transmission of submittals to the employer's Representative and the consultants.

2152. **Submission transmissions.** Accompany submissions by a transmittal form provided by the Contractor in A4 size and in a format and with text suitable for the project and provide the following printed or typed information of each transmittal form:

a. Project name and number.
b. Name of the Contractor, and when appropriate the name of the subcontractor and / or supplier or manufacturer whose submission is being transmitted.
c. Name of the Contractor's employee responsible for the Contractor's review.
d. Transmittal number which shall be consecutive throughout the works.
e. Date of submission.
f. Number each new submission item consecutively and asuffice (alphabetical or numerical but of consistent type throughout the work) to submission number for each resubmission. Suffixes shall be consecutive.
g. Number of submitted items and a description of the item.
h. The specification section number relevant to the submission, with further reference to the paragraph number of the section if required for precise identification. Do not make submission of items from more than one specification section on the same transmittal form.
i. Drawing number, title and date of each shop drawing transmitted.
j. Parts, areas etc. of the works to which samples pertain and date on which sample products are scheduled for incorporation in the works.

k. The Contractor's remarks pertinent to the submission including exceptions to, or deviations from the contract and the reason thereof.

2153. Also provide spaces on the transmittal forms for information to be inserted as designated following:

a. Date submission received by Employer's Representative.
b. Date submission returned by Employer's Representative to the Contractor.
c. Name of person to whom submission is sent for review and the date on which it was sent.
d. Name of owner's consultant reviewing submission and date returned to Employer's Representative.
e. Number of submitted items and a description of the item.
f. Action taken
g. Owner's consultants remarks including major deviations from the contractor or reasons for action if there are no notes on the submission itself.

2154. Submission which, in the Owner's consultant opinion, are incomplete contain errors or have not been checked or have been only checked superficially will be returned for submission without review.

2. Submission Review and Subsequent Action Procedures

2155. Submission will be returned by the Employer's Representative to the Contractor indicating the appropriate action to be taken by the Contractor as follows:

a. Except in cases where local jurisdictional authority approval is required to validate a particular submittal, fabrication, manufacturer, construction or purchasing may proceed.
b. The submission does not comply with contract requirements, and fabrication, manufacturer and construction shall not proceed. The Contractor shall make revisions and resubmit. The Contractor has 14 calendar days from date of receipt of advice of the Employers representativeas to compliance with his comments and to resubmit drawings evidencing such compliance.

2156. Failure of the Contractor to process submissions for review shall not relieve the Contractor of his responsibilities under the contract.

2157. Do not proceed with work dependent on submissions until the submissions have been verified by the Contractor and reviewed by the Employer. Making good work which has proceeded in error because of non-compliance with these requirements shall be at the Contractor's expense. Review of Resubmissions shall not relieve the Contractor of his responsibility for execution of the works in accordance with contract document.

2158. The Contractor shall not be relieved of responsibility for deviations from the contract or errors of any kind in the submissions or from the necessity of furnishing work required by the contract which may have been omitted from the submissions reviewed by the Employers representative The Employers Representative’s review of individual items in submissions shall not be constructed as a review of the complete assembly in which it functions.

2159. No authorization of an increase in total contracting price or time or completion shall be implied by comments marked on submissions or submission transmittals by the Employers representative

2160. Review of submission shall not absolve the Contractor from the responsibility of correctly locating all items in the works.

2161. Employer's approval of substitutions, alternatives and deviations:Whenever and wherever the Contractor proposes to make substitutions to the specified construction method or process or proposes the use of non-specified manufacturer's, products or to deviate from the material specified, the Contractor must make a full submission as required in the contract. The Contractor is advised that only the Employer has the final authority to approve or reject proposed substitutions, alternates and / or deviations from the contract.

3. Construction Photographs

2162. Work shall include progress photographs for each work of construction taken from minimum six viewpoints each month made by a professional photographer. Take one photograph from each viewpoint.

2163. Photographs shall show general extent of the works by both exterior and interior views. Each viewpoint will be selected and the number of monthly repetitive photographs taken from exactly the same viewpoint as decided by the owners authorized representative.

2164. Submit six 200mm x 254mm glossy Colour prints of each photograph to the owners authorized representative at the first of each month duly attached / pasted in the Progress Report.

2165. Title and mount each photograph per the owners authorized representative's requirements. As a minimum include on title: Project name, direction of view, and date when taken.

4. Quality Assurance

2166. The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract. Such system shall be in accordance with the details stated in the Contract. Compliance with the quality assurance system shall not relieve the Contractor of his duties, obligations or responsibilities.

2167. Details of all procedures and compliance documents shall be submitted to the Employers representativefor his information before each design and execution stage is commenced. When any document is issued to the Employers representative, it shall be accompanied by the signed quality statements for such document, in accordance with the details stated in the Contract. The Employers representativeshall be entitled to audit any aspect of the system and require corrective action to be taken. The quality assurance system and the audit of any aspect of system and necessary corrective action shall be at contractor’s risk and cost.

2168. Quality assurance shall include, but shall not be restricted to as noted herein.

2169. The Quality Assurance system should ensure the quality and quantity continuously through monitoring systems as envisaged in Project Management and Construction (PMC) proformas so as to give daily progress report, labour / manpower deployed, quantity executed on periodic basis, observations thereof through following PMC proformas placed at the end of this subsection.

- Bar bending schedule
- Pour Card
- Post Concreting check ups

- Form work check up
- Tests on materials

2170. The above shall be conformed through records of precious materials viz. Cement, steel, anti-termite chemicals, water proofing chemicals, etc.

a. The Contractor's provision and maintenance of a quality assurance program in conjunction with his subcontractors as approved by the Employer's Representative. The program shall provide inspection and testing of products during fabrication and installation as Employer's Representative may deem necessary to ensure that work is performed in compliance with the Contract. Such inspection and testing shall be performed at no additional expense to the Employer.
b. Inspection and testing required by the orders, laws, ordinances, rules and regulations of local authorities.
c. Employment of independent professional inspection and laboratory testing firms to supervise laboratory testing services as specified in the applicable codes or specifications and under the review and approval of the Employer's Representative.
d. Provision of inspection and testing instruments and devices required to ensure proper performance of quality assurance at the job site.
e. Verification by affidavits and certification that specified products meet requirements of reference standards as specified in applicable codes / specification.
f. Testing, balancing and adjusting of equipment as specified in applicable codes.

2171. **Quality Assurance in General.**

a. Maintain continuity of quality assurance surveillance throughout fabrication of products and execution of work.
b. Submit details of quality assurance tests and methods inclusive of the specification.
c. Perform inspection and testing in accordance with specified reference standards, or as otherwise approved by the Employer's Representative.
d. Calibrate measuring and testing devices periodically against certified standard equipment. Calibration shall be verified by inspection firm.

2172. **Quality Assurance of The Works on Site**

a. Provide an assurance system to ensure quality assurance by phased inspection as follows:

i. Preparatory Phase Inspection – Perform inspections prior to commencement of each part of the works which shall include a review of requirements with the supervisors directly responsible for that part of the works. Such review shall be in the form of written statements of the processes to be followed and critical characteristics, tests and similar evaluations which will be a part of inspection procedures. Verify that products incorporated with that part of the works which have been tested and applicable submissions have been made for control testing. Verify that preceding work has been completed and approved. Verify products incorporated with that part of the works

conform to submission data and Contract requirements and that necessary materials and equipment are easily and readily available.

ii. Continuing Inspection – Perform inspection on a continuing basis as each part of the works commences and on a regular basis to ensure constant compliance with the requirements.

b. Provide samples of materials to be tested in required quantities at locations where testing is performed.

c. Provide labour, instruments, testing devices, facilities and required shelter at the site:

i. To determine ambient and material temperature by thermometers with Celsius scale.
ii. To determine relative humidity of air and moisture content of materials.
iii. To facilitate inspection and tests.
iv. For obtaining and handling of samples at site and plant.

d. Upon receipt of items at the job site, the Contractor's quality assurance representative at the site shall be responsible on receipt of items at the site for noting damage suffered by them during transit and for directing that they be replaced.

e. The Contractor shall be responsible for protecting and maintaining items on the site free from damage during storage, erection, installation and maintenance.

f. When it is discovered on inspection that work is proceeding with incorrect materials or methods, ensure that corrections are immediately made and that improperly complete work is replaced.

2173. **Quality Assurance of Off-Site Works**

a. The Contractor shall impose quality assurance methods at the location of manufacture, fabrication and assembly of items to be incorporated in the works to ensure that they conform to requirements of the Contract Documents. This quality assurance shall not apply to proprietary catalog production products except as may be deemed necessary by the Contractor or as directed by the Employer's Representative.

b. The Contractor's quality assurance representative off-site shall be responsible for the release of items for transit to the job site.

c. In addition to the Contractor shall provide notice to the Employer's representative in writing at least 4 weeks in advance of packing of every batch of product components or assemblies so that the Employer or Employer's Consultants and their designated representatives may have opportunity at his / their choice of inspecting any such product components or assemblies prior to transportation at the cost of the bidder.

d. The products requiring factory, shop, supplier's or sub-contractor's inspection are identified in relevant specification in the specific codes.

e. Acceptance of product components or assemblies prior to transportation shall not imply final acceptance under the Contract.

2174. **Schedule of quality assurance operations.** Provide the Employer's Representative with a minimum of three copies of a schedule of quality assurance operations, both on-site and off-site, to outline the procedures, instructions and reports which will be used, as follows:

a. Quality assurance organization.

b. Qualifications of quality assurance personnel.
c. Authority and responsibilities of each quality assurance person.
d. Schedule of inspections and tests with personnel assigned to each task and duration of each task.
e. Schedule of required services to be provided by inspection and testing firms.
f. Coordination required in order that quality assurance is integrated.
g. Test methods which will be utilized.
h. Methods of performing and documenting quality assurance operations.

2175. **Tests Required By Jurisdictional Authorities**

a. The Contractor shall be responsible for inspection and testing required by jurisdictional authorities in conformance with the performance requirements.
b. If the Employers representativeso desires, he may delegate inspection and testing of materials or Plant by an independent body / agency. Any such delegation shall be effected for this purpose shall be considered as an assistant of the Employers representative Notice of such appointment (not being less than 14 days) shall be given by the Employers representativeto the Contractor.

2176. **Quality Assurance Reports**

a. Document each test and inspection on a report and submit the report in triplicate to the Employer's Representative.
b. Reports shall be in an approved format and shall certify off-site items produced correctly for on-site work of installed correctly, as applicable. Similarly the report shall certify items that are defective with a statement of records on corrective measures taken.
c. Include on each report the purpose of the inspection or test, a description of methods used, observations made and personnel involved.
d. The Contractor shall also maintain in the approved format a log book of all tests performed which shall include the date of test, type of test and the results of the test.
e. If inspection and testing procedures are sub-contracted to an approved inspection and testing firm, only copies of test reports signed by the approved inspection and testing firm will be acceptable.

SUB-SECTION 6.3

TEST AND SCHEDULE OF GUARANTEES

2177. Reference Sub-clauses of "Conditions Contract for Design, Build and Operate" in the Contract:

11 Testing;
11.1 Testing of the works;
11.4 Failure to Pass Tests on Completion of Design and Build
11.9 Procedure for Tests Prior to Contract Completion
11.11 Failure to Pass Tests after Completion
11.12 Retesting prior to contract Completion

2178. Contractor shall carry out tests on Completion of the Works as per clause 11.1 and sub-clause 7.4 in accordance with sub-clause 5.5 of the Conditions of Contract. Minimum test performance of works shall be as per sub-clause 10.7 and as mentioned in item 5 Schedule E: Schedule of Guarantees Part A, Part B and Part C of the Particular Conditions of the Contract.

2179. The Contractor shall carry out tests on completion of Design and Build as per sub-clause 7.4 and follow sequence in accordance with sub- clause 11.1 (a), (b) and (c) of the Conditions of the Contract.

2180. The Contractor shall design , Build and operate the works to perform as per sub-clause 10.7 under part A contract data of Particular conditions and in accordance with item 5 schedule E: Schedule of Gaurantees Part A, Part B and Part C under the Particular Conditions of the Contract In case of Contractor's failure to attain Employer's desired performance liquidated damages shall be applicable in accordance with the penalty rates mentioned in item no. 5 Schedule of Guarantee Part C of the Contract under Particular Conditions of the Contract.

2181. The Contractor shall follow the testing procedure which includes sub-clause 11.1, 11.2, 11.3, 11.6 and 11.9 of the Conditions of the Contract and as per standard testing procedure (BIS) of to be followed for different Civil and Electro-mechanical works and as per QA/QC manual works but not to be limited to the following components:

- Details of Tests relating to Plant, Materials and Parts of Works to be carried during manufacturing and/or execution of the Works as per sub-clause 28 item no.9 section 6 of Employer's Requirement.

- Minimum criteria to be attained during performance tests to be carried out on Completion is mentioned in item no.5 Schedule E: Schedule of Guarantees Part A, Part B and Part C of the Particular Conditions of the Contract and else where in Section 6 of Employer's Requirement.

- Details of Tests on and after Completion including specification of the inputs and preconditions for testing of the performance of the Works e.g. outside temperatures, operating staff, fuel, consumables, etc shall be carried out in accordance with relevant standards mentioned in sub-clause 10 and else where in section 6 of Employer's Requirement.

- Method of calculation of damages for failure to attain minimum criteria during performance tests shall be adopted as per the rates of the liquidated damages; mentioned in item no.5 Schedule of Gaurantee PartC of the Particular conditions of the contract and else where in Section 6 of Employer's requirement.

- Method of calculation of relevant sum or sums payable as non-performance damages for failure to pass any of Tests after Completion shall be adopted as per the rates of liquidated damages mention ed in item no. 5 Schedule of Guarantee Part C of the Partcular conditions and sub-section 6.4 item no. E penalties for failure to achieve the process guarantees Serial no. 2361 to 2372 of Section 6 Employer's requirement.

SUB-SECTION 6.4

OPERATION AND MAINTENANCE

A. Operation and Maintenance

2182. The Contractor is required to operate and maintain the entire Bhagalpur Water Supply System, consisting of the intake, Raw water pumping main, the water treatment plant, clear water reservoir, Transmission Main, Settled Water Pumping Station and clear water pumping station, electrical substations at the intake and WTP, electrical, instrumentation and control systems including Local SCADA system, all support buildings, roads and ancillary civil structures for the production of requisite quantities of treated water as mentioned in the table below for the period of 10 years from commissioning of the system. The operation and maintenance of clear water transmission system up to the reservoirs is proposed in the networks is included in O&M for period of 10 years

Table 125: Requirement of treated water (Year wise break up schedule)

Sl.no	O & M period	Quantity of treated water in MLD
1	During 1st year of O & M	60
2	During 2nd year of O & M	63
3	During 3rd year of O & M	66
4	During 4th year of O & M	69
5	During 5th year of O & M	72
6	During 6th year of O & M	75
7	During 7th year of O & M	78
8	During 8th year of O & M	81
9	During 9th year of O & M	84
10	During 10th year of O & M	87

2183. This section applies to the specifications for the activities and materials to be used during the Operation and Maintenance (O&M) Period. The required degree of workmanship, the performance requirements for the acceptable quality of treated water, the keeping and maintenance of records, and the responsibilities during the O&M Period are described herein.

2184. The Contractor shall operate and maintain the following major components:

a. Intake structure and raw water pump station
b. Pre-settling tank and Settled Water Pumping Station
c. Raw water transmission main
d. Water treatment plant
e. Clear water pumping station
f. Clear water pipelines for storage reservoirs (South and West)

2185. The ancillary facilities to be operated and maintained shall also include, but not be limited to: all associated buildings; campus area; on-site utilities including roadways and drainage; HV and LV substations/electrical equipment; booster chlorination system, instrumentation and SCADA systems.

2186. **Activities during O&M period.** The Contractor shall carry out the following activities. These shall not limit the requirement for other activities which are required in accordance with the terms and conditions of the Contract or are essential as per good industrial practices. The Contractor shall be responsible for, but not limited to, the following:

a. Providing treated water at the desired daily flow production as specified in Table 139 Subsection 6.4 at the outlet of the water treatment plant (discharge of the clear water pump station), with the quality of the treated water as specified or as directed by the Employer's Representative. Supply of potable drinking water of desired quality as per WHO standards and as Specified in the Central Public Health and Environmental Engineering Organization (CPHEEO) Manual on water supply and treatment.
b. Providing the required qualified staff, but not less than the minimum specified numbers at the specified levels, during the Operation and Maintenance Period and providing additional staff as required during periodic maintenance activities and during emergency situations.
c. Providing all labour, equipment, materials, fuel, consumables and all other things necessary, except Electricity, require to properly operate and maintain the constructed facilities as specified in Table 139 in Subsection 6.4 for period of time as specified in the form of contract agreement for operation and maintenance after completion of the works, all in accordance with the conditions of the contract. The Employer will furnish fuel for emergency standby engine generators that has been expended for operation during power outages from the local electrical utility. Fuel for other usages of the standby generators for testing, maintenance, etc. shall be borne by the Contractor.
d. Maintenance of HV and LV substations, electrical and mechanical equipment, etc., at the raw water intake, pumping stations, water treatment plant, the buildings, clear water pumping station and their surroundings, etc. (all works constructed in this Contract) in a neat and clean condition.
e. Maintenance of the lighting fixtures and the lighting system of all indoor and outdoor areas and replacement of all non-functional lighting fixtures within 24 hours of discovery that they are non-functioning.
f. Maintenance of roadway with drainage system for necessary repairs and planting with watering, feeding of fertilizer as required and removal and restore of dead plants.
g. Maintenance of clear water pipelines supplying water to reservoirs (South and West transmission System).

2187. **Specific maintenance activities** to be performed during the O&M Period shall include:

a. Providing required spares and maintaining adequate inventory of required accessories for equipment and for repair of operating systems so that the electrical, mechanical, instrumentation and control systems can work efficiently as per the guarantees or minimum required efficiencies stated in the Contract, without any additional costs to Employer. The Contractor may use spares and tools supplied with the Contract as required for O&M of the systems. However, at the end of the O&M Period the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the items used with new supplies of the same specifications.
b. Providing manpower for the required repairs of all facilities along with the manpower and materials for repair of the roads, buildings and utilities in campus area.
c. Maintaining the drinking water supply facilities in intake pump house buildings, WTP campus and all its units.
d. Maintaining stores for the electrical, mechanical and instrumentation and control equipment, spares, pipes and specials, valves, flow meters as well as

that for the chemicals and laboratory consumables at the water treatment plant. The maintenance of stores shall include but shall not be limited to:

- Loading and unloading of materials received and issued for the works
- Proper arrangement of material in stores to ensure its safety and easy availability
- Maintaining store areas in a neat and tidy condition
- Keeping records and accounting for the incoming materials
- Keeping records and accounting for the consumed materials

e. The Contractor shall be solely responsible for the safety and security of the goods in the stores and shall be responsible for any loss or damages occurring in the stores. He may opt for insurance coverage against the value of the goods to be stored without any additional cost to the Employer.

f. Providing periodic routine maintenance as per the manufacturer's recommendations and recommended schedules, as well as emergency (breakdown) maintenance as and when required. The Contractor shall maintain a fleet of sufficient inspection vehicles and material hauling vehicles and any other vehicles or machinery for adequate and timely repairs and/or for routine maintenance and patrolling of the systems.

g. Providing periodic routine maintenance of structures and buildings. Such maintenance shall ensure adequate cleanliness, ventilation, illumination and structural safety. In addition, the general hygienic standards shall be maintained and adequate re-planting and other horticultural activities shall be undertaken to maintain the total environment of the campuses.

h. Providing adequate manpower for security of the treatment plant, intake structure, and transmission system up to reservoirs.

i. Providing transportation services between the various areas.

j. Updating and periodic submittals of the Operation and Maintenance Manual as defined in specifications.

k. Submission of monthly reports.

l. Co-ordination with other Contractors and/ or agencies responsible for the execution, installation, operation and maintenance of the transmission and distribution system and electric service.

m. Providing all machinery like generators, drain pumps, cranes, welding machines, necessary tools, etc., as required for proper and timely maintenance activities.

B. Specifications for Materials

2188. The specifications for materials used for repairs and replacement items shall be the same as those that have been used in the original work. Specifications for any materials which were not used during the construction phase (prior to Commissioning) shall be approved by the Employer's Representative prior to usage and shall be incorporated in the updated O&M manual. During O&M period, without being limited by this clause, the Contractor shall use appropriate materials for repairs even if the material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to the use of such material, the Contractor shall submit proposals for the approval of the specifications for such material. The approved material will subsequently be included into the O&M Manual.

C. Record Keeping

2189. The Contractor shall maintain the following records and logbooks:

a. A repair history of all architectural, structural, mechanical, electrical and instrumentation control equipment. The repair log shall be categorized by the facility and the fore mentioned classifications of work.
b. Logbooks of each PLC system are functioning: alarms, troubleshooting, etc.
c. Daily power usage, input voltage and current, frequency, power factor, kWh meter readings and kW/KVA readings for the substations, including a log of time and duration of power outages and the reason for the outage's occurrence.
d. Daily usage of chemicals
e. A daily log of operations of all of the major equipment items such as clarifiers, filters, sludge dewatering equipment, chemical dosing, etc., with time tags.
f. A daily log of the start–stop operation of pumps with hourly readings for operating voltage, amperage and power factor;
g. Hourly readings of the discharge header pressure and flow rate, if metered, from pumping systems.
h. Raw and clear water quality test results on water temperature, pH, turbidity, Alkalinity, residual chlorine levels (every 6 hours) for daily record.
i. A daily log of a list of alarms with time tags.
j. A log showing the last periodic maintenance done for all pieces equipment and buildings and the time for the next maintenance check to be scheduled;
k. Observations made during patrolling of the pipelines and roads.

2190. The logbook formats and the data to be included in each logbook shall be decided during Pre-commissioning and commissioning in consultation with the Employer's Representative.

2191. In addition to the logbooks the Contractor is required to keep for the maintenance of the above items, the Contractor is required to maintain one inspection book at each pump station and the WTP. The complaints entered in the complaint register must be investigated and remedial measures must immediately be taken to correct any deficiencies.

D. Insurance

2192. The Contractor shall, without limiting his or the Employer's obligations and responsibilities, insure the following:

a. The work together with all plant and material for incorporation therein, to the full replacement cost including the Contractor's overhead and profit.
b. The Contractor's equipment and other assets brought onto site by the Contractor, for a sum sufficient to provide for their replacement at the site.
c. Insurance against sickness, diseases, body injury or death of any persons which may occur during operation and maintenance period.
d. The insurance shall be in the joint names of the Contractor and the Employer at the Contractor's cost and shall cover the Employer and the Contractor against all losses or damages from whatsoever cause from the start of the O&M Period until the date of completion of O&M Period in respect to the facilities or any sections or parts thereof as the case may be.
e. Any amounts not insured or not recovered from the insurer shall be borne by the Contractor.
f. Amount of Professional Liability insurance @ 1% of total professional liability for engagement of Manpower to be borne by the Contractor.
g. Exceptional risk to be insured if different to sub-clause 18.1 of GCC to be borne by the Contractor.
h. Employer risk to be insured if different to sub-clause 17.1 of GCC.

i. Amount of fire extended cover insurance to be borne by the Contractor.

E. Experience and Qualifications of Staff

2193. For all operations and maintenance work, the Contractor shall provide skilled staffs, who have adequate qualifications and sufficient experience of in performing similar work. Curriculum vitae (CV's) of the General (Project) Manager, Plant Supervisor and Shift Supervisors require approval of the Employer, before these personnel have being mobilized. Table 140 outlines the minimum levels (number) of staffing, and their minimum qualifications and experience on similar projects, that the Contractor shall be required deploy for carrying out the O&M functions.

Table 126: Minimum Requirements for Contractor's O & M Staff

The Minimum staff for the operation and maintenance of the project shall be employed by the contractor as specifiifed in section 6 Employer's Requirement

F. Operation and Maintenance of Specific Facilities

2194. **Pumping stations.** The general operation and maintenance functions and procedures to be performed at the Raw Water, Clear Water and Recirculation Pump Stations are listed below. These shall also apply to the Backwash Water and Sludge pumping systems and to the Backwash Air Blowers.

General

a. The following records should be kept with entries made on an hourly basis (at the same time each hour):

   i. Status of each pump (on or off)
   ii. Current draw
   iii. Electrical service voltage
   iv. Electrical service Frequency
   v. Power factor
   vi. Water level in intake well, CW reservoir
   vii. Suction and discharge pressure gauge readings
   viii. Rate of flow through meters
   ix. Total flow pumped during the last period
   x. Any alarms annunciated (time and reason)
   xi. Any abnormal operational of maintenance incidents

b. The following records should be kept with entries made on a daily basis (at the same time each day):

   i. Total number of hours of operation that day
   ii. Total quantity of water pumped that day
   iii. Total energy (kWh) consumption that day
   iv. Summary of any major alarm conditions
   v. Summary of any abnormal operational of maintenance incidents that day

c. The Contractor shall prepare and submit daily and monthly customized reports, produced from the output of the local SCADA system.
d. The usage of consumables and an estimate of that remaining in inventory at the WTP site shall be recorded on a daily basis.

Pumps and Motors

a. Operation of the pumps (starting and stopping), either in automatic (if available) or manual modes, as required.
b. Routine maintenance of the pumps and motors as per the recommendations of the manufacturer.
c. Replacement of bearings, damaged impellers and other damaged parts so that the operation of the pumps ensures the guaranteed efficiencies.
d. Maintenance of the cooling and lubricating systems.
e. Monitoring of temperature, noise and vibration levels and further investigating any potentially damaging trends of increases in temperature, noise or vibration levels.

Instrumentation

a. Maintaining the pumping station's PLC and instrument control panel (ICP), including hardware and software along with all instruments, in proper working condition. The downtime of the control system shall not exceed 4 hours for any maintenance activity, without approval of the Employer's Representative. During any downtime, the Contractor shall continue to operate the pumping station in manual mode using the local panel controls, the readings and recordingfrom local instruments and manual measurements as required.
b. Routine and periodic maintenance of the entire control system and instruments in accordance with the manufacturer's recommendations.
c. Replace any damaged control, communication and power supply cables.
d. Repair or replacement, as required, of all instruments such as flow meters, pressure sensors, pressure gauges, level sensors, float level switches, temperature scanners, vibration sensors, data loggers along with all other equipment. The down time of any individual instrument shall not exceed 24 hours without approval of the Employer's Representative.
e. Perform periodic on-site calibration of all measuring and metering equipment at 6 month minimum intervals or as recommended by the manufacturer. The calibration at the manufacturer's facility or independent laboratory shall be carried out only in case of a major failure of the instrument.
f. Update or reprogram the PLC and SCADA software at periodic intervals, as required to incorporate any process or equipment changes or upgrades at the pump station.

Other Equipment

a. Perform routine and periodic maintenance of the EOT cranes and air conditioning/ventilation systemsas per the manufacturer's recommendations.
b. Re-painting of the exposed mild steel components of piping systems, door and window frames, ladders, railings etc. in the pump house in the 3rd and 5th year of O&M to keep them in good surfaces.
c. Maintaining the surrounding areas of the pumping stations and service roads free from shrubs, weeds, grass and other unwanted vegetation.

Electrical

a. Repair or replace, as required, any damaged electrical equipment or parts for proper functioning of the electrical system.
b. Perform routine monitoring of substation equipment and taking preventive measures as required.
c. Perform routine maintenance of drives as per the manufacturer's recommendations.
d. Replace any damaged power supply cables.
e. Routine maintenance works of lighting and earthing systems.

Specific Requirements

2195. Specific requirements for pump station maintenance procedures are listed in Table.

Table 127: Maintenance Schedule for Pumping Stations

Activity	Frequency
Removal of clogged materials from coarse screens (for the raw water pump station only)	4 times per Day
Temperature of WTI/OTI w/ respect to ambient temperature	4 times per Day
Watering plant andgardens around the facility provided	2 times per Day
Check oil levels in the tank	Daily
Oil level in the bushing	Daily
Temperature of RTD, BTD in motors w/ respect to ambient temperature	Daily
Housekeeping (includes removal of dust, dirt, cobwebs, etc.)	Daily
Check vibration and noise levels of pump sets	Weekly
Check operation of disconnect switch	Weekly
Check operation of crane for all motions	Monthly
Clean level sensors	Weekly
Exercise (fully closing and opening of) sluice gates and valves	Monthly
Submission of report on maintenance to Employer	Monthly
Check IR and PI values of motors	Monthly
Condition of silica gel in breather and replacementif required	Monthly
Inspection of pump bearings	Every 6 Months
Preparation of list of spares for satisfactory operation	Every 6 Months
Perform a transformer oil sample analysis	Every 6 Months
Inspection of switchboards, cabling, junction boxes, etc.(i.e. visual inspection), check tightness of nuts and bolts, earthing contacts, checking tightness of terminal blocks, etc.)	Every 6 Months
Inspection of pump impellers and wear rings	Every 12 Months
Inspection of motors including windings, poles and bearings	Every 12 Months
Measurement of earth resistance	Every 12 Months
Checking of relays and alarms (trough secondary injection)	Every 12 Months
Check conditions of gaskets and replace them if required	Every 12 Months
Replacement of bearings	After 90% of stated life, or when they become noisy, and within a day of breakdown
Replacement of bulbs, lamps etc.	Within a day of breakdown
Tightening or replacement of glands	When leakage increases beyond an acceptable limit
Lubricating equipment (greasing, oiling)	As per manufacturers recommendation
Attending to breakdowns	As and when they occur

2196. The Contractor shall also perform the following:

a. Dispose of screened material.
b. Provide consumables such as grease and oil
c. Maintain office furniture and tools for operating and maintenance staff.
d. Provide safety accessories as gloves, shoes, first aid kits, fire extinguishers etc.
e. Ensure the safety of plant and equipment.
f. Furnish the required information to the Employer.

2197. **Water treatment plant.** The general operation and maintenance functions to be performed at the Water Treatment Plant are listed below.

General:

a. The operation and maintenance of the WTP shall include all of the water treatment process facilities from the inlet chamber ahead of the pre-settling basins to the clear water reservoir/pump station.

b. Providing the required manpower for routine operation of all units including aeration, flow metering, flash mixing, flocculation, settling, filtration including backwashing, clear water pumping, chemical feed, the HV/LV substation, PLC control, all motors and valves in the system, and laboratory.

c. The following records should be kept for each major piece of equipment and operating system with entries made on an hourly basis (at the same time each hour):

i. Status of each motor/drive (on or off)
ii. Current draw
iii. Electrical service voltage
iv. Electrical service Frequency
v. Power factor
vi. For backwash water pumps and blowers, starts and run time during that period
vii. Water level in CW reservoir
viii. Suction and discharge pressure gauge readings on pumps
ix. Rate of flow for meters
x. Total flow metered during the last period
xi. Any alarms annunciated (time and reason)
xii. Any abnormal operational of maintenance incidents

d. The following records should be kept for each major piece of equipment and operating system with entries made on a daily basis (at the same time each day):

i. Total number of hours of operation that day
ii. Total quantity of water metered that day
iii. Total energy (kWh) consumption that day
iv. Total chemical consumption of each chemical and chorine that day
v. Summary of any major alarm conditions
vi. Summary of any abnormal operational of maintenance incidents that day

e. Major pieces of equipment and operating systems shall include:

i. Raw water flow meter
ii. Flash mixers and Flocculators (if applicable)
iii. Sludge scraper and extra actionvalves (settling tanks)
iv. Filter backwash pumps
v. Filter backwash airblowers
vi. Backwash water flow meter and control valve
vii. Treated (Clear) water flow meter
viii. Clear water reservoir levels
ix. Clear waterpumps (see Subsection 14.5.1)
x. Utility water pumps, if applicable
xi. Chemical mixing systems (alum and lime)
xii. Chemical dosing systems (alum and lime)
xiii. Chlorine dosing system

xiv. Polymer dosing systems (for water purification process and sludge handling)
xv. Chemical usage (alum, lime, chlorine and polyelectrolyte)
xvi. Sludge transfer (to thickeners) and Thickened sludge extraction (to Dehydrator) pumps
xvii. Sludge thickening (sludge concentration) including sludge scraper and supernatant water quality
xviii. Thickened sludge feed pumps
xix. Sludge dehydrator
xx. Sludge hauling (truckloads)
xxi. Laboratory (records kept separately)

f. Perform weekly lubrication of all gears of reduction motors, motorized valves, gate operators and other parts of the system.
g. Periodically exercise and check all valves and gates for their manual and electrically actuated operation. Test the operation of electrically actuated valves from the local control console and PLC also. Correct any defects in the operation.
h. The Contractor shall prepare and submit daily and monthly customized reports, produced from the output of the local SCADA system.
i. The usage of consumables and an estimate of that remaining in inventory at the WTP site shall be recorded on a daily basis.
j. Lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.
k. Operation and maintenance of all circuits and buildings associated with the treatment works.
l. Breakdown maintenance of all electrical, mechanical and instrumentation equipment.
m. Routine maintenance works of lighting and earthing system.
n. Providing safety accessories, e.g. gloves, shoes, first aid box, etc.
o. Ensuring and maintaining fire and safety equipment.
p. Maintenance of roads and lighting fixtures and lighting circuits in WTP campus.

Pre-treatment Processes:

a. Inspection of thecascade aerator (if applicable) and each flash mixing, flocculation tanks and platesettlers at least once a year. Each tank shall be completely dewatered and cleaned. The concrete shall be structurally inspected for any leakage or damages. The flash mixers, flocculators and sludge scrapers (if applicable)shall be inspected for any structural damage, damages to the moving parts, unbalancing of their rotations, chains, etc. and any damages to their coatings and other items as stated in the manufacturer's O&M Manuals. Any inspections stated in the manufacturer's O&M Manuals to be performed at a more frequent interval shall be added to this list.
b. The PVC components of the plate settlers shall be carefully inspected for breaks, cracks, pitting and any signs of the detrimental effects of heat or the sun's radiation. Any damaged plates or tubes shall be replaced. The fastening system shall be thoroughly checked to replace or retighten any nuts and bolts that have worked loose.
c. All required repairs shall be made before placing the tankage back into service. Any damages to coatings shall be touched-up or repaired after structural and mechanical repairs have been made, but before refilling the tank with water. Cleaning shall be performed prior to placing the tank back into service after repairs have been made.

d. Routine maintenance of the mixers,flocculatorsand sludge scrapers as per the recommendations of the manufacturer.
e. Replacement of bearings, damaged impellers/paddles and other damaged.
f. Maintenance of the gearboxes (gear reducers).
g. Monitoring of noise and vibration levels and further investigating any potentially damaging trends of increases in noise or vibration levels.
h. Monitor the automatic and manually initiated automatic functioning of PLC and SCADA system to initiate and operate the sludge extraction cycle of each settling tank. Repair any hardware, software or mechanical equipment malfunctioning as soon as they are noted.

Filtration:

a. Inspection of each filter cell at least once a year. Each filter shall be completely dewatered and the top layer of the sand media raked and mud balls and other impurities removed. The sand media shall be 'topped off' with new media to achieve its original design layer thickness. The exposed concrete shall be structurally inspected for any leakage or damages. The exposed air piping shall be cleaned and the coating repaired or touched up. The gates and valves shall be inspected including the seals and any leakage repaired.
b. Cleaning and disinfection shall be performed prior to placing the tank back into service after repairs have been made
c. The integrity of the under drain system shall be monitored for any irregularities in the backwash water and backwash air flow patterns. An unbalance of water or air distribution that can be noted visually shall warrant further inspection by taking the filter cell out of service and removing the sand media and support gravel in an area to inspect the nozzles. Bubbling or a higher rate of flow in an area usually indicates a broken or damaged nozzle. Lack of flow in an area usually indicates some degree of plugging.
d. Monitor the automatic and manually initiated automatic functioning of the PLC and SCADA system to initiate and operate the backwash cycles of each filter. Repair any hardware, software or mechanical equipment malfunctioning as soon as they are noted.

Clear Water Pump Station:

The Clear Water Pump Station O&M is covered in Subsection 14.5.1 Pumping Stations. The utility water pumps shall be maintained and inspected as discussed below:

a. Maintenance and inspection of the utility water pumps on a regular basis with the dismantling and complete inspection of the pumps at least once a year. The wear rings, impellers and bearings shall be replaced when they show abnormal or excessive wear, or cannot pump their rated capacities any longer.
b. Maintain and regularly inspect the seal water system, if applicable. Replace the packing in accordance with the pump manufacturer's recommendations, but no less frequently than every 4 months.

Sludge Dewatering:

a. Inspection of the sludge pump sump and thickener tank at least once a year. Each tank shall be completely dewatered and cleaned. The concrete shall be structurally inspected for any leakage or damages. The thickener sludge scraping mechanism shall be inspected for any structural damage, damages to the moving parts, unbalancing of their rotations and damages to their coatings and other items as stated in the manufacturer's O&M Manuals. Any inspections stated in the manufacturer's O&M Manuals to be performed at a more frequent interval shall be added to this list.
b. All required repairs shall be made before placing the tankage back into service. Any damages to coatings shall be touched-up or repaired after structural and mechanical repairs have been made, but before refilling the tank with water. Cleaning shall be performed prior to placing the tank back into service after repairs have been made.
c. The dehydrator units shall be inspected and maintained in accordance with the manufacturer's recommendations, and at least once each year shall undergo a thorough inspection of the wearing surfaces, hydraulic systems, gear reducers, etc., to assure their long-term reliability.
d. Maintenance and inspection of the sludge transfer (to the thickener), thickened sludge extraction and dehydrator feed pumps, mixers on sludge storage and day tanks, polymer dosing system and dehydrator units on a regular basis with the dismantling and complete inspection of the pumps and mechanism at least once a year. The wear rings, impellers and bearings of pumps shall be replaced when they show abnormal or excessive wear, or cannot pump their rated capacities any longer.
e. Ensuring environmentally friendly disposal of the dewatered sludge at approved site(s).
f. Maintenance and inspection of the polyelectrolyte dosing systems. Calibrate the dosing system at least once every month. Install permanent calibration columns on the pump suctions to verify and readjust the pumping capacities as required.

Chemical Systems:

a. The Contractor shall provide the required chemicals such as alum, lime, chlorine and nontoxic polyelectrolyte. The samples shall be tested prior to use and shall be approved from the employer.
b. A minimum 30 days stock required for average dosage of all chemicals and chlorine chemicals shall be maintained at the site to ensure an adequate supply. The Contractor shall optimize the usage of the chemicals to avoid overdosing and wastage.
c. Inspection of the chemical dissolution/mixing tanks at least once a year. Each tank shall be completely dewatered and cleaned. The concrete and tiles shall be structurally inspected for any leakage, damages or un-bonding. The mixers shall be inspected for any structural damage, damages to the moving parts, unbalancing of their rotations and damages to their coatings and other items as stated in the manufacturer's O&M Manuals. Any inspections stated in the manufacturer's O&M Manuals to be performed at a more frequent interval shall be added to this list.
d. All required repairs shall be made before placing the tankage back into service. Any damages to coatings shall be touched-up or repaired after structural and mechanical repairs have been made, but before refilling the tank with water. Cleaning and disinfection shall be performed prior to placing the tank back into service after repairs have been made.
e. Routine maintenance of the mixers as per the recommendations of the manufacturer.

f. Replacement of bearings, damaged impellers and other damaged parts.
g. Maintenance of the gearboxes (gear reducers).
h. Maintenance and inspection of the chemical dosing pumps on a regular basis with the dismantling and complete inspection of the pumps at least once a year. The wear rings, impellers and bearings shall be replaced when they show abnormal or excessive wear, or cannot pump their rated capacities any longer.
i. Calibrate the dosing system at least once every 30 days. Install permanent calibration columns on the pump suctions to verify and readjust the pumping capacities as required.
j. Monitoring of noise and vibration levels and further investigating any potentially damaging trends of increases in noise or vibration levels.
k. All the testing laboratories/test equipment responsible for effective O&M shall have to be updated/suitably calibrated/renewal of warranty/repaired, etc. by the Contractor.

Instrumentation:

a. Maintaining the pumping station's PLC and instrument control panel (ICP), including hardware and software along with all instruments, in proper working condition. The downtime of the control system shall not exceed 4 hours for any maintenance activity, without approval of the Employer's Representative. During any downtime, the Contractor shall continue to operate the pumping station in manual mode using the local panel controls, the readings from local instruments and manual measurements as required.
b. Routine and periodic maintenance of the entire control system and instruments per the manufacturer's recommendations.
c. Replacement of damaged controls, communication cables and power supply cables.
d. Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment. The downtime of any individual instrument as referred above shall not exceed 24 hours without approval of the Employer's Representative.
e. Periodic site calibration of all measuring/metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done only in case of major failure/ repairs of the instruments.

Other Equipment and Systems:

a. Perform routine and periodic maintenance of the EOT cranes and monorail hoisting systems in accordance with the manufacturer's recommendations
b. Re-painting of the exposed mild steel components of piping systems, door and window frames, ladders, railings etc. in the pump house in the 3rd and 5th year of O&M to keep them in good shape.
c. Maintaining the surrounding areas of the WTP campus and service roads free from shrubs, weeds, grass and other unwanted vegetation.
a. Annual cleaning and disinfection of the clear water reservoir(s).
b. Providing safety accessories, e.g. gloves, shoes, first aid box, etc.
c. Ensuring fire and safety equipment.
d. Maintenance of safety equipment in chlorination unit and chlorination storage unit.

Electrical

a. Operation and maintenance of all circuits and buildings associated with the treatment works.
b. Maintenance of all electrical, mechanical and instrumentation equipment.
c. Routine monitoring of HV/MV Substation equipment (transformers and switchgear) and taking maintenance measures as required.
d. Routine maintenance of lighting and earthing systems.
e. .
f. Replacement of damaged power supply cables and wiring.

Common Facilities and Equipment Items:

2198. **Lubrication.** The Contractor, in the Operation and Maintenance Manuals, shall furnish a complete schedule of recommended oils and other lubricants. The number of different types of lubricants shall be kept to a minimum. For grease lubricated bearings for electric motors, lithium based grease is preferred.

2199. The Contractor shall indicate the brand names of indigenously available equivalent lubricants, with their complete duty specifications, in the O&M Manual. The Contractor shall also furnish the schedule of quantities for each fill or replacement, the frequency of filling or replacing lubricants and any seasonal requirements in the O&M Manual.

2200. Where lubrication is with grease, preference shall be given to a pressurized system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month.

2201. Where more than one type of special grease is required, a grease gun for each special type shall be furnished and utilized.

2202. All lubrication systems shall be designed so as not to cause a fire hazard or a pollution hazard. Curbing shall be installed around lubrication systems to contain any spillage or leakage.

2203. **Spare parts.** All spare parts used for any piece of equipment for its maintenance shall be from the manufacturer of the equipment, or if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment as supplied and installed.

2204. All spare parts shall be packed for long storage under the climatic conditions prevailing at the Project Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

2205. **Buildings.** The Contractor shall carry out ordinary repairs to buildings during the O&M period. The repairs may include but not limited to the following items:

a. Easing of doors and windows
b. Replacement of broken, including cracked, window panes
c. Repairs to roofs, especially after periods of heavy rain
d. Attention to drains, especially after periods of heavy rain
e. Repairs of rain water spouts
f. Attention to plinth protection.
g. External white or Colour wash,
h. Repainting and touch-up: external or internal surfaces
i. Replacement of cracked or broken floor tiles

j. Repair of cracks in concrete walls and floors
k. Repair of service within the campus.
l. The frequency of repairs must not be less than as specified below:

Table 128: Frequency of Repairs

Sr.No.	Nature of Repair	Frequency of Repair
1	External coating after attending to minor repairs such as damage to plaster, etc.	Every 2 yrs (Four in the O&M Period)
2	Internal finishing (painting) after attending to minor repairs such as damage to plaster etc.	In the 3rd6th yr and 9th year of the O&M Period

m. Repairs to buildings, especially painting, shall not be performed during the monsoon season (normally June – September), unless they are critical and can't be delayed.

2206. Performing the following repairs prior to the onset of the monsoon season is essential:

a. Any faults in the electrical installation, stray current, earthing, exposed wire ends and any other electrical related hazards, should be suitably taken care of. Wiring, which is damaged or brittle, shall be replaced.
b. Damaged sanitary sewer lines shall be replaced and clogged lines cleared.
c. Proper drainage of the areas around each building shall be improved to avoid stagnation of rain or wash-down water, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains shall be maintained. Any choked drains should be properly cleared.
d. Leaking roofs should be attended to immediately with suitable repairs and treatment. The rain waterspouts shall also be cleared of blockages, etc. The roof shall be swept clean of leaves, debris, etc., if any start to accumulate.
e. The plaster on outer walls of each building, shall be repaired before the monsoon season starts in order to prevent dampness penetrating inside. Where plinth protection has been provided, it shall be checked and the damaged portions repaired.
f. Damaged flooring shall be repaired or replaced, in order to prevent dampness inside the rooms, etc.
g. Periodic repairs of door and window frames, water taps, furniture, air conditioner, ventilating fan, ceiling fan,electric circuits, etc. shall be made when problems occur using material of the same quality as used during construction.

WTP Campus

a. Providing security guards in the campus areas round the clock, and gardeners, janitors and other manpower to maintain the campus area in a green, neat and tidy condition.
b. Maintenance of the gardens in the campus areas, which will generally involve the following activities:
   - Watering of plants at required intervals.
   - Replacing any dead plants or damaged plants at no additional cost to the Contract.
   - Maintenance operations such as hoeing, weeding, etc.

- Pruning, trimming and cutting of trees to shape them and to enhance growth.
- Removing shrubs, weeds, grass and unwanted vegetation after each rainy season.

c. Maintenance of roads, lighting fixtures and lighting circuits.
d. Maintenance of potable water supplies to buildings and drainage facilities.

2207. **Raods.** Any maintenance and repair for cement concrete as well as bituminous roads shall be carried out in conformity with the relevant Standard Specifications to the required levels, grades and lines using approved materials. In executing maintenance work, a reference is made to the IRC publication: *Manual for Maintenance of Roads* and *Code of Practice for Maintenance for Bituminous Surfaces of Highways, IRC 82-1982* for guidance and compliance wherever applicable. Wherever the Specification is not relevant, 'Good Engineering Practice' shall be adopted for this work to the satisfaction of the Employer's Representative.

G. Miscellaneous Works

2208. The Contractor under this scope of work is also required to maintain the roadways in a clean and unobstructed condition, which includes the removal of stones, fallen trees, dead animals, etc., as and when noticed by the patrolling teams or as directed by the Employer's Representative.

2209. The pipe culverts and the other cross drainage structures built or rehabilitated under the Contract shall be regularly inspected and suitable cleaning and re-grading work shall be done to ensure against impounding water near the structures. Any structural damages shall be repaired or the structures shall be demolished and re-constructed, considering the extent of the damage, as per the directions of the Employer's Representative.

H. Special O&M Activities to be provided

2210. The activities described in this Subsection are O&M activities which may not normally be provided on a project such as this, but the Contractor is alerted that they shall be required here.

2211. **Desilting of the intake well.** During snow water melts down, rains and during the monsoon rains, it is anticipated that a significant amount of sediment (sand and fine silt) will be transported down the Ganga River and be deposited in various locations, depending upon that particular season.

2212. The Contractor shall remove sand and silt deposits (desilt) from in and around the intake well structure so as not to restrict the pumping of raw water. Otherwise, the lower level intake gates may very well not be functional during this rainy high river level period of each year.

2213. The Contractor shall develop a method of keeping the intake well desilted, as illustrated in relevant subsection.

2214. Additional de-silting measures may need to be taken by the Contractor during the O&M Period such as removing sediment from the outside of the well structure by barge, or removing sediment located inside the well from the outside through the intake openings or through openings placed in the pump house floor.

2215. **Replacing pump impellers and bearings.** The raw water, clear water, backwash water, utility water, sludge pumps and waste water recirculation pumps shall have their

impellers (or bowls), mechanical seals and their bearings replaced near the end of the 5th year of the O&M Period. The wear rings and any seal water packing shall be replaced at this time also.

2216. Essentially these pumps shall be rebuilt in accordance with the manufacturer's recommendations for overhauling their pumps at this time, right before handing over the Works to the Employer. All pumps shall be rebuilt no sooner than 6 months before the end of the O&M Period with all work completed no later than 2 months before O&M Period, so as to monitor the pumps for a period prior to the end of the Contractor's responsibilities.

2217. **Cleaning of reservoirs.** Within 6 months before the end of the O&M Period, the Contractor shall dewater, inspect and clean the clear water reservoir and the backwash water storage tank. Any leakage or cracks of 1.5 mm (1/16-inch) or larger in width shall be sealed with non-shrink epoxy grout.

2218. Any signs of algal or slime growth shall be removed. All sediment shall be removed from the tank floors. The walls, floors, pillars, beams and underside of the roofs shall be amply swabbed with a chlorine solution of at least 20 ppm concentration which shall be allowed to remain on the structure for 2 hours before being removed. The tank shall then be filled with potable quality water which shall have a chlorine concentration at least 2 ppm and which shall be allowed to stand for 4 hours, prior to placing the tank back into service. If the water in the tank has become contaminated with debris, etc. it shall be drained and replaced with fresh water at the end of the cleaning cycle.

2219. **Painting and recoating.** The interiors and exteriors of all buildings shall be repainted prior to the end of the O&M Period, as stated in this Subsection.

2220. All submerged and un-submerged concrete and metals which were coated as a part of the construction project, shall be have their coatings inspected within the last 8 months of the O&M Period. These structures and items shall be cleaned; their surfaces prepared and touch-up painted or repainted as required by their condition, as determined by the Employer's Representative.

2221. All concrete flooring which received a coating of sealer/hardener as a part of the construction project shall be recoated with the same within 4 months of the end of the O&M Period. Surfaces preparation shall be in accordance with the coating manufacturer's recommendations.

2222. All tile flooring and wall covering shall be inspected near the end of the O&M Period. Broken or cracked and dull looking (void of luster) tiles shall be replaced with new tile. All other tile shall be cleaned with an appropriate alkaline or acidic cleaning solution. The grout shall also be cleaned, especially to remove all signs of mold and algae. Any cracked, moldy, or broken areas of grout shall be removed and re-grouted. Any areas where the grout has been worn down shall be scarified and new grout added.

2223. The roofing on all buildings shall be thoroughly inspected and any broken tiles or shingles replaced and any loose downspouts made firm.

2224. **Repaving of roads.** All pot holes, damaged pavement edges and all shoulder areas shall be repaired prior to the end of the O&M Period. If necessary, all paved roads shall receive a new surface course near the end of the O&M Period.

I. Penalties for Failure to Achieve the Process Guarantees

2225. In case of failure to supply the required quantity and/or quality of treated water, liquidated damages shall be imposed for such failure to meet the performance criteria, as described in the following subsections. The Employer will be entitled to recover any such damages from the monthly progress payments to be made to the Contractor in the month in which the failure occurred, or at any time thereafter from the subsequent monthly progress payments.

2226. If the Contractor does not meet the daily production (supply) quantity and/or quality as directed by the Employer due to his operational limitations, performance damages shall be imposed on a daily basis, taking into account the following parameters:

a. No performance damage will be imposed for failure to supply treated water due to the non-availability of power on the part of the local electrical utility.
b. The limit of performance damage shall not exceed 5% of total O&M contract.

2227. **Short supply.** The supplied treated water produced and is pumped to the main reservoir and shall be measured for each day from midnight to midnight for 24 hours period. The Contractor is expected to meet the daily supply as per the direction of the Employer.

2228.2228. The Employer may direct the Contractor to produce a daily quantity of treated (clear) water which is less than the full design capacity of the WTP. Such direction from the Employer will alleviate the Contractor from his duty to operate the WTP at full production capacity. Also if the WTP production needs to be shutdown temporarily or restricted due to the main reservoir becoming full and leaving no place to send the treated water, the Contractor will not be responsible for this loss of production.

2229. In case the daily treated water supply is below the requirement (a shortfall condition), performance damages shall be imposed in line with Particular Conditions of the Contract, Part A: Contract Data (subclause 10.7) and Part B: Special Provisions (Schedule E: Schedule of Guarantees).

2230. **Power consumption in WTP and pump stations.** The expected power consumption for the raw, settled and clear water pump stations shall be calculated every month on the basis of the characteristic curves submitted by the Contractor and the actual duty conditions for the month (calculations can be done on an hourly basis).

2231. The calculated power demand will be compared with the actual power consumption and if the actual consumption is more than the calculated (expected) consumption, the excess amount will be recovered from the Contractor per conditions laid out in Particular Conditions of the Contract, Part A: Contract Data and Part B: Special Provisions (Schedule E: Schedule of Guarantees). Assessment of performance damages for excess power consumption will not be subject to any upper limit.

2232. **Chemical consumption (for process).** The estimated chemical consumption for the treatment process shall be calculated on the basis of the raw water quality and submitted by the Contractor. The bid price assumes that the Contractor has considered the cost of chemicals.

J. Payments

2233. The Contractor shall be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, as quoted on monthly basis in the Schedule of Prices, shall include all costs for carrying out O&M responsibilities, except for the following items for which the Employer will bear the cost:

a. The cost of the electric power consumed, starting on the day of Commissioning of the Works, which will be paid directly to local power supply utility by the Employer.

b. This payment is subject to supply of specified quantity of water as mentioned in sub-section 6.4 and treated water supply quality as per CPHEEO Manual, otherwise commensurate performance damages will be recovered from the Contractor's payments.

K. Recording Formats

2234. Suggested formats to be followed for proper recording of pumping and treatment plant operations are given on the pages that follow. The formats can be finalized during the execution stage. These formats shall also be applicable for distribution network wherever applicable and the contractor may produce additional formats as required for submission of water supply record through distribution system in consultation with the Representative of the Employer.

Plant Data:

Pumping Station / Unit Process:
Date:

Time (Hrs)	Current Ampere (A)	Voltage (V)	Frequency (Hz)	Meter Reading (kWh)	Flow Reading (m^3)	Discharge Pressure (kg/cm^2)	Operator's Signature
1							
2							
3							
4							
5							

Pump Operation:

Pumping Station:
Date:

Time (Hrs)	Pump No.						Comments
	1	2	3	4	5	6	
1							
2							
3							
4							
5							
Total hours of operation							

Mark 'X' if pump is not available
Indicate Starting and Stopping Times

Pump Data:

Pumping Station:
Pump No.
Date:

Time (Hrs)	Voltage (V)	Current Ampere (A)	Suction Gauge Reading* (m)	Water Level in Sump (m)	Delivery Gauge Reading (m)	Signature
1						
2						
3						
4						
5						

* For Horizontal pumps only

Power Usage Statement:

Pumping Station:
Month:
Date:

Date	Calculated Power Consumption (kWh)	Allowances(k Wh)	Actual Power consumption (kWh)	Difference (kWh)	Signature
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

Monthly Report:

Pumping Station:
Month and Year:

Component	Pump No							Comments
	1	2	3	4	5	6	7	
No. of Hours of Operation								
Maximum Vibration (mm/sec)								
Maximum Noise Level (dBa)								
Total Quantity Pumped (m^3)								
Power Consumption (kWh)								
Total No. of Hrs of Power Failure								
Total No. of Hrs Pump Not Available								
Reason for Non Availability of Pump[1]								

Component	Pump No							Comments
	1	2	3	4	5	6	7	
Actions Taken for Rectification[1]								
Non Availability of Any Other Equipment[1]								
Reason Other Equipment Not Avail.[1]								
Actions Taken for Rectification[1]								

Note:
[1] Assign a designation letter and enter the explanation below.

Designation	Explanation
A	
B	
C	

Signature

Format 1

Daily Report on Operation and Maintenance

Prepared by: **[Name of Contractor]**
Report For: **[Date]**

A. Consumption Records						
Sr. No.	**Item**	**Meter Reading or Other Records at 9:00 hrs of**		**Daily Quantity**	**Average per m^3 of Raw Water**	**Remarks**
		Reporting Day	**Previous Day**			
A.1	Raw Water Quantity Received (m^3)					
A.2	Alum Quantity Consumed (kg)					
A.3	Lime Quantity Consumed (kg)					
A.3.1	Pre-Lime					
A.3.2	Post-Lime					
A.0.433	Total					
A.4	Polymer (kg)					
A.4.1	For water purification					
A.4.2	For Sludge Handling					
A.4.3	Total					
A.5	Chlorine Quantity Consumed (kg)					
A.5.1	Pre-chlorination					
A.5.2	Post-chlorination					
A.5.3	Chlorine Boosting (distribution)					
A.5.3	Total					
A.6	Calcium Hypochlorite					
A.7	Electrical Power consumed (kWh)					

B. Quality Records							
Particulars		**At 9:00 hrs**	**At 15:00 hrs**	**At 21:00 hrs**	**At3:00 hrs**	**Average**	**Remarks**
B.1	**Raw Water**						
B.1.1	**Clarified Water**						
	Settler No. Settler No.						
	Average (Combined)						
2	**Filtered Water** Each Filter **Average** (Combined)						
	Filter No.						

	Filter No. Filter No.						
	Average (Combined)						
B.2.1	CW reservoir						
B.2.2	Distribution water						
3.1	Raw Water						
3.2	CW water						

Note: Turbidity of clarified and filtered water shall be recorded average or combined one. Those for specific settlers or filters shall be recorded as required by the Employer's Representative

C. Filtration Plant						
C.1	**Quantity of Backwash Water Used (m^3)**	**Record at 9:00 hrs of Reporting Day**	**Record at 9:00 hrs of Previous Day**	**Quantity**	**No. of BW's**	**Remarks**
	Each Filter					
	Average (combined)					

D. Operational					
Sr. No.	**Unit**	**From hrs.**	**To hrs.**	**Total time**	**Remarks**
D.1	**Filters**				
D.1.1	**Backwashing**				
	Filter No.				
	Filter No.				
	Filter No.				
	Total				
	Filter No.				
D.1.2	**Down Time**				
	Filter No. Filter No. Filter No.				
	Total				
D.2	**Plate/Thube Settlers**				
D.2.1	**Down Time**				
	Settler No. Settler No.				
	Total				
D.3	**Downtime of Other Units**				
D.3.1	**Name of facility**				
D.3.2	**Name of facility**				
D.0.433	**Name of facility**				

Signed by: _____
Designation: _____
On behalf of Contractor: _____

Format 2

Monthly Report on Operation and Maintenance

Prepared by: **[Name of Contractor]**
Report For: **[Month]**

A. Consumption Records						
Sr. No.	**Item**	**Reading on Last Day of**		**Quantity Used This Month**	**Average per 1000 m^3 of Raw Water**	**Remarks**
		This Month	**Previous Month**			
A.1	Raw Water Quantity Received (m^3)					
A.2	Alum Quantity Consumed (kg)					
A.3	Lime Quantity Consumed (kg)					
A.4	Chlorine Quantity consumed (kg)					
A.5	Polymer Quantity consumed (kg)					
A.6	Calcium Hypochlorite consumed (kg)					
A.7	Electrical Power consumed (kWh)					

B. Quality Records					
Particulars		**Average During Month**	**Maximum During Month**	**Minimum During Month**	**Remarks**
B.1	**Turbidity** (NTU)				
B.1.1	**Raw Water**				
B.1.2	**Clarified Water** Average (combined)				
B.1.3	**Filtered Water** Average (combined)				
B.4	**Residual Chlorine (ppm)**				
B.4.1	CW water				
B.4.2	Distribution water				
B.3	**pH**				
B.3.1	Raw water				
B.3.2	CW water				

C. Quantity of Dewatered Sludge (by Storage Measurement)				
From Dehydrator(s)	**Total During Month**	**Daily Average**	**Average per m^3 of RawWater**	**Remarks**
m^3				
kg				
Truck Loads				Capacity of truck: tonne

D. Operational				
Sr. No.	**Unit**	**Total Time/Volume During This Month**	**Daily Average**	**Remarks**
D.1	**Filter**			
D.1.1	**Backwash Water (monthly total volume)**			
D.1.2	**Down Time** Filter No. 1 Filter No. 2 Filter No. 3			
D.2	**Plate Settlers**			
D.2.1	**Downtime** Settler No. 1 Settler No. 2 Settler No. 3			
D.3	**Downtime of Other Units**			
D.3.1	**Name of facility**			
D.3.2	**Name of facility**			
D.0.433	**Name of facility**			

Signed by: _____
Designation: _____
On behalf of
Contractor:_____

SUB-SECTION 6.5

SITE CONDITIONS AND REQUIREMENTS

2235. Reference Sub-clauses in the Contract:

1.9	Care and Supply of Documents;
4.6	Co-Operation;
4.7	Setting Out;
4.19	Electricity, Water, Gas;
6.6	Facilities for Staff and Labor;
7.2	Samples

2236. Specify the following information:

1.9 Care and Supply of Documents

The Contractor shall keep a copy of Contract Agreement publication like

i. Copy of all relevant Indian Standards (IS) issued by the Bureau of Indian Standards
ii. IS 732 code of practice for Electrical Wiring Installations.
iii. Latest publication of CPHEEO manual on Water supply and treatment
iv. Quality Assuarance / Quality Control Manual
v. Inception Report
vi. Variation orders and other Communications
vii. Ministry of Road Transport & highway (MORTH) specifications for Roads and Bridge works and relevant IRC specifications.
viii. Construction documents: Process design, system design, site plans, layout plans, drainage & service roads, Pipelines plans & profiles, all approved drawings including structural drawing, reports of survey, investigation data, As built drawing
ix. Each documents shall be in the custody and care of the contractor unless and until taken over by the Employer.
x. Contractor shall supply to the Employer's Representative 6 copies of each of the contractor's document.

4.6 Co-Operation

Contractor shall as specified in the contract or as instructed by the Employer's Representative allow appropriate oppornuties for carrying out work to

- Employer's Representative
- Any other contractors employed by the Employer
- The personnel of any legally constituted public authorities
- Who may be employed in the execution on or near the site of any work not included in the contract

4.7 Setting Out

Contractors shall set out the work in relation to the original lines, levels of reference specified in different sub-section of section 6 Employer's Requirement or notified by the Employer's Representative. Contractor shall be responsible for the correct positioning of all parts of the works as per approved drawing of different components of the work and shall rectify any error in the positions levels

4.19 Electricity, Water, Gas;

Contractor shall be responsible for the provision of all electricity, water and other services like gas he may require. Cost of supply of electricity, water etc from the existing utility services will be as mentioned in item 16b, 16c, 16d of section 6 Employer's requirement.

6.6 Facilities for Staff and Labor;

The contractor shall make his own arrangement for sanitary (Toilet facilities) for his workmen and other staff as mentioned in item 16e temporary sanitary provision sub – section 6.1 of Section 6 Employer's requirement.

7.2 Samples

Contractor shall submit the following samples of materials and informations to the Employer's Representative in accordance with the procedures for contractor's documents as described in sub – clause 5.2of Conditions of Contract

i. Manufacturer's standard samples of materials and samples specified in the contract all at the contractors cost
ii. Additional samples instructed by the Employer's representative as a variation
iii. Each samples shall be labeled as to origin and intended use in the works.

SUB-SECTION 6.6

EMPLOYER'S EQUIPMENT AND FREE-ISSUE MATERIAL

2237. Reference Sub-clauses in the Contract:

4.20 Employer's Equipment and Free-Issue Material

2238. The details of Materials, power and equipment associated arrangements relating to the Employer's "free-issue materials" and Equipment, if any, that shall be available to the Contractor.

The list of free issed materials, Equipment & Cost of Eletricity

i) i) Cost of rated Electric Power consumption during O&M Period (10 years) to be borne by the Employer after successful completion of Trial run & Commissioning of the Plant

Cost not under the Scope of Employer

ii) Cost for tools, tracles & plant mechineries which will be required during (O&M) period for the entire system running of the plant shall must have to be arranged, supplied, installed & cost for those item of works shall be paid by the Bidder and have already included Bid Document. All cost or any payment for suppling equipment, tools, tacles installation & testing etc. shall be borne by the contractor at his own cost & expenses. All Tools & plants shall be replaced(if required) in"NEW" condition as per installed quality, brand & designation. Under any circumstances,no cost will be bear by the Employer except electricity during (O&M) period.

iii) Cost for Electric power,water, health & sanitation shall not be provided by the Employer during construction period.

iv) All permissions from local authorites as rules & regulation of Govt. of Bihar and Govt of India shall be collected & obtained by the contractor for which no cost shall be paid to contractor.