Bihar Urban Infrastructure Development Corporation Limited
A Government of Bihar Undertaking

Bihar Urban Development Investment Program -Project - 1

(ADB Loan No.______IND)

BIDDING DOCUMENT

For

Procurement

Of

Improvement of Water Supply System in Gaya Municipal Corporation

GA/WS/02

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

Volume 1 – Specifications

Technical Specifications for Works & operation and Maintenance

Issued on:

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1.1 PREAMBLE

The Contractor shall be fully responsible to drill the Tube Wells 24 Nos in Phalgu River and are to be redeveloped. The contractor shall undertake a pump test and determine a safe yield of each TW and install pumps of right capacity with suitable electrical system along with electro chlorinator, valves, piping and flow meter etc. as described under the scope of services so that the TW system as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities.

1.2 TIME FOR COMPLETION

The TW related all works will be completed in twenty four months' time from the initial take over date.

1.3 DRILLING OF NEW TUBE WELLS

24 Nos of Tube wells are to be drilled in the place, where it is identified by the ground water investigations done by the Engineer. The exact locations shall be shown by the engineer and the contractor has to drill the tube wells in the specified locations, The tube wells shall be drilled in accordance with specification laid in the IS 2800 part 1 1991 and are narrated below

Test Hole Drilling

The promising points identified on the basis of Vertical Electrical Soundings (VES) (Resistivity Survey & Investigation) data analysis and interpretation shall be taken up for test hole drilling. It will be confined around the area indicating the permeable strata. Initially on the bank of Phalgu River 24 test holes of 675 mm diameter and varying depth between 50 to 60 m below ground level shall be drilled. Depth wise samples of sub-surface formation material encountered during drilling shall be collected and analyzed, to check the occurrence of permeable strata within the explored depth and its thickness.

Initially diameter of hole for Tube Well shall be 400 mm and the depth to be kept as 40m-50m below ground level. On completion of the pilot hole litho log shall be prepared. Based on the physical observation of aquifer material and logging results corrected litho log shall have to be prepared so that productive aquifer zones are to be identified and well pipe assembly shall be recommended for providing screen pipe part. The slot size shall be selected based on the grain size distribution of aquifer material and thereafter pilot hole shall l be enlarged to 675 mm diameter. On completion of reaming (enlargement) of pilot hole, pipe assembly shall be lowered into the enlarged hole. The annular space between the hole and pipe shall be packed with pea size gravel from bottom of well up to the depth of recommended clay packing .For providing sanitary protection from the top of this gravel base up to ground level, a perfect clay packing with impervious clay shall be provided.

Thereafter the well should be developed using compressor of suitable capacity.

CASING PIPE SIZES AND LENGTHS

The length of the casing pipe is selected on basis of static water level, the draw down, the discharge expected from the well and the size of pump to be installed. The size and length of slotted/strainer pipes are selected according to the actual requirement according to the strata met with, the expected discharge and the depth of tube well. The casing pipes of 400 mm shall be adopted and shall generally conform to IS 4270: 1983 and the slotted/strainer pipes shall conform to IS 8110: 198. In the portion where use slotted pipes, 300 mm dia pipe shall be used. A reducer shall be used to connected plain casing pipe and slotted casing pipe. At the bottom, a 300 mm size MS bottom plug shall be used. 400mm MS clamp shall be provided at the top of the casing pipe to hold the casing pipe in its position. At the top of casing pipe a 4000 mm MS cap shall be fixed to protect the Tube well.

First ERW (Electric Resistance Welded) FE410 Mild steel threaded and socked/plain ended confirming to IS 8110 of reputed and approved make shall be used. Plain slotted pipes having a slot size of 1.6/3.2mm having wall thickness not less than 5.40mm shall be used and the pipe shall be painted outside surface with two coats of anticorrosive bitumestic paint of approved brand and make. The rates includes all the rate for labour charges for erection for all depths, fittings and accessories required and all the machinery and labour charges for erection.

The slotted pipe shall be plugged by 300mm Ball plug/Bottom plug as per specification mentioned in IS 2800: part 1

At the top of slotted pipe, ERW (electric Resistance welded) FE410 plain mild steel screwed and socketed pipes/plain ended pipes shall be lowered and fixed vertically in position in bore well and it shall confirm to IS 4270 of reputed and approved make. The MS casing pipe shall be painted in outside surface with two coats of anticorrosive paint of approved brand and make. The rates includes all the rate for labour charges for erection for all depths, fittings and accessories required and all the machinery and labour charges for erection.

MS Clamp of 400 mm size shall be fixed at top of 400mm plain MS pipe/housing pipe of Tube well to hold the entire plain and slotted MS pipes as per specifications mentioned in IS2800: part 1. The cost includes the cost of bolts& nuts required, and all other labour charges for fixing the above.

The slotted pipe and Plain MS pipe shall be joined by 400mm x 300 mm MS Reducer.

DESIGN OF SCREEN SLOTS

The entry of water in the tube well shall be either through screens or slotted pipes. Following are the various types of well screens and slotted pipes used in water wells depending upon the type and size of well:

a) Plain slotted pipe,

b) Bridge slotted pipes,

c) Mesh wrapped screens,

d) Cage type wire wound screens,

e) Pre-packed resin bonded gravel screens,

f) Brass screens.

The design, selection and type of screen or slotted pipe, size and distribution of slots shall be in accordance with IS 8110: 1985.

Thereafter pilot hole will be enlarged to 500mm (20”) diameter. On the completion of reaming (enlargement) of pilot hole pipe assembly shall be lowered into enlarged hole. The annular space between the hole and pipe will be packed with pea size gravel from bottom of well up to the depth of recommended clay packing .For providing sanitary protection from the top of this

GRAVEL PACKING

All gravel to be, used as pack in tube well construction shall be as specified in IS 4097: 1967. The thickness of the gravel shroud around the screen shall generally be not less than 10 cm.

In percussion method of drilling, -gravel is fed into the annular space between the casing pipe and the assembly pipe up to 3 m above the bottom of the slotted pipe. The well is developed using compressed air or by bailers and as the water becomes clear, surging or backwashing is done to make the development more perfect. More gravel is fed, if necessary, and when the water becomes free from sand, the casing pipe is jacked up to some height, and the process is repeated until all the aquifers are gravel packed.

In rotary method, the pipe ~assembly is lowered into position and gravel packing may be done up to a suitable depth below the bottom of the housing pipe in the first instance. Thereafter the gravel packing up to the required depth is completed after keeping the housing pipe vertical within limits. To achieve uniform gravel packing around the pipe assembly inverted cones should be used.

A provision for a well base to eliminate the possibilities of subsidence of the well structure may be incorporated. If the bottom of the well is in a soft formation, the well should be provided with an artificial base for the casing and screen by over drilling the hole about 1 to 2 m and filling the extra depth with concrete or gravel.

DEVELOPMENT OF TUBE WELL

The drilled well shall be developed by any of the methods specified in IS 2800: (part1) and IS 11189: 1985 depending upon the site conditions in order to get maximum sand free yield. The development process shall be continued until the stabilization of sand and gravel pack has taken place. The development shall be done to establish maximum rate of usable water yield without sand content with required capacity of air compressor 250 PSI. The compressor shall be operated for required time till well is fully developed.

The development of the tube well by over pumping should be done at I5 percent to 25 percent higher discharge than the expected discharge from the tube well. The final discharge should be free from sand with a maximum tolerance of 20 parts of sand in one million parts of water by volume after 20 minutes of starting the pump.

The discharge in the Tube well shall be totally sand free. If the discharge is not sand free after 20 minutes of starting the pump, the well shall be redeveloped. In case the discharge is still not sand free even after re-development, the pump set of lesser discharge capacity may be installed to get sand free water suitable for drinking. The turbidity and hardness of water of wells used for drinking purposes, shall be as specified in IS 10500:1983.

After completion of development by over pumping, the well shall be tested for its performance that is yield characteristics and efficiency.

For conducting pumping out test, the main well should be fitted with submersible pump & motor of appropriate capacity.

For uninterrupted continuous power supply, Diesel Generator set of appropriate capacity must be used. Flow Meter method should be used for periodic discharge measurement of pumping well. The discharged water from the discharge pipe should be diverted at long distance in river/stream flow to avoid induce infiltration.

The electrical sounder and tapes should be used for measurement of water level. The time should be measured using Stop Watch.

The static water levels in the pump well and observation wells should be noted before starting the test. The time interval for water level observation and its measurement during pumping should be kept small initially and be increased as pumping period increased. Sufficient technical persons should be deployed for monitoring data at pumping well, observation well.

Recuperation Test

When the pump is stopped after running the pump out test, the draw down and time at which it was shutdown are recorded. Measurement of water level is immediately initiated in the pumped well and in all observation wells. The same procedure and time pattern is followed as at the beginning of a pumping test. As in the pumping (Test) well, the time and depth -to-water level are noted for each measurement. Within reasonable length of time original static water level may not be recuperate to original level. This test should be concluded when water level was recuperated almost 90 percent.

The data collected on discharge measurement. pumping water level and recuperation should be used for drawing different graphs for applying various applicable methods of analysis for estimating the hydraulic characteristics of aquifers like Transmissivity (T), Field Permeability(K), Specific Yield , Storage Coefficient (s’), Specific Capacity (Sp. Cap) Radius of Influence (R) etc.

This shall be achieved by conducting a step draw down test-determine drawdowns at the end of the hour by pumping at 3 to 4 different rates of discharge. The measurement of yield in the well shall be done by V notch method or any other approved method measuring static water level & draw down etc. by step draw down method, collecting water samples and testing the water samples in the laboratory approved by the Engineer and disinfection of tube well shall be done after completion of all the works. The rates includes hire charges for machineries required, labour charges for erection and operation of compressors, pump set, tools and all the accessories. After completion of test, the pump set used for the pumping test shall be removed from the tube well and all the sites shall be cleaned properly. The MS casing pipe of tube well shall be plugged by the MS cover plate or MS cap and the tube wells shall be protected until the pump is erected in tube well.

DISINFECTION

The well shall be disinfected after completion of test for yield. All the exterior parts of the pump coming in contract with the water shall be thoroughly cleaned and dusted with powdered chlorine compound. In fact it should be disinfected every time a new pump is installed or the one replaced after repairs.

A stock solution of chlorine may be prepared by dissolving free chlorinated lime. For obtaining an applied standard concentration of 50 ppm. One litre of the stock solution should be used to treat 300 litres of water.

The quality of water from the Tube well should be as laid down in IS 10500: 1983.

Grouting and sealing of tube well shall be done, depending upon the site conditions and quality of the discharge of the strata encountered. To ensure that the grout will provide a satisfactory seal, it should be applied in one continuous operation. Sealing of the tube well may be done by grouting the annular space between bore and the housing pipe, thickness of grouting depending upon the quality of water. The grouting and sealing shall always be done to ensure safe sanitary conditions.

It is desirable to plan an oversize bore hole of 675 mm more than the diameter of the well casing to an adequate depth during the design of well itself up to the level of plain MS casing pipe. The bore hole shall be reduced to 600mm at bottom where the slotted MS casing pipe are erected. The depth to be grouted varies with geologic and site conditions but a depth of 3 to 4.5 m or the depth specified by the Engineer during construction from the surface is generally adequate.

SURFACE APRON

An apron around the well and sloping away from it protects the well from pollution caused by contaminated water flowing back into it and prevents muddy pools of standing water forming around

The housing pipe should be closed by a well cap for the period between the completions of the tube well and the installation of the pump set.

The following information shall be furnished by the drilling agency on completion of the tube well:

- ✓ Total depth of tube well drilled,
- ✓ Strata chart of the tube well indicating different type of soil formations met with at different depths and indicating the depth of each type of soil formation,
- ✓ Samples of strata collected, neatly packed and correctly marked in sample bays,
- ✓ Position of every joint in well assembly,
- ✓ Method used for development,
- ✓ Total hours of development done,
- ✓ Developed discharge in L.P.S.,
- ✓ Discharge is totally sand free or presence
- ✓ of sand particles is there,
- ✓ P.P.M. and turbidity after development,
- ✓ Pumping water level at developed discharge,
- ✓ Static water level.

INFORMATION TO BE FURNJSHED BY DRILLJNG AGENCY TO ENGINEER ON COMPLETION OF TUBEWELL

1. Agency drilling the tube well.....................
2. Location of the tube well..........................
3. Method of drilling adopted........................
4. Date of starting............................-. ....
5. Date of completion..................................
6. Pilot hole or test hole......... Bit size..........
   Bit type ....Hours ....from...........
   to...
7. Coring done............... Bit size................ Bit type ....Hours ....Recovery...........
   .... from... .... to........................
8. Reaming ....Bit size.....................
   Bit type............ Hours... .... from..........
   .... to... .... *. ....
9. Lithological data
10. Total depth of tube well drilled . . . .
11. Assembly of production well... .....:. Size......
    Length............ Type.................
    Perforation per metre........................

Housing pipe..................................
Blind pipe.......................................
Strainer..
Bail plug..

12. Top of tube well above/below ground level...._...........................
13. Size of gravel............ Quantity used before development............ Quantity used during development..........................
14. Method used for development....................
    Total hours of testing.......................
15. Development discharge..........................
16. Turbidity...
17. Further details appended:
    a) Samples of strata, neatly packed in sample bags,
    b) Chart of pipe assembly lowered, and
    c) Results of mechanical analysis of samples of unconsolidated strata.
18. Remarks:

Static Water level will be measured in the TW and recorded. The diameter of TW housing pipe and total depth of TW will be measured and recorded.

CONSTRUCTION OF OBSERVATION WELLS

The size of observation shall be 150mm. The contractor shall construct 150 mm dia observation well 7 Nos in the locations specified by the Engineer. All specification for construction of observation well shall be applied same as the production well. The initial borehole size shall be 550 mm. The plain MS casing pipe shall have 300 mm dia MS casing plain pipe shall be used at top and at bottom 150 mm size slotted MS Casing pipe shall be used. For connecting the plain and slotted casing pipe, A Reducer of size 300 x 150 mm shall be used. At the bottom of slotted pipe, 150 mm MS plug shall be used for plugging the tube well. AT the top of the plain casing pipe 300 mm MS camp shall be fixed to hold the MS casing assembly in the ground.

LONG DURATION PUMPSET:

In two places, long duration pumpset shall be conducted for 100 hours of pumping in each places.

In case of long duration pumping test, breakup of 100 hours include 72 hours continuous (uninterrupted) pumping or till the steady state is reached whichever is earlier. It will be decided by the Engineer in charge and it will binding. Remaining 28 hours comprises period of well development and preliminary testing period prior to conducting long duration pumping. If the contractor fails to pump continuously for 72 hours and if there is an interruption before 72 hours, the test has to be started freshly and he has to do the test for 72 hours continuous without any interruption. No extra additional charges shall be paid repeated test due to the interruption in the test.

For conducting pumping out test, the main well should be fitted with submersible pump & motor of appropriate capacity.

For uninterrupted continuous power supply, Diesel Generator set of appropriate capacity must be used. Flow Meter method should be used for periodic discharge measurement of pumping well. The discharged water from the discharge pipe should be diverted at long distance in river/stream flow to avoid induce infiltration.

The electrical sounder and tapes should be used for measurement of water level. The time should be measured using Stop Watch.

The static water levels in the pump well and observation wells should be noted before starting the test. The time interval for water level observation and its measurement during pumping should be kept small initially and be increased as pumping period increased. Sufficient technical persons should be deployed for monitoring data at pumping well, observation well.

RECUPERATION TEST

When the pump is stopped after running the pump out test, the draw down and time at which it was shutdown are recorded. Measurement of water level is immediately initiated in the pumped well and in all observation wells. The same procedure and time pattern is followed as at the beginning of a pumping test. As in the pumping (Test) well, the time and depth -to-water level are noted for each measurement. Within reasonable length of time original static water level may not be recuperate to original level. This test should be concluded when water level was recuperated almost 90 percent.

The data collected on discharge measurement. pumping water level and recuperation should be used for drawing different graphs for applying various applicable methods of analysis for estimating the hydraulic characteristics of aquifers like Transmissivity (T), Field Permeability(K), Specific Yield , Storage Coefficient (s'), Specific Capacity (Sp. Cap) Radius of Influence (R) etc.

The other conditions that are to be followed by the contractor are as follows:

- All above work should be carried out as per the standard practices and as per relevant BIS Code for such type of works;
- No deviation in method of construction or material shall be entertained.
- All materials to be used should be as per the specifications of BIS;
- The Contractor will ensure all statutory compliances and clearances;
- The Contractor will ensure compliance with the ADB's Safeguard policy;
- The Contractor will be solely responsible for the safety of its manpower, machinery and loss to any third party;
- The Contractor will have to provide safety gears like Helmets, safety jackets, safety belts, Hand gloves, shoes, etc. to all staff at site and ensure all health and safety aspects;
- The Contractor will ensure proper lighting arrangement if the works are carried out during bad light conditions and night hours;
- The Contractor will take necessary measures to avoid/minimize noise pollution (near VGDS) river; and
- The Contractor will ensure that no excavated material goes into the river.
- The water sample shall be analyzed only in the NABET accredited Laboratory
- The Contractor shall be responsible for the safety of all the activities on the Site.

PUMP HOUSE:

A brick masonry Pump house of size 5.50 m x 3.0 m x 4.0 m – 24 Nos shall be constructed in the bank of River phalgu for each tube wells to accommodate the panel boards for the pumping equipment installed in the each tube well as per the drawings given by the Engineer. The specification of Brick work, plastering, concrete and other items are to be followed as per the Bihar schedule of Rates and as per the standards laid by Bihar state Government.

The Electro Mechanical equipment to be installed in the Tube well and Pump houses are listed below:

PUMPING MAINS

Pumping mains shall be laid from each tube well locations to Clear water Reservoir/to the service Reservoir. The details of the Rising mains is furnished below.

SERVICE ROAD AT POYTECHNIC CAMPUS

Cement concrete road shall be laid in the Polytechnic campus for easy access of vehicle during the maintenance operation. The width of road shall be m as specified in the drawings. Total length of road shall be 100 m. For laying cement concrete road, the surface shall be excavated to a depth of

m. The surplus earth/unserviceable earth after laying the road, shall be disposed in low lying area within 8 km lead. 100 mm thick Dry lean cement concrete shall be laid over the surface cleaned

Above the Dry lean cement, 100 mm thick cement concrete payment shall be laid. Maximum coarse aggregate size shall not exceed 25mm and un reinforced dowel jointed plain cement concrete payment with 43 grade cement at 400 kg/cum coarse and fine aggregate conforming to IS 383 shall be used, Necessary contraction, expansion, construction and longitudinal joints, joint filler, separation membrane, sealant primer, joint sealant, debonding strip, dowel bar, tie rod, shall be provided.

Over cement concrete payment, cement concrete wearing coat of M30 grade shall be provided for 100 mm thick.

BOUNDARY WALL AT POLYTECHNIC CAMPUS AND FENCING OF SUB STATION

For protection of clear water reservoir and other pump house in Polytechnic campus

1.4 **PUMPING MACHINERY**

All the 24 TWs which are to be drilled will be provided with new pump sets. The pumps will be Submersible pump sets as described in scope of works and services. Contractor will design the capacity of the pump based on safe yield of TW determined after development and pumping head required. In the clear water pump house Vertical Turbine pump set 6 Nos shall be erected to pump the water from clear water reservoir to the respective service reservoirs.

1.5 **VERTICAL TURBINE PUMP**

1.5.1 **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:

Table 1 Codes and Standards for Pumps

No.	Standard	Title
1	IS: 1710	Vertical Turbine Mixed and Axial Flow, for Clear Cold Water
2	BS: 5316, Part-2	Acceptance Test for Centrifugal Mixed Flow and Axial Pump Class B
3	IS: 5120	Technical Requirements for Roto-dynamic Special Purpose Pumps
4	ANSI/HI 21-25	Standards of the Hydraulic Institute of USA
5	ISO 1940	Mechanical Vibration- Balance Quality Requirements of Rigid Rotors

1.5.2 **FEATURES OF CONSTRUCTION**

The impeller shall be enclosed type. The impeller shall be fastened securely to the impeller shaft with keys and lock nuts. They shall be adjustable vertically by means of a nut. Impeller shall be dynamically balanced to Grade G 6.3 of IS: 1940. Impeller shall be with replaceable wearing ring. The hardness of impeller ring shall be at least 50 BHN higher than that of casing ring.

The casting of bowls shall be free of blowholes, sand holes and other detrimental defects. The bowls shall be capable of withstanding a hydrostatic pressure equal to twice design pressure or one and a half times the shut off pressure, whichever is higher.

The bowls shall be equipped with replaceable wear ring. Water passages shall be smooth and the bowl shall contain bushes to serve as bearings for the impeller shaft.

Shafts shall be designed to withstand the torque loads throughout the whole range of operating conditions for the selected particular impeller diameter as well as all the impeller diameters covered between minimum and maximum impeller diameters when coupled to the motor shaft through flexible coupling.

The shaft shall be guided by bearings provided in each bowl or above and below the impeller shaft assembly. The butting faces of the shaft shall be machined square to the axis and the shaft ends shall be chamfered on the edges. Shaft shall have a surface finish of 0.75 microns minimum.

The design of the shaft shall also take into consideration the critical speed of the shaft in such a way that the critical speed shall have adequate margin with respect to the operating speed by at least 30 % on either side.

The shaft shall be furnished with interchangeable sections having a length not exceeding 3.0 m. The butting faces of the shaft shall be machined square to the shaft axis and the shaft ends shall be chamfered on the edges. To ensure correct alignment of the shaft they shall be straight within 0.125 mm for 3 m length total dial indicator reading. Shaft shall have a surface finish of 0.75 microns minimum.

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

Transmission bearings shall be designed to be lubricated by water being pumped.

Anti-friction thrust bearings of adequate capacity to carry the weight of all rotating parts plus the hydraulic down thrust shall be provided. The thrust bearing shall be either grease or oil lubricated. Anti-friction bearings shall be of standard type and shall be selected to give 40,000 hours continuous operation at rated operating conditions.

The column pipe shall be of welded mild steel pipes as per IS: 2062. Flanges shall be machined flat, with flange faces vertical and at right angles to the pump mounting surface. Flanges shall be as per relevant Indian Standard.

Flexible pin bush type coupling shall be provided, duly bored and keyed to the pump and motor shafts. For line shafts, threaded barrel couplings shall be used.

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

All the pumps shall be supplied with machined pads to allow the fitting of portable vibration monitoring transducers.

Conical type strainer shall be provided at the bell mouth.

All specified accessories and any other standard accessories required for correct and safe operation of the pump shall be furnished. All incidental piping (including valves) required for sealing and lubricating systems shall be provided by the Contractor.

1.5.3 **DESIGN REQUIREMENTS**

The pumps shall be capable of developing the required total head at rated capacity for continuous operation. The pumps shall be suitable to operate satisfactorily, in parallel, within the operating range. The pumps shall have a stable head curve, i.e. the total head-capacity curve shall be continuously rising towards the shut off. The shut off head shall be at least 15% more than pump head at intersecting point of the pump curve with the upper range system head curve. The design point shall be as close as possible to maximum efficiency point of pump.

The required NPSH at any operating point shall be at least 0.5 meter less than the available NPSH. Minimum submergence of bell mouth shall be 2000 mm.

The pumps shall be capable of reverse rotation up to 125% rated full speed of the drive motor, due to backflow of water, without damage or loosening of threaded components.

Pumps shall run smooth without undue noise or vibration. Noise levels and velocity of vibrations shall be within acceptable limits. Noise level shall be limited to 85 dBA at a distance of 1.86 m. Velocity of vibrations shall be as per relevant American Hydraulic Institute Standards.

The drive motor power rating shall be more than the maximum of the following requirements:

a) 115% of pump input power including losses in transmission shafting and thrust bearing required for the Stage II flow.

b) 105% of the maximum pump input power including losses in transmission shafting and thrust bearing within the operating range between maximum and minimum system resistance curves, considering 1 to 4 pumps operation.

Spare parts supplied for O&M period with the pump shall be identical to respective pump components and shall be from original pump manufacturer.

Bidder shall offer only pumps of proven design, and such pumps of at least the same capacity and type should be in operation for more than 5000 hours satisfactorily in at least two locations. The details of such pumps shall be furnished in Section 4, Schedules.

One set of standard and special tools, centering tools, lifting lugs, pipe and shaft clamps, etc., required for erection and maintenance shall be supplied

1.5.4 **MATERIALS OF CONSTRUCTION**

Table 2 Materials of Construction

S. No.	Component	Material
(a)	Bell Mouth*	Cast Iron: IS 210 Gr. FG 220
(b)	Bowl, Impeller Guide*	Cast Iron: IS 210 Gr. FG 220
(c)	Impeller	Stainless Steel: ASTM A 351 CF8M
(d)	Column Pipe	Mild Steel: IS 2062
(e)	Shafts	Stainless Steel: AISI 431
(f)	Shaft Sleeve with surface hardening of 350 BHN- min.	Stainless Steel: AISI 410
(g)	Transmission Shaft Couplings	Stainless Steel: AISI 410 / 431
(h)	Sleeve for Bearing	Stainless Steel: AISI 304
(i)	Suction Strainer	Stainless Steel: AISI 304

* *Hydraulic passages of these parts shall be coated, as per details below, after conducting performance test to enhance pump efficiency.*

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.

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.

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.

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.

1.5.5 **INSPECTION REQUIREMENTS**

All pumps shall be assembled in the shop to ensure correct fitting of all parts and shall be match marked before shipment.

Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.

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.

Clear water pumps in Clear water Reservoir 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.

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:

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)

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.

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.

Any other tests, including NDT (as applicable), as specified in the data sheets / drawings / specifications/ applicable standards and Codes.

1.6 SUBMERSIBLE PUMP SETS

1.6.1 SCOPE

This includes supply of ISI marked submersible Pumping Sets comprising of Submersible Motor of sufficient horse-power coupled to a Pump of required duty conditions as per detailed specifications given below. The Motor shall have cable leads of length equal to the proposed pump lowering depth in the TW and length required to connect to the motor starter with 5m extra length in each case. The submersible pump set will have a minimum OD of 192mm but less than nominal bore of housing pipe of TW for smooth installation.

1.6.2 DESCRIPTION

- The Submersible Pumping Sets shall be ISI marked as per *IS 8034* (specification for Submersible Pumping Sets for clear, cold fresh water) (amended or revised up to date), 5 star rating as per BEE and should be as per provisions/ specifications mentioned hereunder.
- The overall efficiency of 5 star rated submersible pump set shall be in accordance with star rating plan of BEE for pump set.
- The electric motor is to operate through 3 phase 50 c/s A.C. Supply of 415 volts + 6% &-15% volts i.e. between 352 to 440 Volts. The preferred speed shall correspond to 2 pole motors [3000 rpm (synchronous)]
- The Pump sets shall normally be installed in bore wells and should be suitable for conditions existing for ground waters generally available in Bihar. The water to be handled by the Pump sets may have Total dissolved Solids 1500 PPM (max), Turbidity 50 PPM (silica scale) Chlorides 1000 PPM (max) and PH value between 6.5 and 8.5.

1.6.3 DETAILS OF PUMPS

The material of construction of various components of the pump shall be as under:

Table 3 Details of Pumps

S. No.	ITEM	MATERIAL OF CONSTRUCTION
1	Discharge casing (if provided)	Cast Iron Grade FG 200 of IS: 210-1993
2	Suction casing	Cast Iron Grade FG 200 of IS: 210-1993
3	Pump bowl	Cast Iron Grade FG 200 of IS: 210-1993
4	Diffuser	Cast Iron Grade FG 200 of IS: 210-1993 or glass filled Polyphenylene oxide (modified PPO) or glass filled Polycarbonate of *IS 8034*
5	Pump shaft	Stainless steel grade X 04 Cr12, X 12 Cr12 or X 20Cr13 of IS: 6603
6	Impeller for radial flow/ mixed flow	Bronze grade LTB 2 of IS: 318 or Stainless steel grade X 12 Cr12 of IS 6911 or IS 6603 or glass filled Polyphenylene oxide (modified PPO) or glass filled Polycarbonate of *IS 8034*
7	Casing wear ring (if provided)	Bronze Grade LTB 4 of IS:318

S. No.	ITEM	MATERIAL OF CONSTRUCTION
8(a)	Bearing bush	Bronze Grade LTB 4 of IS:318 or Nitrile rubber/ Cutless rubber
8(b)	Bearing bush in discharge & suction	Bronze Grade LTB 4 of IS:318

- The thickness of impeller vanes shall be as per IS 8034:2002 (amended up to date).
- The rotating element (as assembled rotors) of Pumps should be dynamically balanced at high speed. Each metallic impeller shall be dynamically balanced to grade G 6.3 of IS-11723 (part-I) for ensuring smooth performance free of vibrations.
- 3.4The coupling shall be preferably of mesh type rigid sleeves coupling of stainless steel non-slip type with matching groove, collar and key way arrangement.
- 3.5The pump shall be tested for operating head range of not less than +10 percent and -25 percent of the rated duty head (i.e. head as worked out by the contractor and approved by the Employer's Representative). The duty point of pumps shall be located near the peak efficiency and there should not be steep fall in Q V/S H, efficiency curve in the head range of +10% and -25%. This entire range should be on the stable portion of the curve

1.6.4**DETAILS OF MOTOR**

- The motor shall conform to IS: 9283-1995 (amended up to date). The motor shall be of continuous duty (type S1) specified in IS 12824: 1989.
- The Motor stator should be easily rewire-able and winding should be easily accessible to facilitate checking and locating of any fault without disturbing the full winding and to replace defective coils. It should be possible to rewind the motor with readymade pre tested coils.
- The stator body should preferably be shrunk fitted instead of being only press fitted. The stator body should be tightly welded on the stamping assembly and adequate arrangement should be provided for stopping of rotation or shifting of stampings inside the stator body preferably by providing matching grooves in the stamping assembly and the stator body. Metal rings with rounded fingers should be provided on both ends of stamping.
- Threaded joints in the motor should be avoided to prevent damage due to rusting. Bearing housing should not be threaded but located on spigot and held by suitable bolts.
- The rotor as well as stator should be impregnated under vacuum for air drying and both should be baked repeatedly under controlled conditions to ensure long life of varnish/ galvanising/ chrome plating/epoxy and to give a hard finish to the motor surface. The rotor should be dynamically balanced at high speed.
- All the material and components for the motors shall be suitable for application in respect of corrosion resistance and mechanical performance continuously under water. The typical materials to be used for various parts of motor are given below: -

Table 4 Material of Construction for Motor

S. No.	ITEM	MATERIAL OF CONSTRUCTION
1	Bearing housing & base	Grey cast iron Gr. FG-200 of IS 210:1993
2	Motor shaft	Chromium steel Gr. 04 Cr 13, or 12 Cr 13, or 20 Cr 13 of IS: 1570 (Part-5) 1985.
3	Bearing bush	Leaded tin bronze LTB 3, LTB 4 or LTB 5 of IS 318:1981 or Resin bonded carbon metal or Rubber or Rubber lined
4	Rotor laminations	Electrical sheet of IS 648:1994

S. No.	ITEM	MATERIAL OF CONSTRUCTION
5	Rotor conductor core	Electro grade copper of IS 613:1984
6	Stator laminations	Electrical sheet steel of IS 648:1994
7	Stator winding wire Conductor	Electro grade copper of IS 613:1984
8	Stator winding wire insulation	PVC or with polymer of IS 8783:1978
9	Breather diaphragm	Nitrile rubber
10	Thrust bearing	Vulcanized fibre v/s chromium steel or vulcanized fibre v/s bronze
11	Cable gland	Nitrile rubber
12	Stator Casing	Grey Cast iron FG 200 of IS 210:1993 or Carbon steel (sheet or pipe) or stainless steel sheet Gr. 20 Cr 13 of IS 1570:(Part 5):1985

The materials indicated are typical. Manufacturers may use materials of properties superior as per the properties of materials indicated in manufacturing submersible motor.

- The thrust bearing should be water lubricated and of hydrodynamic Mitchell type and should be able to take all untoward loads at most unfavourable running conditions. It should have swivelling metallic thrust pads.
- The output motor ratings shall be as per Clause 6.3 of IS 9283:1995 (amended up to date). The motor rating beyond 15 kW shall be as declared by the manufacturer. The motor shall be capable of delivering rated output with variations in value of voltage and frequency for Category B as per clause 6.2.2 of IS 9283:1995.
- The motor shall be suitable for entire working range of pump from +10% to -25% of the rated duty head. The motor shall not get overloaded in the entire working range. The criteria for checking non-overloading shall be that maximum current in entire range shall not exceed the limits specified in Table 1 (clause 7.1) of IS 8034: 2002 for various ratings between 1.1 kW to 15 kW. In case of motor rating more than 15 kW the manufacturer has to declare maximum current, which the motor can take. The permissible limit of maximum current in the operating head range for checking non-overload requirements is 1.07 times of Maximum current declared by the manufacturer.

1.6.5 SUBMERSIBLE CABLE

- The cable shall be *ISI marked* as per IS 694:1990. It shall be PVC insulated and PVC sheathed, flexible, 3 core flat type having copper conductors suitable for working voltage up to and including 1100 Volts. Size of Cable shall be such that voltage drop between motor starter and motor terminal does not exceed 3% of rated voltage. The method of starting of submersible pump set will be as follows:

Table 5 Method to start submersible pump set

S. No.	*Motor kW Rating (in kW)*	*Type of Starting*
1	Up To 3.7 kW	Direct on line
2	From 4.5kW to 100 kW	Star Delta

S. No.	***Motor kW Rating (in kW)***	***Type of Starting***
3	Above 100 kW	Soft Starter

1.6.6**TESTING & INSPECTION**

- Testing of the pump sets shall be carried out as per relevant IS codes. The inspecting agency shall test & inspect the pump set and cable as per details given below. The manufacturer shall have all required facilities and shall get pump sets tested & inspected in accordance with procedure specified below.
- The manufacturer should have facilities for dynamic balancing at high speed, vacuum impregnation/air drying of rotors and stator, high tension electrical testing and pump performance testing. Details in this regard should be shown to the inspecting agency.
- The contractor shall submit detailed test report on each finished pump set and reports of various tests conducted during manufacture at the time of delivery at site.
- MARKING: The marking shall be as per relevant IS code. The pump set shall invariably be marked with BIS standard mark. Purchasers mark `BUIDCO' & `Year of Manufacture' shall also be mentioned on each pump & motor.

1.6.6.1 Inspection of Submersible Pump sets shall be carried out as per provisions of IS 8034 (amended/ revised up to date) and specifications given above.

1.6.6.2 RAW MATERIAL CHECK: Correlate material certificates to ensure that quality of material has been used in respect of major components like Bowl Casing, Impellers, Shaft, Motor casing pipe etc. - (Chemical/physical testing)

1.6.6.3 IN-PROCESS/WORKMANSHIP/ CHECKS:

- Verification of vendor's own Q.A. system for incoming items/bought out item's Inspection and acceptance criteria.
- Epoxy painting quality check of wetted parts of pump & motor randomly to verify paint thickness.
- Check positive locking of stampings
- Check thrust bearings of motor. These shall be tilting pads type resting on S.S. balls. Check tilting action. Hardness of thrust bearings pads should be verified on random sample.
- Check dynamic balancing records of vendor and randomly check/verify balancing & calibration of balancing machine.

1.6.6.4 MOTOR TESTS/CHECKS:

- Check H.V. testing of coils after immersion in water for minimum 4 hrs.
- 100% H.V. tests and insulation resistance tests for 12 hours after immersing in water in all motors by vendor.
- 100% motors routine tests as per IS-9283 & IS-325 by vendor. Records of test to be submitted for review of Inspection Authority.
- Type Test of motor - Heat run-Test for each lot/type, at minimum voltage for performance.

1.6.6.5 PERFORMANCE TEST CHECKS:

- Performance test procedure set up as per IS: 8034/ IS: 11346
- Run pump for one hour at duty point prior to recording readings for performance.
- Witness performance test in terms of head, flow rate, pump efficiency at rated volts and minimum voltage specified for motor for at least 4 hours on the selected sample.

1.6.6.6 OBJECTIVES:

(a) To check for any damage during the running of pump set especially with regard to wearing of parts, general workmanship/surface finish of bearings/castings etc.

(c) Check Running Clearances are within specified limits

(d) Check for locking arrangement of wearing rings, lock-nuts etc.

1.6.6.7 PROCEDURES:

(a)Pump-motor set shall be completely dismantled after performance test.

(b)All components with relative movement shall be visually checked for any objectionable rubbing/wear/scoring marks.

(c)To check all running clearances/play to ensure they are within specified tolerance.

(d)To check shaft/rotor run out is within design specified limits.

(e)Check for peeling of rotor paint/rusting etc.

1.6.6.8 In case pump set is found not to meet the acceptance criteria during strip test the pump set will be rejected.

1.6.6.9 MARKING: The marking shall be as per relevant IS code and as per BEE guidelines (for 5 star rated pump sets). The pump set shall invariably be marked with BEE standard mark (for 5 star rated pump sets). Purchasers mark `BUIDCO' & `Year of Manufacture' shall also be mentioned on each pump & motor.

1.7 **VALVES**

1.7.1 **GENERAL**

Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN1.0.valvesshallhaveintegralflangesdrilledasspecifiedinrelevantlatestISspecificationsorBS:4504.

Throughout erection, the valves shall be supported properly on wooden sleepers, etc. and shall be concreted immediately thereafter, as directed. Before the valves are actually fixed, they shall be cleaned and greased and it should be seen that all parts are in perfect working condition.

One Dual Plat Check Valve, one Butterfly valve, one dismantling joint and one Electro Magnetic type flow meter shall be provided in the delivery pipe of each TW. The size of these items will be same as that of the delivery pipe. The valves, dismantling joint and the water meter shall be placed in Valve chamber.

1.7.2 **GASKETS AND PACKING**

Gaskets shall be of Nitrile rubber and readymade matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.

1.7.3 **NUT, BOLTS, WASHERS**

The Contractor shall provide the jointing material such as nuts, bolts, washers, pig lead, rubber packing, etc.

All bolts, nuts and studs shall be SS 304/316 and shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions. All studs and screws shall be made of SS304/316.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary.

The Contractor shall supply all holding down, 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.

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.

1.7.4 VALVE ACTUATORS

Codes and Standards

This specification covers the general requirements of Electric Motor Actuators for valves. All electrical equipment shall conform to the latest applicable IS, ANSI and NEMA Standards except when stated otherwise here in or in valve specification.

Design Requirements

The actuator shall be suitable for operation in hot, humid, dusty and tropical atmosphere. Type of actuator offered should be in satisfactory operation under similar conditions. For isolating service, the actuator shall be rated for three successive open-close operations of the valve or 15 minutes, whichever is longer. For regulating service, the actuator shall be suitably time rated for the duty cycle involved with necessary number of starts per hour.

The actuator shall open and close the valve completely and make leak tight valve closure without jamming. The actuator shall attain full speed operation before valve load is encountered and impact an unseating blow to start the valve in motion (hammer blow effect). The actuator shall operate the valve stem at standard stem speed and shall function against design differential pressure across the valve seat.

The actuator motor reduction gearing shall be sufficient to lock the shaft when the motor is de-energized and prevent drift from torque switch spring pressure. The entire mechanism shall withstand shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.

Features of Construction

(i) The actuator shall essentially comprise integral starter, drive motor, torque/limit switches, gear train, clutch, hand wheel for manual operation, position indicator/ transmitter, space heater thermal overload protector and internal wiring. The actuator enclosure shall be dust tight, weather-proof suitable for outdoor use without necessity of any canopy. The weather protection class of actuator shall be IP 65 for indoor and IP 68 for outdoor installations.

(ii) All electrical equipment accessories and wiring shall be provided with tropical finish to prevent fungus growth. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficulty.

(iii) The actuator motor shall be three phase, squirrel cage, induction motor with class B insulation and IP 68 protection, designed for high torque and reversing service.

(iv) The motor shall be designed for full voltage direct on-line start with starting current limited to 6 times full-load current.

(v) The motor shall be capable of starting at 85 percent of rated voltage and running at 80 percent of rated voltage at rated torque. Earthing terminals shall be provided on either side of the motor.

(vi) Each actuator shall be provided with following limit switches.

- 2 torque limit switches, one for each direction of travel, self-locking, and adjustable torque type.
- 4 end-of-travel limit switches, two for each direction of travel.
- 2 position limit switches, one for each direction of travel, each adjustable at any position from fully open to fully closed positions of the valve.

(vii) Each limit switch shall have 1 NO + 1 NC potential free contacts. Contact rating shall be 5A at 240 VAC.

(viii) Each actuator shall be provided with relay for monitoring the availability of valve for remote operation. The contact rating shall be 5A, 240 VAC. The available signal shall comprise of the following:

- Actuator mounted Local-Off-Remote. Selector switch set to remote.
- No power failure at starter.
- Emergency stop not operated.
- No drive fault.

(ix) The torque switch shall have a minimum accuracy of 3% of set value. The torque switch shall be provided with calibrated knobs for setting desired torque and separate knobs shall be provided for open and close torque switches.

(x) The torque and limit switches shall be housed in a separate enclosure with protection class as that of actuators.

(xi) Each actuator shall be provided with a hand wheel for emergency manual operation. The hand wheel shall de-clutch automatically when the motor is energized.

(xii) The actuator shall have:

- One (1) built-in local position indicator for 0 to 100% travel.
- Two (2) position transmitters, potentiometer type of 100 ohm rating for remote indication.

(xiii) All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be of sufficient size for the power rating involved but in no case less than 1.5 mm^2 copper. All wiring shall be identified at both ends with ferrules.

(xiv) The terminal box shall be weather proof with removable front cover and cable glands for cable connection. The terminal shall be suitable for connection of 2.5 mm2 copper conductor.

(xv) The terminals, terminal boards, terminal boxes, winding tails and associated equipment shall be suitable for connection to supply system having 'adequate short-circuit capacity and clearance time determined by associated fuses’. The terminal boxes shall be totally enclosed.

(xvi) All terminals of limit and torque switches, space heater, position transmitters, shall be brought to a common terminal box. There shall be at least five (5) terminals spare to terminate spare cores of cable.

(xvii) The actuator shall be painted with epoxy paint. The colour shall be got approved from Engineer.

(xviii) The nameplate shall be provided on the actuators as per relevant IS. In addition, the following shall also be marked:

- Tag number
- Torque rating
- Full travel time

(xix) Local controls shall be protected by a lockable cover.

(xx) Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The gearbox shall be grease filled, and capable of installation in any position. All operating spindles, gears and head stocks shall be provided with adequate points for lubrication.

(xxi) The valve actuator shall be capable of producing not less than 1½ times the required valve torque and shall be suitable for at least 15 minutes continuous operation.

(xxii) The actuator starters shall be integrally housed with the actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

(xxiii) The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication, and shall also be fitted with internal heaters so as to provide protection against damage due to condensation. Heaters shall be suitable for single phase operation. The heaters shall be switched "ON" when the starters are "OFF" and shall be switched "OFF" when the starters are "ON".

(xxiv) The following shall be included as standard feature for valve actuators

- Two (2) DC interposing relays for matching the low voltage of remote commands with the control voltage.
- The motor shall be specially designed for valve operation, combining low inertia with a high torque and with linear characteristics.
- Each electric-motor operator shall be provided with a hand-wheel with handle for manual operation. The hand-wheel shall be automatically de -clutched when the electric motor is operating, but shall be capable of being engaged at other times by positioning the clutch lever. The electric operation shall override the manual operation.
- All motor operators shall be provided with visible local valve position indicators mounted on the operator assembly itself.
- The torque switch shall function to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close. A minimum of two (2) torque switches, one for closing direction and one for opening direction shall be provided.
- The non-adjustable limit switches shall stop the motor and give indication when the disc has attained the fully open or close position.
- All wiring connections from the various switches shall be brought out on to separate terminal box mounted on the valve, having liberal space for wiring and making connections.
- The terminal box shall be suitable for outdoor use and shall be weatherproof and dust tight.

(xxv) Reversing starters

- The reversing starters shall comprise forward and reverse contactors, electrically interlocked with each other.
- The terminal overload relays provided with the reversing starters shall be three elements, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.
- Thermal overload relays shall be hardest type.
- 'STOP' push button of the starter and hand-reset device shall be separate from each other.
- Overload relay reset push button shall be brought out to the front and made easily accessible.
- Overload relay shall be provided with at least one 'NO' and one 'NC' or one change-over contact.
- The minimum continuous current rating of the Contractors shall be 16Amps for all actuator valve motors up to 6 kW.

1.8 **GEARBOX FOR VALVES**

Gearbox must be self- locking type, with a continuous indicator. Traveling nut and screw type of gearboxes are not acceptable

The gearbox must conform to the provisions of AWWA C-504. The rated torque capability of each operator shall be sufficient to seat, unseat and rigidly hold in any intermediate position the valve disc it controls under the operating conditions specified.

The operator must essentially be of worm and worm wheel design, self-locking type with or without additional spur gear arrangement to ensure that the effort on hand wheel is limited to the pull specified.

All valve operators shall be equipped with adjustable mechanical stop-limiting devices to prevent over-travel of the valve disc in the open and closed positions. Either end of the worm shaft must be provided with needle roller bearing to take on the lateral thrust.

The housing for the gearing must be enclosed and sealed in such a way that there is no leakage of oil / grease even after long period of un-use and there is no ingress of rainwater. Operator for valves, which are likely to be submerged in water for long period during the rainy season, must be watertight.

The hand wheels may be provided with extension for easy grip. The hand wheels must have a provision for locking with a chain and pad lock. All operators when fitted to the valve shaft must ensure clockwise closing and this must be indicated on the housing. A mechanical indicator is to be provided to show disc travel and end of travel.

1.9 **NON-RETURN VALVE**

Specification of Non-return Valves for water application:

1. The valves shall generally conform to IS: 5312(latest revision) Part 1 (Single Door Type) for sizes 100 to 150.
2. The valve shall be suitable for mounting on a horizontal pipe line and flow direction shall be clearly embossed on the valve body.
3. Valves shall have in built quick closing non-slam characteristics achieved by suitable dispositions of weight on door and the hydraulic passage. No spring loaded / spring return action or external dampening arrangement is acceptable.

During testing there shall be no visible evidence of structural damage to any of the valve component.

The supply and installation of valve shall include all necessary fittings including bolts, nuts, gaskets, counter flanges, jointing material etc. as required

Manufacture, supply and delivery of DI D/F Slanted seat Tilting Disc Swing Check Valve in single piece body and closed eye disc construction. The hemispherical disc is inclined nearly 59 degree for fast open and closing. The corrosion proof and wear resistant disc face & body seat face, both made of fusion bonded Nickel Chromium weld overlay and micro finished. Body and disc of ductile cast iron GGG-40, medium free (dry) shafts of stainless steel and bearings of Zinc-free Bronze. *The* Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 150 microns. The EPDM rubber & Epoxy Powder should be approved by W 270. (EP-P à it is a resi-coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200°C). Face to face dimensions as per EN 558-1 Series 14 and flange connections as per EN 1092-2 / IS1538. Specification and dimensions as per EN 12334.

1.9.1 **MATERIAL OF CONSTRUCTION:**

Table 6 Material of Consruction-1

Body	Ductile iron to EN-JS 1030 (GGG-40)
Disc	Ductile iron to EN-JS 1030 (GGG-40)
Shaft	Stainless Steel 420 with 13%chromium (1.4021)
Seat	Integral Nickel weld overlay, micro finished
Shaft Sealing	EPDM rubber
Surface Protection	Epoxy liquid lacquer coating, min. 150 microns, color: RAL 5005 blue

1.9.2 **INSPECTION AND TESTING**

The Non Return Valves shall be inspected at manufacturing works before dispatch by Employer's representative for MOC and all routine tests specified in relevant Indian Standard and European Standard.

1.10 **BUTTERFLY VALVE**

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

1.10.1**MATERIAL OF CONSTRUCTION:**

Table 7 Material of Construction-2

Body	Ductile iron to EN-JS 1030 (GGG-40) & Epoxy Coated
Disc, Retainer Ring	Ductile iron to EN-JS 1030 (GGG-40) & Epoxy Coated
Shaft	Stainless Steel 420 with 13% chromium (1.4021)
Shaft Bearing Bushes	Zinc free Bronze
Seat	Integral Nickel Weld Overlay & Micro finished
Disc Sealing	EPDM Rubber [Grade- W 270]
Surface Protection	Up to DN 600, Epoxy powder coating and above DN 600 with epoxy liquid lacquer min. 250 microns thickness, color RAL 5005 Blue
Gearbox Housing	Ductile iron to EN-JS 1030 (GGG-40)
Mode of Operation	with hand wheel

1.10.2 **INSPECTION AND TESTING**

The Butterfly Valves shall be inspected at manufacturing works before dispatch by Employer's representative for MOC and all routine tests specified in relevant Indian Standard and European Standard.

1.11**KINETIC AIR VALVE**

GENERAL

Locations with long rising main lengths need to be provided with Air Valves at every hump or steep slope to provide ventilation to the Rising main. The valves shall generally conform to IS: 14845 – 2000 (latest revision)

Air Valves are used on water mains to release air when the main is being filled in and to remain closed when the pipes is full to prevent loss of water. The valve also will open to admit air while the main is being emptied and to release air accumulated under pressure during normal working conditions in the pipe.

In kinetic air valves, this operation is effected automatically by means of a ball float working in conjunction with an orifice of appropriate type for the duty.

Kinetic Air Valves is a Combination of a small orifice and a large orifice Air Valve. A Separate conventional isolating sluice Valve non rising type with/without bevel gear arrangement is provided for inspection/maintenance of Air Valve without closing of the main line.

Small office single Air Valves, Screwed or Flanged with or without isolating stop cock to release air at or below the maximum working pressure.

Manufacturing, supply and delivery of single chamber, double orifice DI Air Valve with Triple function (Venting, admitting and venting during operation), Tamper proof in one piece construction (Both Large and small orifice housed in the housing itself), with capacity to handle air up to sonic velocity (300 m/s), with flange dimension acc. To EN 1092-2/ IS 1538. Body and cover in ductile cast iron of grade GGG 40. All internal parts such as float, shell etc. & all cover bolts of austenitic alloy steel and DN 50 float of HOSTAFLON and gaskets and seals of EPDM approved for anti-bacterial which is mandatory for drinking water, with Electrostatic epoxy powder coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 250 microns. The EPDM rubber & Epoxy Powder should be approved by W 270. (EP-P à it is a resi-coat powder approved for drinking water application, applied through fusion bonding technology process by dipping the shot-blasted casted components heated up to 200 degree C)

1.11.1 **MATERIAL OF CONSTRUCTION:**

Table 8 Material of Construction-3

Body	Ductile iron to EN-JS 1030 (GGG-40)
Float	Stainless steel (ASTM A240 Grade 316 Ti/AISI 316 Ti); DN 50 float of Hostaflon- Polypropylen
Internal Shell, Shut off device & Ring	Stainless Steel(ASTM A240 Grade 321/AISI 321)
Gasket & Seal	EPDM Rubber [Grade- W 270]
Lead Screws	Stainless Steel (ASTM A194 Grade 303/AISI 303)/ (ASTM A194 Grade 304/AISI 304)
Surface Protection	Electro static epoxy powder coating min. 250 microns thickness, color RAL 5005 Blue

1.11.2 **INSPECTION AND TESTING**

The Air Valves shall be inspected at manufacturing works before dispatch by Employer's representative for MOC and all routine tests specified in relevant Indian Standard and European Standard.

The supply and installation of valve shall include all necessary fittings including bolts, nuts, gaskets, counter flanges, jointing material etc. as required

1.12 **SLUICE VALVES**

Manufacturing, supply and delivery of DI D/F non-rising spindle soft seated glandless Gate Valves with body and bonnet of ductile cast iron of grade GGG-40, wedge with fully encapsulated EPDM rubber W-270 (approved for drinking water) and seals of NBR. The valves should be with replaceable stem nut and replaceable sliding shoes. The valve stems shall be of single piece thread rolled. Valve shall have 3 "O" rings of NBR for stem sealing. Gate valve shall be compatible for buried applications without valve chamber. Face-to-face dimensions as per BS 5163-89/IS 14846-PD/EN 558F5 and flange connections as per IS 1538,Maximum Valve operating torque should be at least 40% less than the torque as stated in the standard EN 1074. The Electrostatic epoxy powder/liquid coating (EP-P) inside and outside color blue RAL 5005 with minimum coating thickness of 250 microns. The EPD All sluice valves shall be coated by dipping in a bath of tar base composition as given in IS: 14846 for sizes from 100 mm to 250 mm.

All components susceptible to corrosion attack shall be coated internally and externally. Protective coating shall always be applied to the individual components before they are assembled, following shot blasting to give good adhesion.

1.12.1 **MARKING, TESTING AND INSPECTION**

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

Testing of sluice valve shall be done for close end in accordance with IS: 14846 for sizes from 100 mm to 250 mm.

All the valves shall be inspected for flaw detection test in accordance with IS: 14846 for sizes from 100 mm to 250 mm.

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.

M rubber & Epoxy Powder should be approved by W 270.

1.12.2**MATERIAL OF CONSTRUCTION:**

Table 9 Material of Construction-4

Body, Bonnet	Ductile Iron GGG 40 (EN-JS- 1030) /Spheroidal Graphite Iron IS: 1865 Gr 400/12
Wedge	Ductile Iron GGG 40 (EN-JS- 1030) /Spheroidal Graphite Iron IS: 1865 Gr 400/12, fully vulcanized with EPDM rubber [Grade-W 270]
Stem	SS: IS: 6603 12Cr13/22Cr 13;AISI 410/AISI 420
Stem Nut	Brass
Bonnet Gasket	EPDM Rubber grade W-270
Stem Sealing	3 O-rings of NBR
Surface Protection	Electro static epoxy powder coating min. 250 microns

	thickness, color RAL 5005 Blue.
Mode of Operation	Hand wheel

1.12.3 **INSPECTION AND TESTING**

The Sluice Valves shall be inspected at manufacturing works before dispatch by Employer's representative for MOC and all routine tests specified in relevant Indian Standard and European Standard.

1.13**DUAL PLAT CHECK VALVE**

1.13.1**FEATURES OF CONSTRUCTION**

Dual plate check (non-return) valves shall conform to API 594 (Check Valves: Flanged, Lug, Wafer and Butt-welding) and API 598 (Valve Inspection & Testing). They shall have metal to metal sealing. The spring action shall optimize the equal closing rates of each plate. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition. The valves shall be of the flanged type suitable for mounting in a horizontal plane.

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

The minimum body-wall thickness shall conform to those given in Table 1B of API Standard 594.The face-to-face dimensions of valves (including valves with ring-joint facings) shall conform to those mentioned in Table 2B of API Standard 594.

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

Maximum permissible seat leakage shall be 7 cc/hr./cm of the nominal valve diameter.

1.13.2**MATERIALS OF CONSTRUCTION**

The materials of construction for dual plate check valves shall be in accordance with the Table 10 below.

Table 10 Material of Construction for Dual Plate Check Valves

Item	**Material**
Body	For PN 10 - CI IS 210 Grade FG 260 For PN 16 - SG Iron IS 1865 Grade 500/7
Plate	For PN 10 – CI IS 210 Grade FG 260 For PN 16 - ASTM, A 216 Grade WCB
Hinge Pin / Stop Pin	SS AISI 431
Springs	SS ASTM A 313
Seat	SS AISI316
Retainer	Carbon Steel

1.13.3**INSPECTION AND TESTING**

The Sluice Valves shall be inspected at manufacturing works before dispatch by Employer's representative for MOC and all routine tests specified in relevant Indian Standard and API Standard.

1.14 DISMANTILING JOINTS

Manufacturing, supply and delivery of Dismantling Joints with composite fitting feature (a telescopic action designed to provide longitudinal adjustment between flanged pipe and flange equipment).Hot rolled Asymmetric Steel T–Section according to BS EN 10025: 2004 which is free from circumferential welds providing integral strength. The offset T profile shall have a perfect seal on the gasket and straight line bolt travel. Profiled Rolled steel sleeve according to BS EN 10025: 2004 allows angular deflection of the pipe ends due to a thinner mid-section. Rolled sleeve ends should match the gasket profile exactly. Certified Non Toxic WRAS Approved for use on potable water distribution systems in accordance with BS 6920 of EPDM Gasket with self-centering lip according to the standard BS EN 681-1: 1996 and Fusion Bonded Epoxy coating with a thickness of 250 microns minimum.

1.14.1MATERIAL OF CONSTRUCTION

Table 11 Material of Construction-5

Sleeve	50 – 200 NB Ductile Iron. (GGG 40), BS EN 1563:1997 250 – 2000 NB Rolled Steel, BS EN 10025:2004
End Ring	50 – 300 NB Ductile Iron. (GGG40), BS EN 1563:1997 300 – 2000 NB Rolled Steel, BSEN 10025:2004
Flange	50 – 125 NB Rolled Steel, BSEN 10025:2004 100 – 200 NB Ductile Iron (GGG 40), BS EN 1563:1997 250 – 300 NB above Rolled Steel, BSEN 10025:2004
Spigot	Rolled Steel, BS EN 10025:2004
Fastener Studs	304 Stainless Steel
Fastener Tie Rods	Electro Galvanized
Gasket	EPDM Gasket with SELF CENTERING LIP, BS EN 681-1:1996, ISO 4633:1983
Coating	50-1400NB Fusion Bonded Epoxy Non Toxic WRAS Approved Coating and Gaskets with BS 6920 Certification. 1500+ Sigma Guard 720.

1.15GENERAL REQUIREMENTS FOR PIPES, SPECIALS AND VALVES

The pipes and valves are specified in detail in subsequent sections of this document. Some general requirements are pointed out in the following paragraphs.

1.15.1DI PIPES

Pipes carrying raw, settled or filtered water shall be of Ductile Iron, flanged or with spigot and socket joints with rubber rings, according to individual circumstances. Generally, the following material is used:

Table 12 Material of Pipes as per Component

Raw water, clear water, interconnection between the units	DI socket/spigot LA class and flanged medium range
Sludge, waste water, overflow	Cement concrete pipes with rubber rings

Process water in the plant, internal drinking water supply	Galvanized Iron pipes, threaded joints; PVC class 3 for underground pipes
Air	DF/DI pipes threaded joints
Conduits	Mild steel (visible) or PVC (cast in concrete slabs etc.)

Pipes carrying chemical solutions or solutions or gases shall be selected according to the properties of the medium after approval of the Engineer-in-Charge. Jointing shall be kept to a minimum. All flexible pipes shall be supported on walls, or laid on trays or in pipe channels etc., to avoid sagging. Drain cocks shall be provided to empty the pipes whenever necessary.

All pipe work and fittings etc., shall conform to the appropriate Indian Standards and shall be to a class in excess of the maximum pressure they will attain in service including any surge pressure and shall be supplied by an approved manufacturer. All pipelines shall be tested at 1.5 times the design working pressure.

The internal surfaces of all pipe work shall be thoroughly cleaned before and during erection and before the pipe work is placed into commission. All pipelines shall be properly painted as per the specifications.

1.15.2 **VALVES AND APPURTENANCES**

All sluice gates, butterfly valves, air release valves, check valves shall be designed for the medium carried in the respective pipeline, according to the diameter and the design working pressure of the pipeline.

The valves shall be installed between flanges. The dismantling shall be possible by the use of rigid or flexible dismantling pieces or flange adapters at one side. For this purpose, suitable flange adapters may be provided. All valves shall be installed in the pipe work in such a manner that they can easily be removed from the line for dismantling and maintenance.

The non-return valves on the pump delivery branches shall be spring loaded and will have high speed non-slam closing characteristics.

Valves used in lines conveying chemical solutions and gases shall be manufactured of material suitable for the purpose and to withstand the corrosive and aggressive action of the medium.

1.16**ELECTRO CHLORINATOR**

The Electro chlorinator shall be capable of producing Hypochlorite solution of strength 02 to 0.8% which is non-hazardous from common salt (NACL) using low voltage DC supply at site for on line disinfection of potable water supply. The equipment is proposed to be installed on a TW or for a group of TWs for online chlorination/disinfection of pumped water in the pumping main. The capacity of the unit will be adequate to disinfect the TW water such that a dose of 3mg/l could be given to TW water online. The equipment shall be complete with required rectifier unit, operating panel, dosing pump and shall be of continuous operation type. The equipment shall have the following and complete in all respect:

1. Electrode shall be Titanium grade I as per ASTM for long life
2. Electrode DSA with MMO grade
3. Low power consumption
4. Low salt consumption
5. Large installation base
6. In built protection against over voltage and over current in rectifier
7. IEC 146 code compliant (Continuous Operation)
8. Dosing pump
9. Container of suitable material which has adequate structural strength and not subject to corrosion for long life. Capacity of the container shall be adequate to

house the brine solution and electrodes and other ancillaries and adequate storage for hypo-chlorite solution for continuous dosing.

10. Operating Voltage : 220V, 50Hz
11. Protection: IP65
12. Back pressure against which the solution dosing will be done ranges from 2om to 200m.
13. Suction and delivery valves shall be of PVC
14. Provision for synchronization of chlorination system with TW operating panel.

1.17 INSTALLATION OF VALVES

1.17.1 GENERAL

The installation of valves shall be installed between flanges according to the instructions of the manufacturer and the Engineer in Charge.

Valves shall be placed on a support of concrete so that no shear stress is in the flanges. In case of axial thrust due to closure of a valve against pressure the valve shall be anchored in the support in a suitable manner to transfer the thrust into the floor slab of the chamber.

1.17.2 CHAMBERS FOR VALVES:

The work consist of construction of Valve Chambers, Flow Meter Chambers, Anchor Blocks, Thrust Blocks, Pipe Supports, etc., required to be provided for various water supply pipelines

Valve chambers and Flow meter chambers shall be constructed as per arrangement to be given by **Engineer**. They shall be constructed in brick masonry / Cement concrete with cement plaster on the walls. The top slab cover shall be cast in situ in reinforced concrete.

The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The size of the chambers shall be according to the following criteria as per direction of **Engineer**

- distance of flanges from walls: 30 cm
- distance of sockets from walls: 30 cm
- distance between highest point of equipment and roof slab: 30 cm

A suitable locking device may be got constructed by **Engineer**, if required at site.

Anchor Blocks, Thrust Blocks, Pipe Supports, etc. shall be constructed as per the site condition or as directed by the **Engineer** as per the specification of the drawing.

The work shall include excavation, consolidation, leveling, lean concrete, foundations, finishing, refilling. It shall include all labour and material required for the complete chamber.

1.17.3 EXCAVATION

Excavation shall be done in accordance with Sub-Section- 5 and Sub-Section- 11 of this Specification. The rate quoted for manhole shall be inclusive of excavation and backfilling, bailing or pumping out water and shoring.

1.17.4 BED CONCRETE

The bed concrete shall be done in accordance with relevant Specification.

1.17.5 BRICK MASONRY

1.17.5.1 *Description*

This work shall consist of construction of valve/meter chambers in brick work together by cement mortar in accordance with the details shown on the Drawings or as approved by the Engineer, as per the standard specification of brick masonry.

1.17.5.2***Cement plaster work***

All joints in masonry shall be raked to a depth of 12 mm with a hooked tool made for the purpose when the mortar is still green and in any case within 8 hours of it's laying. The surface to be rendered shall be washed with fresh clean water to make it free from all dirt, loose material, grease, etc. and thoroughly wetted for 6 hours before plastering work is commenced.

Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

The proportion of the cement mortar shall be as specified on relevant Drawings. Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to stand for more than 25 minutes after mixing with water.

Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. The decision as to when the plaster has hardened, will be given by Engineer. Curing shall be done by continuous applying water in a fine spray and shall be carried out for at least 7 days.

Plastering shall be done on inside faces of brick masonry in CM 1:4, 12mm thick and outside faces of brick masonry in CM 1:4, 15 mm thick as shown in the drawing or as directed by the Engineer.

SPECIFICATION FOR CHLORINATION EQUIPMENT AND CONTAINER ROOM

1. INSTALLATION

Chlorine gas units and cylinders shall be housed in separate rooms, easily accessible, close to the point of application and convenient for truck loading and safe container handling. The floor shall be flat and at least 150 mm above the surrounding ground and drainage shall be adequate.

The height of the container room should be at least 4·0 m. Under no circumstances such units shall be housed in basement or below ground level since the chlorine gas is heavy and settles into depressions.

The exits shall lead directly out in the open and the doors shall open outward. The hinges of the doors should be of parliamentary type. At least two exits shall be provided in each such rooms.

Adequate arrangements for air circulation and cross ventilation shall be made in the rooms. Air entry shall be from above and air exit shall be from below. Exhaust fans shall be provided at floor level.

The blade and the motor (totally enclosed) of the exhaust fan shall resist corrosion by chlorine.

Natural ventilation and means of cross ventilation that allows an air change in approximate 10 minutes is desirable. For small installation, provision of ventilator openings at the bottom, one opposite the other is adequate.

Separate and reasonably gas tight enclosers openings to the outdoor shall be provided for housing the chlorine feeding equipment in large installations (where tonne containers are used). These enclosers shall be vented to the upper atmosphere and equipped with positive means of exhaust (near the floor level, at the centre of the room or opposite to the entrance) capable of a complete air change within 2 to 4 minutes in an emergency. A satisfactory ventilation scheme involves a. combination of fresh air and exhaust system, consisting of fans that force the fresh air into the encloser through openings near the ceiling with exhaust fans to clear away any chlorine contaminated air near the floor level. The design or exhaust system shall not include the natural ventilation that may be available.

Rooms for chlorine containers in which more than 200 kg chlorine is stored shall be separated from the chlorine gas apparatus room and shall be accessible only from outside.

Containers shall rest securely on cradles or on a level rack equipped with adequate safety block to prevent rolling and be slightly elevated from the floor to keep them dry.

The temperature in the installation room shall be within the range of +4 to + 40°C. The chlorine gas containers and chlorine gas pipes shall not be exposed to direct heat radiations and shall be protected from sun rays.

Electrical installations inside the chlorine gas rooms shall be limited to the absolute minimum required. While laying electrical wiring and fixtures adequate safety precautions shall be observed during their installation of ensuring safe use of electricity as per IS: 732-1963· and IS : S216-1969

Rigid PVC conduits should be preferred.

The following information shall be indicated prominently on the outside entry door:

- "Chlorine gas dosing apparatus room"
- "Smoking and handling naked flame prohibited"
- "Admission restricted".

2. HANDLING

Ordinarily a plant labourer can handle up to tOO-kg cylinder when aided by small hand cart. Heavy containers shall be handled with the aim of mechanical contrivance, such as trucks, monorails, cranes or other such equipment.

Chlorine gas containers shall not be bumped, dropped or rolled on the ground and no object shall be allowed to strike them with force.

Use of mechanical lifting devices is recommended. For lifting one tonne container, the capacity of the mechanical device should be about 2 tonnes.

2 A. SAFE HANDLING OF CHLORINE CYLINDERS & TON CONTAINERS

- Store chlorine cylinders up-right and secure them so that they cannot fall.
- Ton containers should be stored on their sides on rails, a few inches above the floor. They should not be stacked or racked more than one high.
- Keep enough room between containers so that all are accessible in case of emergency.
- Store the containers in a covered shed only. Keep them away from hot sun or any other source of heat like hot water, steam, direct flame and furnace, because excessive heating may tremendously increase the chlorine pressure inside the container resulting in its bursting.

- Do not store chlorine containers with explosives, acids, turpentine, ether, anhydrous ammonia, finely divided metals or other flammable materials.
- Do not store containers in wet and muddy areas.
- Cylinders should be stored on a cement floor sloping towards a pit capable of collecting all the liquid in the cylinders. Under no circumstances should water be allowed to run on to the chlorine in this pit.
- Use cylinders in the order of their receipt, as valve packing can harden during prolonged storage and cause gas leaks when cylinders are finally used.
- Filled and empty cylinders should be stored separately.
- Protective covers for valves should always be secured, even when the cylinders are empty
- No oil or any lubricant shall be used on any valve of the containers.
- Badly fitting connections should not be forced and the correct tool should not be used for opening and closing valves, they should never be hammered.
- When being emptied, the key should be opened fully, it should not be used at any time to regulate the flow of chlorine.
- Implements and other equipment used for emptying the cylinders should be clean and free of grease, dust or grit.
- Cylinders should never be lifted by means of the metal cap, nor should rope slings, chains or magnetic devices be used. The ton containers should be handled with a suitable cradle with chain slings combinations with a hoist or crane having at least 2 metric tonnes capacity.
- Never use cylinders as a roller to move other equipment.
- Never tamper with any fusible plugs of tonners or apply heat to them.
- In case of large leaks first escape is try to stop the flow of liquid by closing the valves.
- Try to contain the spilled liquid by making bunds of sand.
- Ensure that the escaped liquid chlorine does not enter the drains.
- After containing the liquid one can use fluoro protein foam to prevent evaporation of the liquid.
- In case of large leakages the alternative solution is to absorb the chlorine in an alkaline medium such as caustic soda, soda ash or lime slurry.

3. STORAGE

All plants, particularly small ones, should keep on hand at all times sufficient supply of chlorine cylinders or drums.

Special consideration shall be given to requirements of monsoon seasons.

Cylinders shall conform to IS: 7681-1975· and the provisions of IS : 8198 { Part 6)-1979t for filling, inspection, testing, maintenance and use of containers for storage and transportation of liquefied chlorine in cylinders shall be observed.

Cylinders shall be stored vertically so that a leaking container, if found, can be removed with the least possible handling of others. Tonne containers shall be stored on the sides all the time horizontally with suitable rollers or saddles.

Tonne containers are equipped with two valves each with an internal eduction pipe. A removable hood is provided to protect the valves from injury during shipment and handling. In placing tonne containers in position for use, the two valves shall be in vertical alignment. The eduction pipes then permit the upper valve to discharge gas and the lower valve liquid chlorine.

No other objects except chlorine gas storing containers shall be kept in the room.

4. SAFTY

All operating and storing rooms for chlorine gas appliances and container shall be fire proof.

Chlorine storage rooms should preferably be provided with chlorine gas alarm device which gives out an acoustic or an optical signal when the chlorine gas concentration is reached, the set value for which is 1·0 rng chlorine per cubic metre of air in case of a person working in the room and 20 mg chlorine per cubic metre of air when no human being is inside the room.

The sensor for alarm device shall be placed not higher than 300 mm above the floors of the room. '

A bottle of ammonia is essential to detect leaks, etc, in case alarm device is not provided.

Cylinder as well as chlorine shall be tested at every shift period for leaks, first by trying to detect the sharp irritating smell of chlorine, then by passing over each cylinder and around each valve and pipe connections, a rod with a small cotton-wool swab tied on the end, dipped in an aqueous solution of ammonia. If chlorine is present in the air, the swab will appear to smoke due to formation of white cloud of ammonium chlorine. If the leak appears to be heavy, all persons not directly concerned should leave the area and the operator should put on his mask and make a thorough

5. SEARCH OF THE LEAK.

In tracing. a leak, always work down-stream that is start at the cylinder and work down~donl the line of flow until the leak is found.

Safety equipment, like gas masks, rubber gloves, aprons shall be housed in easily accessible (unlocked) cupboard placed outside the chlorination room.

Faulty las mask is worse than none at all. Hence these shall be tested frequently and canisters shall bechanlcd at proper intervals.

First aid box and eye wash fountain shall be provided outside chlorinator room.

The provisions shall be made for emergency disposal of chlorine from leaking containers. The proportions of alkali and water recommended for this purpose are given in Table 1.

TABLE I RECOMMENDED ALKALINE SOLUTIONS FOR

ABSORBING CHLORINE

Container	Caustic soda		Soda ash		Hydrated lime	
Capacity	100%	Water	kg	Water	kg	Water
Kg	kg					
45	S7	180	136	450	57	S70
67	85	275	204	680	85	850
1 000	115	3640	2272	9090	115	1 150

When chlorine is to be absorbed in hydrated lime, the solution should be continuously and vigorously agitated.

Water shall never be applied to the chlorine leak to stop it, as it will only make it worse.

When a chlorine leak occurs, the ventilation system should be operated immediately before any person enters the chlorination room.

Ventilation system should be controlled from outside.

The exhaust pipe of the apparatus shall lead to the open through the shortest path and the outlet of this exhaust pipe shall not be readily accessible.

In case of fire, the cylinders and drums containing chlorine shall be protected by spraying with water since the containers can burst at temperatures of over 70°C. Source of pressurized water shall be provided adjacent to the chlorination room.

Fusible plug, a safety device, shall be provided over all cylinders and containers designed to melt or soften between 70 to 75°C to preclude a build-up of hydrostatic pressure resulting from thermal expansion due to fire and other hazardous conditions.

Before disconnecting the flexible leads from containers to gas headers, the cylinder valves should be closed first and then the gas under pressure should be drawn from the header and flexible leads before the header valve is closed.

Solvents. such as petroleum, hydrocarbons or alcohols should not be used for cleaning parts which come in contact with chlorine. The safe solvents are chloroform or carbon tetrachloride. Grease should never be used where it comes in contact with chlorine.

No direct flame should be applied to the chlorine cylinder when heating becomes necessary.

The protective hood over the valve should always be kept in place except when the cylinders are in use.

In addition to this, the relevant provisions of IS: 4263-1967* shall also be observed as for as applicable.

7. VACUUM FEED TYPE CHLORINATORS

Vacuum feed type chlorination apparatus works according to indirect method where aqueous chlorine solution is prepared at site before delivering it to the water to be treated. The system is brought under vacuum by using high pressure water passing through the injector. The minimum pressure of the water depends upon the mixing equipment which may be 0'1 to 0'5 N/mm^2 according to the capacity of plant and depends also on the pressure that has to be overcome at the inlet. The quantity of the water should correspond to the solubility of chlorine gas in water.

If the pressure of water exceeds 0.5 N/mm^2, pumping is necessary to regulate the required chlorine doze.

The chlorinators are made in different sizes with chlorine supply up to 50 kg/h.

Typical flow diagram of vacuum feed type chlorinator is shown in Fig. I.

In formulating this standard assistance has. been derived from the following:

In the formulation of this standard due, weightage has been given, to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

For the purpose of deciding whether a particular requirement of' this standard is complied with, the final value, observed or calculated, as per the result of a test or analysis, shall be rounded off in accordance with IS: 2-1960. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

8. TYPES

The chlorinators shall be of the following types:

- Wall- mounted,
- Pedestal mounted, and
- Cylinder mounted.

9. APPARATUS

3.1 Vacuum feed type chlorination equipment is provided with the following:

a. Chlorine gas stop valve in the tube connecting the chlorine gas container and chlorination apparatus;
b. In case of chlorination apparatus with several chlorine gas container connections, a stop valve shall be provided for each container;
c. Pressure gauges, one for indicating the cylinder, pressure and the other for delivery pressure;
d. Filter for retaining solid impurities of chlorine gas before it enters the main units;
e. A desiccator valve or non-return valve containing concentrated. sulphuric acid or calcium chloride through which chlorine should pass to free it from moisture;
f. Chlorine gas automatic closer (rapid closing valve) which closes when there is a reduction of vacuum due to stoppage of water supply;
g. A compensating vacuum regulating valve to maintain a constant upstream pressure;
h. A back pressure valve to maintain constant downstream pressure;
i. Device for keeping constant the adjusted quantity of chlorine gas;
j. Device for measuring the chlorine gas flow;
k. Automatic switch device may be provided for shifting to a full chlorine gas container if a continuous chlorination has to be ensured;
l. Stop valve and measuring device for the water passing through the injector;
m. Injector for creating vacuum to control ff ow of gas from the main unit and for mixing chlorine gas with water prior to injection to main supply. The injector is either of fixed throat type, adjustable throat type or anti syphon fixed throat type;
n. Safety device or non-return valve which prevents backflow of chlorine water in the main unit under adverse condition;
o. Venting device which prevents the building up the pressure in the vacuum dozing apparatus. The vent line shall lead outside the building housing the chlorination equipment;
p. Evaporators are provided in case liquid chlorine is to be withdrawn from tonne container;
q. Chlorine gas pressure reducing valve, shut off valve and evaporator pressure relief system are provided where evaporators are used; and
r. Diffusers for. Delivering the chlorine water solution into the main line (for dia exceeding 300 mm)/open channel.

10. MATERIALS

Main body of units should be fiber glass reinforced polyester in case of plants of large capacity (equipment with chlorine supply above 60 kg/h) and in smaller plants, the main body of units may be of rigid PVC.

The injector should be of chlorine resistant PVC, bronze, hard rubber in cast iron or ebonite body with renewable nozzle and throat.

All the metal parts inside the main body coming in contact with chlorine shall be made of corrosion resistant material, such as silver plated brass, monel, nickel or silver.

The pipeline for carrying dry chlorine or liquid chlorine under pressure should be either phosphorus dioxide non-arsenical copper conforming to IS : 191 (Part 8)-1980* phosphorous dioxide arsenical copper conforming .to IS : 191 (Part 10)-1980* or carbon steel conforming to IS : 1030-1974t.

Minimum wall thickness for tubes is recommended below :

Material	Outside dia in mm	Minimum wall thickness in mm	Tolerance in mm
Copper Tubes	Up to 5	0.80	± 0.08
	Above 5to 12	1.00	± 0.10
	Above 12to 20	1.20	± 0.10
Carbon steel	Up to 20	2.50	± 0.10
	Above 20 to 30	3.00	± 0.15
	Above 30 to 40	3.20	± 0.20

For carrying moist chlorine, the pipelines should be made of silver, platinum, corrosion resistance alloy steel conforming to grade 19 of IS : 3444-1978$, HDEP conforming to IS : 4984-19788 or UPVC conforming to IS : 4985-198111.
Diaphragm of gauges should be of silver and body should be of cast iron alloy, finished in enamel, brass or aluminium alloy. The dial and the pointer should be of anodised aluminium.

Diaphragm of valves should be of teflon silver, or bronze or steel backed with silver or teflon foil.

Filter for retaining impurities of chlorine gas should be of silvered metal with renewable glass wool insert.

Flowmeter tube should be of borosilicate glass.

Nuts, bolts and brackets should be of chromium plated brass or cadium plated mild steel.

Gaskets and packing should be of bonded asbestos fibre or antimony lead (with 2 to 3 percent antimony).

11. OPERATION

With the start of water supply the entire system shall come under vacuum.

The built up valve in the main unit shall be able to reduce pressure.

Only after the system comes under vacuum the valve of the chlorine cylinder shall be opened slowly and then the rate of flow control valve in the unit shall be adjusted.

At the point of injection the chlorine water concentrate line should dip to about 1’5 m in the receiving tank.

12. CHLORINE REQUIREMENT

Rate of withdrawal of chlorine from container depends upon the size of container and the surrounding temperature. For guidance, Table 1 may be followed.

RATE OF WITHDRAWAL OF CHLORINE FROM CONTAINER

Temperature ^{0}C	Kg of Chlorine Discharge per day		
	Cylinders		Tonne container
	45 kg	67 kg	
4	2.72	4.08	45
10	6.35	9.50	110
15	10.75	16.10	130
20	14.50	21.54	254
Above 27	18.70	28.12	315

When the gas discharge rate from a single container does not meet the requirements, two or more containers can be connected to a manifold and discharge simultaneously. It is advisable not to couple more than four containers to a manifold.

When discharging through a manifold, all the containers shall be at the same temperature, particularly when connecting a new cylinder to the manifold.

When more than 3 cylinders are used, the connections should be arranged in groups so that one complete group can be changed at a time.

13. INSTALLATION AND SAFETY

For installation of the chlorination plant including handling, storage and safety of chlorine cylinder and drums IS: 10553 (Part 1)-1983 shall be followed.

14. STORAGE LICENSE.

According to the Compressed Gas Cylinder Act Government of India, it is necessary to obtain a storage license when five or more containers are to be stored. For obtaining the storage license safety equipment are essential along with scrubber system. Also the building has to be constructed as per norms suitable for storing toxic gas cylinders with adequate ventilation systems and handling accessories.

15. STATUTORY REQUIREMENT FOR OBTAINING STORAGE LICENCE

- Leak detector with audible alarm.
- Disaster plan for operation during emergency leak of chlorine.
- One or more Hydrant point with adequate pressure near the premises.
- At least one air breathing apparatus and 2 cannister gas masks.
- Ammonia torch.
- Weather cock.
- Emergency kit.
- Lime pit with gas manifold leading to pit.
- Suitable plant layout as per statutory requirements.

2 SECTION 2: PUMPING MAINS

2.1 GENERAL REQUIREMENTS

This part covers additional specifications for civil construction works, supplementing the general specifications for material and workmanship. The tender is based on design and drawing given by the Employer and shall be inclusive of cost of labor, materials, tools and plants and specialized machinery for completing the various components of the project and all operations connected therewith, under all conditions of site, moisture, weather etc.

2.2 RISING MAIN

On award of the contract, the Contractor will carry out the laying of rising mains from various Tube wells to various Service Reservoirs as per the specifications given by the Engineer.

2.3 LAYOUT INVESTIGATION

The Contractor in co-ordination with the Engineer has to determine the Layout in which the rising main has to be laid, The Engineer will give the design of main along with the alignment of the main and the location of valves etc.,

Before taking up the work, the contractor has to do the trial pits in the alignment to know the underground utilities to lay the pipes and he shall submit the layout plan of the pipes to be laid depending upon the underground utilities available in the alignment. The work can be started after getting the approval the layout plan submitted by the contractor.

2.4 SCOPE

The scope of works to be carried out under the contract includes:-

(i) Conducting trial pits to know the underground utilities available in the alignment of rising main.

(ii) The work includes Laying, jointing and testing of DI rising mains from various Tube wells to the respective Service Reservoirs including related earthwork, Procurement of DI pipes, specials Valves etc., etc., as per design given to the contractor and construction drawings showing type of Valves and their locations and sizes.

(iii) The work also includes providing supporting arrangements of the pipes if they are laid on the ground itself, culvert crossings, Railway crossings, NH and other road crossings and laying the pipes by trench less technology where there is restriction to cut the roads or cross the railway lines etc., as in the drawing and other related work, etc., complete for all Rising mains from various Tube wells to Various Service Reservoirs including conducting satisfactory Pressure testing of the pipe laid to the required pressure specified by the Engineer.

(iv) Supplying and fixing of Air valves, Scour valves, Sluice Valves in the specified locations including supply and fixing the specials required for fixing the valves and construction of valve chamber as per the drawings specified.

(v) Each Rising main shall be connected to the out let of the Pump set erected in Tube well in the beginning and shall also connected to the inlet of the Service Reservoir at the end of the main.

(vi) Necessary bends shall be provided to the required degree, wherever the alignment deviate from the straight line. Thrust blocks of sufficient size shall be provided whenever the main rises or falls in gradient suddenly and the work should be taken up after getting the approval from the Engineer.

(vii) The Earth excavated shall be refilled after the satisfactory completion of Hydraulic pressure test in the field to the required pressure as per specifications and as per the directions of Engineer. The water required for hydraulic pressure test shall be arranged by the contractor at his cost and no additional payment shall be made for supplying water for testing.

(viii) The excess earth shall be removed 8km away from GMC from the site and necessary payment will be made as per the BOQ item.

(ix) The contractor shall make Barricading arrangement during earth work, laying, jointing and testing of pipes and up to the refilling the trench to safe guard the public. Necessary sign boards, shall be provided well in advance so that the public may know that there is any development activities is going on.

(x) After laying the pipes in each main for specified length, it shall be tested for Hydraulic pressure test as per the procedure given in the specifications. In case leakages are observed, appropriate rectification measures should be carried out to arrest the same, and again the Hydraulic test has to be conducted as per specifications or as directed by the Engineer. No additional payment shall be made for carrying out such rectification work, if found necessary.

(xi) The scope of work also includes cleaning, washing and disinfection of pipes for free from any foreign matter, loose particles, debris, etc., and makes it suitable for conveyance of potable water.

(xii) Commissioning the rising main shall be carried out after completion of rising main and creation and development of Tube well and erection of new Pumping machinery in the Tube well. During Commissioning if there is any leak occurred in the main, the same should be rectified by the contractor at free of cost.

(xiii) The rising main has to be maintained during its defects liability period for which no extra payment will be made to the contractor. Whatever the defect noticed during defects liability period, the contractor should rectify the defects at free cost.

(xiv) The Contractor shall Hand over the Rising Mains to the GMC, after the satisfactory completion of defect liability period and then completion of maintenance period.

(xv) Any statutory and other clearances and or approvals that may be required to complete the work are covered under the scope. No additional payment shall be made for carrying out the work.

(xvi) Submission of “As built drawings”.

(xvii) Dressing up of area.

2.4.1 DETAILS OF AIR VALVES AND SLUICE VALVES AS LISTED BELOW

- Air Valves

  Non Tamper DI Double Air Valves of following sizes has to be installed in the Rising main as per the alignment plan of the Rising mains.

  1. 150 mm Double Air valve – 10 Nos
  2. 200 mm Double Air Valve – 4 Nos

- DI D/F Sluice Valves of the following sizes has to fix in the Rising mains in locations as shown in the alignment plan of the Rising mains.
  1. 200 mm Dia sluice valve – 3 Nos

Butterfly valves to be fixed in the rising main in the locations as shown in the alignment plan of Rising main

1. 350 mm Dia Butterfly Valve – 1 Nos
2. 400 mm Dia Butterfly Valve – 2 Nos
3. 600 mm Dia Butterfly Valve – 11 Nos
4. 800 mm Dia Butterfly valve – 1 No
5. 1000 mm Dia Butterfly Valve – 6 Nos

Necessary K12 specials shall be used for fixing the Sluice valves and Air valves as per the item specified in the BOQ.

Air valve chamber and Sluice Valve Chambers shall be constructed for each valve location as per the drawings of valve chambers.

2.5 SUPPLY OF DUCTILE IRON PIPES, SPECIALS, VALVES AND LAYING OF PIPES FOR WATER SUPPLY

General Standards

Except as otherwise specified in this technical specification, the Indian/International Standards and Codes of Practice in their latest version shall be adhered to for the design, manufacturing, inspection, factory testing, packing, handling and transportation of product. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Engineer in Charge.

Ductile Iron Pipes

This specification requires a reference to the following standard specifications for Ductile Iron Pipes

Table 13 Standard Specification for DI Pipes

IS: 12288	Code of practice for use and laying of ductile iron pipes
IS: 1363	Hexagon head bolts, screws and nuts of product grade A and B (part:1-5)
IS: 3624	Pressure and vacuum gauges
IS: 341	Black Japan, types A, B and C
IS: 9862	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water and chlorine resisting
CPHEEO	Manual on Water Supply and Treatment, III edition, Ministry of Urban Development, New Delhi-1999

The pipes will be centrifugally cast (spun) Ductile Iron pipes for Water and Sewage confirming to the IS 8329: 2000. The pipes used will be either with push on joints (Rubber Gasket Joints) or Flanged joints. The class of pipe to be used shall be of the class K-7 for distribution network and class K-9 for raising main.

The pipes shall be outside coated with zinc with a finishing layer of bituminous paint as per Appendix 'A' and have factory provided cement mortar lining in the inside as per the provisions of Appendix 'B' of the IS 8329: 2000.

The pipes will be supplied in standard length of 4.00, 5.00, 5.50 and 6.00 meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber EPDM gasket. Any change in the stipulated lengths will be approved by the Engineer – in charge. The gaskets will confirm to the IS 5382:1985.

The gaskets 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 manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub contractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

The flanged joints will confirm to the Clause 6.2 of IS 8329. The pipe supply will also include one rubber gaskets for each flange.

2.5.1**INSPECTION AND TESTING:**

The pipes will be subjected to following tests for acceptance:

Visual and dimensional check as per Clause 13 and 15 of IS 8329

Mechanical Test as per Clause 10 of IS 8329

Hydrostatic Test as per Clause 11 of IS 8329

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

The sampling shall be as per the provisions of the IS 8329

2.5.2**MARKING**

All pipes will be marked as per Clause 18 of IS 8329 and show as below:

Manufacturer name/ stamp

Nominal diameter

Class reference

A white ring line showing length of insertion at spigot end

2.5.3**PACKING AND TRANSPORT:**

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage.

2.5.4**HYDRAULIC TESTING**

Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per IS: 8329 and IS: 12288.

2.5.5**SPECIALS FOR DUCTILE IRON PIPES**

General

This covers the general requirements for Ductile Iron (DI) fittings suitable for Tyton joints to be used with Ductile Iron pipes with flanged and Tyton jointing system.

Types of specials

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

- flanged socket
- flanged spigot

- socket bends (90^0, 45^0, 22 1/2 ^{0}, 11 1/4 ^{0})
- double socket branch flanged tee
- all double socket tee
- double socket taper
- retrained joints
- All the fittings shall be of class K-12.

Supply

All the DI fittings shall be supplied with one rubber ring for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382 as described in the preceding chapter. Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts.

2.5.6 LUBRICANT FOR DUCTILE IRON PIPES AND SPECIALS

General

This section covers the requirements for lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-in rubber ring joints

Specification

The lubricant has to have the following characteristics:

- 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 odor
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf life not less than 2 years
- Acceptance tests
- They shall be conducted in line with the provisions of the IS 9523

Packing

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

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 manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/sub contractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

2.5.7SPECIFICATIONS FOR LAYING AND JOINTING OF PIPE LINE SYSTEM FOR WATER SUPPLY

2.5.7.1*Preparatory work*

The contractor will inspect the route along which the pipe line is proposed to be laid. He should observe/ find out the existing underground utilities/ construction and propose an alignment along which the pipeline is to be laid. He should make all efforts to keep the pipe as straight as possible with the help of ranging rods. Where ever there is need for deviation; it should be done with the use of necessary specials or by deflection in pipe joints (limited to 3 to 5^0 where long radius curves are permitted). The alignment as proposed should be marked on ground with a line of white chalk and got approved from Engineer In charge. The Contractor will than prepare an L-Section along this alignment showing the location of proposed pipe line. The L-section should be got approved from the site Engineer. The position of fittings, valves, should be shown on the plan.

2.5.7.2*Alignment and the L-Sections*

The alignments, L-section (depth of laying) and location of specials, valves and chambers may be changed at site in co-operation with and after approval of the Engineer in Charge.

2.5.7.3*Standards*

Except as otherwise specified in this technical specification, the Indian Standards and Codes of Practice in their latest version, National Building code, PWD specification of the state of Bihar and Manual of water supply of GOI shall be adhered to for the supply, handling, laying, installation, and site testing of all material and works.

2.5.7.4*Tools and equipment*

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 Engineer in Charge a detailed list of tools and equipment available. If in the opinion of the Engineer in Charge 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 Engineer in Charge. The Contractor will always have a leveling instrument on site.

2.5.7.5*Transportation of pipes and specials*

The Contractor has to transport the pipes and other materials from manufacturer to the site of laying as indicated by the Engineer in Charge. 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 rests uniformly on the vehicle bed in their entire length during transportation. Pipes shall be loaded and un-loaded manually or by suitable mechanical means without causing any damage to the stacked pipes.

The transportation and handling of pipes shall be made as per IS 12288. 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.

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 engineer in charge.

Cranes or chain pulley block or other suitable handling and lifting equipment shall be used for loading and un-loading of heavy pipes. 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. Damage to lining must be repaired before pipe laying according to the instructions of the pipe manufacturer. Pipes shall not be thrown directly on the ground.

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 should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

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

2.5.7.6***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.

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 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 made to prevent excessive soil, mud etc. entering the pipe.

Generally, the pipes shall be laid within two weeks from the date of their dispatch from the manufacturer/store.

The joint gaskets shall be kept in wooden boxes or their original packing and stored in cool conditions and not exposed to direct sunlight. Gaskets must not be deformed. They shall be taken out only shortly before they are needed.

2.5.7.7***Pipe trench***

All excavation of pipe trenches shall be done in accordance to Chapter 4 of this specification and following detail specification are applicable.

2.5.7.8***Trench excavation***

The trench excavation of pipe line shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels shown on the drawings or as directed by the Engineer in Charge. The depth of the excavated trench shall be as given in the drawings or as directed by the Engineer in Charge. The width of the trench at bottom between the faces of sheeting shall be such as to provide as per the approved drawings No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Engineer in Charge.

The bottom of the trench shall be trimmed and leveled to permit even bedding of the pipes. It should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation shall be made at the joints of the pipes, so that the pipe is supported along its entire length.

All excavated material shall be stacked in such a distance from the trench edge that it will not endanger the work or workmen and it will avoid obstructing footpaths, roads and drive ways. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible during the construction work. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural water-courses shall not be obstructed.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the work and until it is safe for traffic to use the roadways. All materials, piles equipment and pipes which may serve as obstruction to traffic shall be enclosed by fences or barricades and shall be protected by illuminating proper lights when the visibility is poor.

As far as possible, the pipe line shall be laid below existing services, like water, cables, cable ducts and drains but not below sewers, which are usually laid at greater depth. Where it is unavoidable, pipe line should be suitably protected. A minimum clearance of 150 mm shall be provided between the pipe line and such other services.

Trees, shrubbery fences, poles, and all other property and surface structures shall be protected. Tree roots shall be cut within a distance of 50 cm from pipe joints in order to prevent roots from entering them. Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be provided. The structures, which will be disturbed, shall be restored after completion of the work.

Where water forms or accumulates in any trench the Contractor shall maintain the trench free of water during pipe laying.

Wherever necessary to prevent caving, trench excavations in soils such as sand, gravel and sandy soil shall be adequately sheeted and braced. Where sheeting and bracing are used, the net trench width after sheeting shall not be less than that specified above. The sides of the excavation shall be adequately supported at all times and, except where described as permitted under the Contract, shall be not battered.

The Engineer in Charge in co-operation with the Contractor shall decide about the sheeting/ bracing of the trench according to the soil conditions in a particular stretch and taking into account the safety requirements of the Contractor's and ENGINEER-IN-CHARGE's staff. Generally, safety measures against caving have to be provided for trenches with vertical walls if they are deeper than 2.0 m.

2.5.7.9***Trench excavation to commensurate with the laying progress***

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 defined by the Engineer in Charge. 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 and testing of the pipes

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

2.5.7.10***Bedding of the pipes***

The trench bottom shall be even and smooth so as to provide a proper support for the pipe over its entire length, and shall be free from stones, lumps, roots and other hard objects that may injure the pipe or coating. Holes shall be dug in the trench bottom to accommodate sockets so as to ensure continuous contact between the trench and the entire pipe barrel between socket holes.

2.5.7.11***Laying and jointing of pipes***

General

The pipes will be cleaned in the whole length with special care of the spigot and sockets on the inside/ outside to ensure that they are free from dirt and unwarranted projections. The pipes and specials should be cleaned with water having 10ppm residual chlorine. 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. Vertical and horizontal deflections between individual pipes need the approval of the Engineer in Charge. In no case the deflection shall be more than 75% of those recommended by the manufacturer.

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, particularly the spigot end and the socket including the groove for the rubber ring.

Pipes and the related specials shall be laid by using the recommended tools.

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. The spigot end has to be chamfered again at the same angle as the original chamfered end. Cutting shall be perpendicular to the Centre line of the pipe. In case of ductile iron pipes the cut and chamfered end shall be painted with two coats of epoxy paint. If there is no mark for the insertion depth on the spigot ends of the (cut) pipe it shall be marked again according to the instructions of the manufacturer.

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, particularly the spigot end and the socket including the groove for the rubber ring. End caps are removed only just before laying and jointing.

All specials like bends, tees etc. and appurtenances like sluice 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.

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.

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 Engineer in Charge, the trench conditions or the weather are unsuitable for proper installation.

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 links in laying.

2.5.7.12***Laying and jointing of DI pipes***

Pipes should be lowered into the trench 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.

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

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.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.

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

The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot end 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.

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

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.

2.5.7.13***Anchoring of the pipeline***

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 per design of Engineer- In- Charge 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.

2.5.7.14***Testing of the pipelines***

Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer in Charge. 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, other chamber).At the beginning, the Contractor shall test stretches not exceeding 2 km. After successful organization and execution of tests the length may be extended to more than 2 km after approval of the Engineer in Charge.

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, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol if required:

- 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)
- at the lower end with a precision pressure gauge and the connection to the pump for establishing the test pressure
- 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 rising 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 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 and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.
- Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches.
- The testing conditions for the pipelines shall be as per the test pressures and condition laid out in IS 8329 for DI pipes.

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 Engineer in Charge until all requirements of the test have been obtained.

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.

2.5.7.15***Leakage Test***

After the successful completion of the pressure test, Leakage test at site after proper installation of pipeline shall be conducted at a pressure to be specified by the Engineer for duration as specified below:

The field test pressure to be imposed should be not less than the maximum of the following:

a) 1.5 times the maximum sustained operating pressure.

b) 1.5 times the maximum pipeline static pressure.

c) Sum of the maximum sustained operating pressure and the maximum surge pressure.

d) Sum of the maximum pipeline static pressure and the maximum surge pressure, subject to a maximum equal to the work test pressure for any pipe fittings incorporated.

Pretest and saturation period with addition of make-up water

Pressure: Operating Pressure (7 kg/cm$^{2)}$

Duration: 24 hrs for pipes with cement mortar lining

Pressure test / Leakage Test with addition of make-up water

Pressure: Test Pressure

Duration: 2 hrs.

Test criteria for DI pipes: Q = 1.0 liter per km per 10mm dia of pipe.

Test Pressure per 24 hrs.

No pipe installation shall be accepted until the leakage is less than the amount ‘Q’, as determined by the above formula:

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount 'Q', calculated by the above formula. Where any test of pipe laid indicates leakage greater than that specified as per the above formula, the defective pipe(s) or joints(s) shall be repaired/replaced as per the satisfaction of engineer in charge until the leakage is within specified limits. The Contractor has to make his own arrangements for water of approved quality, required for testing pipeline

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 Engineer in charge until all requirements of the test have been obtained.

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.

2.5.8**FAILURE TO PASS THE TEST**

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to the unsatisfactory in any way shall be redone by the Contractor.

2.5.9**FLUSHING AND DISINFECTING OF PIPELINES**

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Engineer in Charge. Disinfection of drinking water pipelines shall be made by Engineer- in charge.

2.5.10**BACKFILLING OF THE PIPE TRENCH**

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:

Zone A: From the bottom of the trench to the level of the Centre line of the pipe	Back-filling by hand with sand, fine gravel or other approved material placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width of 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 center 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 hand or 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 Engineer in Charge.

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the sub grade of the structures shall be made with sand/ fine clay in accordance with IS 12288.

The excavated material may be used for back-fill in the following cases, provided it complies with IS 12288 Clause 4.11.1:

a) In Zone C: In cases where settlement is unimportant the back-fill shall be neatly rounded over the trench to a sufficient height to allow for settlement to the required level.

b) In any zone, when the type of back-fill material is not indicated or specified, may be back filled with suitable material consists of loam, clay, sand, fine gravel or other materials in the opinion of the Engineer In Charge.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise mentioned or 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 Engineer in Charge, 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.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, 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.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

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 of refuse or unsuitable soil.

2.5.11 **MEASUREMENT**

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

2.5.12 **RATE**

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

2.6 **TRANSPORTATION, HANDLING AND INSPECTION OF PIPES AND SPECIALS**

2.6.1 **GENERAL**

Ductile iron pipes are less susceptible to cracking or breaking on impact but the precautions set out should be taken to prevent damage to the protective coating and brushing or damage of the jointing surfaces.

2.6.2 **TRANSPORTATION**

Pipes should be loaded in such a way that they are secured and that no movement should take place on the vehicle during transit.

The pipes should be loaded on vehicles in pyramid or straight sided formation. In case of pyramid loading, the pipes in the bottom layer should be restrained by the use of broad wooden wedges secured to the vehicle being loaded. The pyramid is to be formed by resting pipes between the pairs of pieces in the preceding layer with the sockets in layers reversed. Straight sided loading may be used with supports along the sides of the vehicles. The use of straight sided loading is advantageous for utilizing full capacity of the vehicle.

2.6.3 OFF-LOADING

Cranes should be preferred for off-loading. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used.

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 should be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

Where the crane operator does not have a clear view, he should be guided by the personnel supervising the operation. When cranes are used, the whole sequence of operation should be carried out smoothly and without snatch. Properly designed hooks and adequate stead ropes are essential. The hooks should be of suitable shape to ensure positive engagement when entered into the ends of the pipes and then should pass over any protective packing fitted around the pipe ends.

The use of slings passed around bundles of pipes is not recommended because bundles become unstable as the sling is drawn tight or released. However, when it is necessary to use the central slinging method for lifting single pipe, a broad webbing sling is recommended which minimizes the risk of the pipe slipping. Chain slings may slip and are dangerous.

2.6.4 STACKING

Pipes being taken to a stock ground for storage and held pending further distribution should be arranged into stacks. The first layer of pipes should be laid on a firm foundation consisting of solid timbers set level on the ground. Subsequent layers should be placed according to the method of stacking adopted. Care should be taken so that the pipes do not rest on their sockets. The height of any stack should not exceed 2 m.

Methods adopted for stacking pipes are described below.

2.6.5 SQUARE STACKING

In square stacking method, second and subsequent layers are set at right angles to the previous layer with spigots and sockets alternating in each layer and sockets project beyond spigot end. The pipes rest directly upon those beneath it and care is needed in placing to prevent damage.

2.6.6 PARALLEL STACKING WITH TIMBERS

All the pipes are parallel with the sockets of successive layers reversed end-to-end with sockets projecting beyond spigot end. Timber battens, placed about 600 mm from each end at right angles to the pipes, are used to separate the successive layers. Wedges at both ends of each batten prevent pipe movement.

2.6.7 NESTED STACKING (PYRAMID STACKING)

Nested stacking consists of placing each pipe between the two pipes underneath it, with the sockets being all at one end of each layer and being reversed in successive layers. The bottom layer should be firmly anchored to prevent the stack collapse.

2.6.8 SPECIAL PRECAUTIONS FOR BITUMEN-SHEATHED PIPES

Bitumen-sheathed pipes should be handled with care to avoid any damage to the sheathing. They should not be stacked but laid in a single layer supported on timbers placed under the uncoated portions of the spigots and sockets. Sheathed pipes should be lifted by means of properly designed hooks, fittings into the spigot or socket, or by specially designed slings which will not damage the sheathing. Wire rope, chains or hemp slings should not be used.

2.6.9STRINGING

Stringing consists of placing pipes on the ground in line ready for laying. Care should be taken to prevent damage during this operation.

2.7CIVIL WORKS FOR PIPE LAYING

For general civil works, standard specification shall be followed.

2.7.1 PARTICULAR REQUIREMENT

The details and specifications of the works are contained in this subsection.

2.7.2 GENERAL

(i) The design of rising main will be given to the contractor by the employer for laying mains from various Tube wells to the various Service Reservoirs/clear water Reservoir.

(ii) The alignment of rising main may alter in some cases due to underground utilities available in the alignment. The contractor has to determine the underground utilities by putting trial pits in the alignment before he take up the work.

(iii) The work shall be executed only after getting necessary permission from the Road authorities, local body, Traffic police and any other government organization as the case may be. The employer will assist the contractor for getting the permission from the concerned authorities. It is the responsibility of the contractor to get the permission from the concerned authorities and no extra payment will be made for this purpose.

(iv) Testing of Hydrostatic pressure test in the laid mains

2.8LAYING OF PIPES

2.8.1LAYING UNDERGROUND

Pipes should be lowered into the trench 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, either a well-designed set of shear legs or mobile crane should be used. When lifting gear is used, the positioning of the sling to ensure a proper balance, should be checked when the pipe is just clear of the ground. If sheathed pipes are being laid, suitable wide slings or scissor dogs should be used.

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. When laying is not in progress, a temporary end closure should be securely fitted to the open end of the pipeline. This may make the pipe buoyant in the event of the trench becoming flooded, in which case the pipes should be held down either by partial re-filling of the trench or by temporary strutting. All persons should vacate any section of trench into which the pipe is being lowered.

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 backfilled over the barrel of the pipe. The backfill should be well compacted.

2.8.2LAYING ABOVE GROUND

The ground should be dressed to match the curvature of the pipe shell for an arch length subtending an angle of 120° at the centre of the pipes. Alternatively, the pipeline should be laid either on saddle, roller or rocker supports as specified by authority. The pipes may be allowed to rest on ground if the soil is non-aggressive.

2.8.3SUPPORTING PIPES ABOVE GROUND

The following recommendations assume that no additional bending moments above those due to the self-weight of the pipe and its contents are present.

With Spigot and Socket Pipes—It is recommended that above ground installations of spigot and socket pipes be provided with one support per pipe, the supports being positioned behind the socket of each pipe.

This results in a normal distance between supports of 4 m as shown in Fig. 2A.

Pipes should be fixed to the supports with mild steel straps so that axial movement due to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipeline. In addition, joints should be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate these thermal movements.

Pipes supported in this way are capable of free deflection and axial movement at the joints which accommodate small movements of the pipe supports.

The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.

Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse. The concerned authorities may be consulted to ascertain the nature of bed, scour levels, maximum velocities, and high flood levels, seasonal variation, etc., which affect the design and laying of pipeline. Early consultation with river authorities will assist in evaluating the effect of river characteristics (for example, nature of bed, scour levels, maximum velocities, high flood levels, seasonal variations, etc.), on design and construction.

If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports relative to the pipe joints as shown in Fig. 2B

With Flanged Pipes—the recommended maximum unsupported span is 8 m. The supports shall be located at the center of every second pipe as shown in Fig. 3A.

The recommended maximum unsupported span at water course is 8 m. The relative positions of pipe joints and pipe supports should be as shown in Fig. 3B.

The supports of all flanged pipework spans should be stable and unyielding due to movements in the pipeline.

The straps should prevent any lateral movement or lifting of the pipelines but not restrict expansions and constructions caused by temperature fluctuations.

2.8.4CUTTING OF PIPES

The cutting of pipe for inserting valves, fittings, etc., shall be done in a neat and workman like manner without damage to the pipe or lining so as to leave a smooth end at right angles to the axis of the pipe. Methods of cutting ductile iron pipes are given below.

By Hacksaw—Hand or power operated hacksaw should be used with blades having teeth at a pitch of 1 mm.

By Manually Operated Wheel Cutter—the type of cutting wheel used for cast iron pipes is not suitable for ductile iron pipe. Special wheels, as used for cutting steel pipes, shall be used and cut ends are trimmed with a file.

By Pipe Cutting Machine—Machines with cutter heads or abrasive wheels shall be used. Cutter head should have a front rake angle of 7° as used for steel pipes

2.8.5END PREPARATION OF CUT PIPES FOR JOINTING

The burr left after cutting should be trimmed off by light grinding or by filling.

2.8.6WRAPPING

When ductile iron pipes are to be laid in aggressive soils, the pipes should be wrapped externally with protective coatings, such as bitumen or coal tar sheathing protective tapes or by loose polythene sleeving, or in certain circumstances, concrete before laying. At joints, bends and valves, precautions should be taken to provide sufficient overlap of the wrapping sleeve so that no pipeline is exposed to the aggressive soil.

2.8.7 PIPELINE MARKERS

Distinctive markers should be erected at all roads, railways, river and canal crossings, and elsewhere as required to identify the pipeline and to indicate its position. Markers should be placed at field boundaries, preferably in such a way that they are not obscured by vegetation. At all valve installations, plates should be provided to give the same information as on the makers. Markers should not be treated with any substance likely to be harmful to livestock.

2.8.8 PIPELINE ANCHORAGE

All pipelines having unanchored flexible joints require anchorage at changes of direction and at dead ends to resist the static thrusts developed by internal pressure. Dynamic thrusts caused by flowing water act in the same direction as static thrusts. This thrust is of sufficient magnitude at high velocities to warrant safety consideration.

Anchorages to resist the thrust should be designed taking into account the maximum pressure the main is to carry in service or on test, and the safe bearing pressure of the surrounding soil.

Where possible, concrete anchor blocks should be of such a shape as to allow sufficient space for the remaking of the joints.

2.8.9 JOINTS AND JOINTING

Two main types of joints are used with ductile iron pipes and fittings:

a. Socket and spigot flexible joints:
    1. Push on joints; and
    2. Mechanical joints;
b. Rigid flanged joint.

2.8.10 FLEXIBLE JOINT

The spigot and socket flexible joint should be designed to permit angular deflection in direction and axial movement to compensate for ground movement and thermal expansion and contraction. They incorporate gasket of elastomeric materials and the joints may be of the simple push-on-type or the type where the seal is effected by the compression of a rubber gasket between a seating on the inside of the socket and the external surface of spigot. Joints of the latter type are referred to as mechanical joints. Both push-in (Fig. 5A) and mechanical joints are flexible joints. Flexible joints require to be externally anchored at all changes in direction such as at bends, etc., and at blank end to resist the thrust created by internal pressure and to prevent the withdrawal of spigots.

2.8.11 FLANGED JOINT

Flanged joints are made on pipes having a machined flange at each end of the pipe. The seal is usually effected by means of a flat rubber gasket compressed between two flanges by means of bolts which also serve to connect the pipe rigidly (*see* Fig. 5B). Gaskets of other materials, both metallic and non-metallic, are used for special applications.

2.8.12 JOINTING PROCEDURE

Procedure for jointing will vary according to the type of joint being used. Basic requirements for all types are:

a. Cleanliness of all parts,
b. Correct location of components,

c. Centralization of spigot within socket, and

d. Strict compliance with manufacturer's jointing instructions

2.8.13 TESTING PROCEDURE

All rising mains shall be tested for Hydrostatic pressure test as per provisions of IS: 12288

After a new pipeline is laid and jointed, testing shall be done for:

a. mechanical soundness and leak tightness of pipes and fittings;

b. leak tightness of joints; and

c. Soundness of any construction work, in particular that of the anchorages.

2.8.14 HYDROSTATIC TESTING

The completed pipeline may be tested either in one length or in sections; the length of section depending upon:

1. availability of suitable water,
2. number of joints to be inspected, and
3. Difference in elevation between one part of the pipeline and another.

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

It is prudent to begin testing in comparatively short length of test section. Progressively as experience is gained, lengths of about 1·5 km or more, are tested in one section, subject to consideration of length of trench which can be left open in particular circumstances.

Each section should be properly sealed-off, preferably with special stop ends secured by adequate temporary anchors. The thrust on the stop ends should be calculated and the anchors designed to resist it. All permanent anchors should be in position and, if of concrete, should have developed adequate strength before testing begins. The section under test should be filled with water, taking care that all the air is displaced either through vents at the high points or by using a pig or a sphere.

The test pressure to be applied should be not less than any of the following:

a. The maximum sustained operating pressure,

b. The maximum static pressure plus 5 N/mm^2, and

c. The sum of the maximum sustained operating pressure (or the maximum static pressure) and the maximum calculated surge pressure.

After filling, the pipeline should be pressurized to the specified operating pressure and left for a period of time to achieve stable conditions.

The length of this period of time depends on many factors such as slight movement of the pipeline under pressure whether air is trapped in the pipeline or whether the pipeline has a concrete lining which absorbs water.

The pipeline is then pressurized up to the full test pressure and the section under test completely closed off. The test should be maintained for a period of not less than 10 minutes to reveal any defects in the pipes, joints or anchorages.

The test pressure should be measured at the lowest point of the section under test or alternatively, an allowance should be made for the static head between the lowest point and the point of measurement, to ensure that the required test pressure is not exceeded at the lowest point.

In case of extreme temperature conditions, there may be a tendency of hydraulic pressure building up inside the pipeline because of expansion of water during the high day time. This should normally not be of any major concern as the joints and the pipes are manufactured to resist a much high pressure. However, sufficient care should be taken to prevent floating bulging of the pipeline because of building up of such high pressure during the temperature rise.

If the test is not satisfactory, the fault should be found and rectified. Where there is difficulty in locating a fault, the section under test should be sub-divided and each part tested separately.

Methods employed for finding leaks include:

a. Visual inspection of each joint if, not covered by the backfill;

b. Use of a bar probe to detect signs of water in the vicinity of joints, if backfilled;

c. Aural inspection using a stethoscope or listening stick in contact with the pipeline;

d. Use of electronic listening device which detects and amplifies the sound or vibrations due to escaping of water, actual contact between the probe and the pipe is not essential;

e. Injection of a dye into the test water-particularly suitable in water-logged ground; and

f. Introduction of nitrous oxide in solution into the test water and using an infra-red gas concentration indicator to detect the presence of any nitrous oxide that has escaped through the leak.

After all sections have been joined together on completion of section testing, a test on the complete pipeline should be carried out. This test should be carried out at a pressure not less than the maximum sustained operating pressure or the maximum static pressure of the pipeline and, during the test, inspection made of all work which has not been subject to section tests. During the test, the pressure at the lowest point in the pipeline should not exceed the maximum given in Table 14

Table 14 Pressure in DI Pipes

MAXIMUM FIELD HYDROSTATIC TEST PRESSURE FOR DUCTILE IRON PIPELINES WITH FLEXIBLE JOINTS

NOMINAL BORE	MAXIMUM FIELD HYDROSTATIC TEST PRESSURE
mm	N/mm^2
Up to 300	4·5
350 to 600	3·0
700 to 1200	2·1

NOTE 1—The above pressures are 0·5 N/mm^2 higher than the pressure ratings for ductile iron pipes and fittings with flexible joints. It is not considered necessary to field test ductile iron pipelines to 1.5 times the design operating pressure as is often the practice with grey iron pipelines.

NOTE 2—The field test pressures is applied to ductile iron pipelines only when the pipeline and its fittings are properly anchored.

It is important to ensure that proper arrangements are made for the disposal of water from the pipeline after completion of hydrostatic testing and that all consents which may be required from authorities have been obtained. In some cases, for example, heavily chlorinated water, some treatment may be necessary before final disposal.

2.9PIPE PEDESTAL FOR DUCTILE IRON PIPES

In case of ductile iron pipes to be laid above ground they shall be laid on pillars (pedestal) as directed by the Engineer. The pipe is supported at the plain end and behind the socket. One pillar shall support the socket end of one and the plain end of the other pipe. The pillars shall be of RCC and shall be founded on solid soil, not subject to erosion by wind or water. The foundation of the pillars has to be calculated according to the soil conditions.

The top of the pillar shall form two saddles for the pipe having the same radius as the pipe. The socket will be lying free between the two saddles. The pipes shall be laid on a coat of polyethylene of 2 mm thickness, put on mortar. It has to be ensured that the spigot end of the pipe is supported by the saddle and does not unduly compress the rubber ring in the lower part. Each pipe is fixed by one adjustable galvanized steel spanner, fixed to the pillar with anchor bolts.

In case of vertical deviations the pipes shall be protected against uplift by additional reinforced clamps of mild steel. In this case, the design of the pillar has to be made taking in account these uplift forces and design will be given by Engineer.

2.10THRUST BLOCKS

The thrust blocks shall be of concrete M15 cast on site with proper reinforcement as per design and drawings. The thrust blocks shall be cast directly against the undisturbed soil. If this is not possible, the backfilled soil at the contact surface shall be compacted well to full satisfaction of Engineer so that anchor block is not displaced during operation and testing.

2.11 BACKFILLING AROUND CHAMBERS AND THRUST BLOCKS

After the completion of chambers and thrust blocks the space between the structure and the excavation shall be backfilled with compacted material. Such backfill shall be placed in layers of 15 cm measured before compaction, wetted, if necessary, to optimum moisture and compacted well as per instruction of Engineer.

Embankment around structures shall be done at levels and with slopes.

2.12 OTHER CIVIL AND RELATED WORKS

Crossing of existing Distribution Pipes and connecting pipes

Existing transmission and distribution pipes and connecting pipes of standpipes have to be protected during the laying of the pipes. In case of impossibility of deviation, the pipes have to be replaced according to the instructions of the Engineer and in co-operation with the local representative of line Dept. of PHED. The Contractor has the full responsibility in case of destruction of pipes due to inattention of his staff. All costs for the reinstatement of the original status of the pipes in case of damage have to be borne by him.

2.13 POLES OF ELECTRIC OR TELEPHONE LINES

In case of impossibility of deviation of pipeline, poles of electricity lines (33, 11, 0.4 KV), telephone lines or anchor cables of poles have to be relocated. These works have to be executed by the respective department or according to its instructions. The cost of such works shall be reimbursed from Provisional sum. The Contractor has the full responsibility in case of destruction of lines or poles due to inattention of his staff. In such cases all costs for the reinstatement to the original status of the lines have to be borne by contractor.

2.14 BRICK MASONRY

2.14.1 DESCRIPTION

This work shall consist of construction of structures with bricks jointed together by cement mortar in accordance with the details shown on the Drawings or as approved by the Engineer.

2.14.2 **APPLICABLE CODES**

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

Table 15 List of applicable IS Code

IS - 1077	Specifications for common burnt clay building bricks
IS - 1200	Measurements for Building works
IS - 1905	Code of practice for structural safety of buildings: Masonry walls.
IS - 2116	Sand for masonry mortars
IS - 2212	Code of practice for brick work
IS - 3466	Specification for masonry cement

Other I.S. Codes not specifically mentioned here but pertaining to the use of bricks for structural purposes form part of these Specifications.

2.14.3 **MATERIALS**

All materials to be used in the work shall confirm to the requirements laid down in Chapter 5.

2.14.4 **PERSONNEL**

Only trained personnel shall be employed for construction and supervision.

2.14.5 **LAYING**

Bricks used in works shall conform to the relevant Indian Standards. They shall be sound, hard, and homogeneous in texture, well burnt in kiln without being vitrified, table molded, and deep red cherry or copper colored, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing ingrained particles and / or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Over-burnt or under-burnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 75 kg/sqcm. Unless otherwise noted in Drawings. The class and quality requirements of bricks shall be as laid down in IS: 3102.

The size of the brick shall be 190x90x90 mm or 190x90x40 mm unless otherwise specified; but tolerance up to ± 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brick bats shall be used only with the permission of Engineer to make up required wall length or for bending. Sample bricks shall be submitted to Engineer for approval and bricks supplied shall conform to approval samples. If demanded by Engineer brick sample shall be got tested as per IS: 395 by Contactor at no extra cost to Engineer. Bricks rejected by Engineer shall be removed from the site of works within 2 hours.

2.14.6 **CEMENT MORTAR**

Mortar for brick masonry shall be prepared as per IS: 2250. In valve chambers, brickwork shall have cement mortar (1:4). Gauge boxes for sand shall be of such dimensions that one bag containing 50 kg. of cement forms one unit. The sand shall be, free from clay, shale, loan, alkali organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer. Sand shall be thoroughly washed till it is free of any contamination.

For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry conditions. Water shall then be added and mixing continued to give a uniform mix of required consistency. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

2.14.7 **WORKMANSHIP**

All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work of manholes shall be in the proportion specified. Brick work 230 mm thick and over shall be laid in English Bond. 115 mm thick brick work shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be leveled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes. All interconnected brickwork shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed at an angle not exceeding 5o. But in no case the level difference between adjoining walls shall exceed 1.25 m. Workmanship shall conform to IS: 2212.

Brick shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plaster or pointing to be done. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower courses has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid. No extra payment will be made for raking joints.

Curing shall be commenced as soon as the brick work has hardened sufficiently not to be damaged during curing. It shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages.

Green work shall be protected from rain by suitable covering and shall be kept constantly moist on all faces for a minimum period of seven days.

2.14.8 **MEASUREMENT AND RATE**

The brick work shall be measured in cubic meters. The unit rate of brick masonry work shall be inclusive of all labour, material, tools & plant and incidental charges to the satisfactory competition of the work.

2.14.9 **CEMENT PLASTER WORK**

All joints in masonry shall be raked to a depth of 12 mm with a hooked tool made for the purpose when the mortar is still green and in any case within 8 hours of it’s laying. The surface to be rendered shall be washed with fresh clean water to make it free from all dirt, loose material, grease, etc. and thoroughly wetted for 6 hours before plastering work is commenced.

Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.

The proportion of the cement mortar shall be as specified on relevant Drawings. Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain workable consistency. The quality of water, sand and cement shall be as per relevant I.S. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to stand for more than 25 minutes after mixing with water.

Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. The decision as to when the plaster has hardened will be given by Engineer. Curing shall be done by continuous applying water in a fine spray and shall be carried out for at least 7 days.

3 SUB-SECTION 3: SERVICE RESERVIORS

3.1 GENERAL REQUIREMENTS

This part covers additional specifications for civil construction works, supplementing the general specifications for material and workmanship. The tender is based on design and drawing and shall be inclusive of cost of labor, materials, tools and plants and specialized machinery for completing the various components of the project and all operations connected therewith, under all conditions of site, moisture, weather etc.

3.2 SITE INVESTIGATION

On award of the contract, the Contractor will carry out the Geotechnical and topography survey work (by using Total station equipment).

The Contractor will transfer the bench mark to be provided by the Employer and a permanent bench mark will be established at the project site(s). On completion of the survey work, a detailed layout plan will be prepared by the Contractor showing all plant and non-plant units etc., complete. The Contractor will also prepare a separate layout plan including location of site office, batching plant, go-down, steel yard, store, workshop etc., complete. Engineer in charge will approve both the layout prior to commencement of construction work.

Soil investigation will be taken up on approval of the layout plans. Various preliminary works are to be carried out as per the following details.

3.3 SURVEY AND SOIL INVESTIGATION

The Contractor will carry out his own survey in the area ear-marked for the Overhead Tank (OHT) or Service Reservoir, as shown in the layout drawing enclosed, by using Total station equipment. Guidelines for details of survey to be carried out are as follows:

- Preparation of contour plan of the site using a grid of 10 m x 10 m.
- Collection of details for all features such as utilities, existing roads, electric and telephone poles , huts, adjacent buildings, or any other structure, fencing and trees (with girth greater than 0.3 m) etc., falling within the extent of survey.
- The existing details of water mains, sluice valves, chambers, reservoirs, tube wells etc., to be covered in topography survey and all details to be incorporated in the plans.

The Contractor in co-ordination with the Engineer has to determine at each location of OHT the soil characteristics (safe bearing capacity, angle of friction, cohesion) in order to calculate the dimensions of the foundations. It is also important to assess the potential of changes in water table, erosion and exposure of foundations and the stability of the soil with view to the lateral resistance to be taken into account.

On finalization of the layout, the Contractor will conduct additional soil investigation to find out actual soil condition at the site. The Contractor shall submit the report to Employer for their comments/approval. In case there is a discrepancy between the two reports lower of the values of the safe bearing capacity shall be considered for the design.

3.3.1 PENETRATION TESTS

Standard penetration test to a depth corresponding to at least 1.5 times the width of the structure foundation; at least 3 tests per structure; distance between the penetration points less than 20 m.

3.3.2 PLATE LOAD TESTS:

- To assess soil bearing capacity at the foundation level (Plate test).
- To take samples for laboratory analyses.

3.3.3 **LABORATORY ANALYSES FOR**

- Granulometry.
- Cohesion.
- Angle of friction.
- Proctor density.

At least 3 test pits shall be made for each site of a tank/structure, preferably after having fixed the location of the building. The distance should be less than 20 m. In addition the following soil data have to be obtained from the test pits:

- Composition and classification of the soil (sand, clay, silt, organic matter etc., soft, medium, hard, decomposed rock, rock etc.) with view to:
- Excavation.
- Need to support walls of trenches.
- Compacting.
- Permanent or temporary groundwater (water logging).
- Hard pans below the sand (depth, thickness, type of layer).
- Clay lenses.

The results of the survey, the sampling, the laboratory analyses and the calculations have to be presented in a report in three copies to the Engineer. The execution of the foundations shall be started only after approval of the Engineer. The Contractor however will be responsible for design of the structures based on these investigations.

Along with the excavation for the buildings and storage structures the Contractor has to assess /complete the type of soil, the strata, the level of groundwater and other parameters important for design. He has to establish soil profiles and submit these to the Engineer for approval.

3.4 **EMPLOYER'S REQUIREMENT FOR DESIGN WORK**

The Design of the Reservoirs shall be given to the contractor. The contractor has to undertake the soil bearing capacity of the site. The soil bearing capacity arrived by the contractor shall be compared with the capacity adopted by the Engineer. If the soil bearing capacity is found less than that adopted by the Engineer and it shall be intimated to Engineer for revising the design. The Engineer will redesign the reservoir and fresh working plan shall be issued to the contractor. Scope

The scope of works to be carried out under the contract includes:-

(i) Conducting topographical survey / and soil investigation report for the site.

(ii) The work includes Construction of Service Reservoirs including related earthwork, construction of foundations, erection, piping works, etc., as per design and construction drawings showing detailed reinforcement and sizes.

(iii) Providing and fixing PVC water bars at construction joints.

(iv) The work also includes providing and fixing of outlet, inlet, washout and overflow pipes (flanged) along with specials, blank flanges, puddle flanges etc., as in the drawing and other related work, etc., complete for all Service Reservoirs including conducting water tightness test of the same.

(v) Supplying and fixing of valves, dismantling joints, level indicator, strainer, float valve and other necessary fixtures as shown in the drawing.

(vi) Each Service Reservoir shall also be provided with staircase, ladders, ventilators, lightening arrester, G I railing, manhole cover with frame, etc., as required for completing the same in all respects.

(vii) Inlet pipe of Service Reservoirs shall be up to the location of the sluice valve as shown in the layout plans.

(viii) Outlet pipe of Service Reservoir shall be up to the location of the sluice valve as shown in the layout plans.

(ix) After construction of each Service Reservoir, it shall be tested for its water tightness as per the procedure given in the specifications. In case leakages are observed, appropriate rectification measures should be carried out to arrest the same, as per specifications or as directed by the Engineer. No additional payment shall be made for carrying out such rectification work, if found necessary.

(x) The scope of work also includes cleaning, washing and disinfection of inside of Service Reservoir making it free from any foreign matter, loose particles, debris, etc., and makes it suitable for storage of potable water, commissioning and handing over the Service Reservoirs and piping works with all other items included in the scope of work as described. Any statutory and other clearances and or approvals that may be required to complete the work are covered under the scope. No additional payment shall be made for carrying out the work.

(xi) Construction of Boundary wall as shown in layout plan of OHTs.

(xii) Construction of surface drains.

(xiii) Lighting facilities throughout the premises, i.e., internal illumination of shaft and external illumination of ground.

(xiv) Construction of access and internal road.

(xv) Submission of “As built drawings”.

(xvi) Dressing up of area.

3.5 **CIVIL WORKS**

For general civil works, standard specification shall be followed.

General

(v) GLSR of circular/rectangular / any other type approved by the employer with RCC stair case as per designed capacities at different locations.

(vi) Site location of OHT/CWR may alter in some cases due to unavoidable circumstances. The contractor/ Contractor has to determine the soil bearing capacity accordingly for those sites / locations where the soil data has not been provided.

3.5.1**BASIC DATA**

Structural design will be given to the contractor by the employer for the most critical combinations of dead loads, imposed loads, equipment loads, piping loads (static and dynamic), wind loads, seismic loads and temperature loads.

3.5.2 **TESTING OF WATER TIGHTNESS FOR WATER RETAINING STRUCTURES**

All water retaining structures shall be tested for water tightness as per provisions of IS: 3370 and IS: 6494.

3.5.3 **TEST AND PRECAUTIONS**

3.5.3.1 ***Water Tightness Test***

The tanks shall also be tested for water tightness test at full supply level as described in 10.1.1, 10.1.2 and 10.1.3 of latest revision of IS 3370 (Part I).

On completion of the Service Reservoir works and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition i.e., with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of Service Reservoir (i.e., construction of container part in all respect) is done and when it is possible to fill the reservoir and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before starting of the filling operations, the reservoir shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the reservoir by way of floodlights, circulators etc., for carrying out proper inspection of the surfaces and inner conditions if so desired by the Engineer. For this purpose, it shall be verified that sluice valves provided on the various pipes connected to the reservoir then shall be carried out gradually at the rate not exceeding 30 cm rise in water level per hour. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept. The water for testing the structure shall be supplied by the contractor and cost of water and cost of filling charges shall be borne by the contractor and no additional payment shall be paid to the contractor.

The reservoir once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the reservoir, which for all practical purposes shall not exceed 40 mm. Also there shall be no indications of the leakage around the puddle collars or on the walls and bottom of the reservoirs.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the reservoir at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned and the Contractor will dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the rates quoted of different items of work of Service Reservoir.

3.5.4 **PRECAUTION**

As soon as possible after completion of reservoir and after all pipes have been laid the Contractor shall remove all dirt, debris, materials, tools etc., from the reservoir and shall wash and brush down with water the whole of the interior. He shall also if required by the Engineer incorporate a mixture of chloride of lime in the water wash required.

The greatest care shall be taken to keep the entire reservoir free from any contamination. Strict supervision shall be maintained over the workmen entering after first washing down. Provision shall be made to enable workmen to wash their feet or footwear clean and sterilize them before entering.

3.6 PIPING SYSTEM

3.6.1 PIPES AND VALVES

All pipes shall be installed as per the details provided in the drawings and of suitable size. Overflow pipes will be of one higher size than the inlet pipes. Valves of same size shall be as per the specifications provided in the bid document.

3.6.2 FLOAT VALVE SYSTEM

The float valve system shall be installed at inlet pipe inside the container portion. The material of construction for different components, are given below in Table 16:

Table 16 Material of Construction for Float Valve System

Part No.	Name of Part	Material	Specification
1.	Body	Cast iron	ISD 210, FG 200
2.	Valve	Cast iron	ISD 210, FG 200
3.	Bottom plate	Cast iron	ISD 210, FG 200
4.	Washer plate	Gun metal	IS 318
5.	Seat ring	Gun metal	IS 318
6.	Link	Gun metal	IS 318
7.	Liner	Brass	-
8.	Eye Bolt for Valve	Brass	-
9.	Lever fork	Mild steel	-
10.	Valve face	Synthetic rubber	-
11.	Float ball	Copper	-

The float ball is to be suspended in cylindrical vessel fabricated from 5 mm hot-dip galvanized MS sheet, so that free upward / downward movement is offered to the ball as the water level rises / falls in the cylindrical vessel. The valve shall provide watertight closing with an upward movement of 165-175 mm in the vessel.

The material of construction for different components, are as follows:

Table 17 Material of Construction-6

Part No.	Name of part	Material	Specifications
1	Float ball	Copper	-
2	Ball Cap	Gun Metal	BS 1400 LG 2

Part No.	Name of part	Material	Specifications
3	Lever	Brass rod	BS 2872 or 2874 CZ 114
4	Spilt Pin	Brass	-
5	Piston	Gun Metal	BS 1400 GL
6	Piston Cap	Gun Metal	-
7	Washer	Nitrile rubber	-
8	Body	Gun Metal	BS 1400 GL

The above valves shall be tested for the following hydrostatic pressure. The lever and its connections to the ball must be designed for heavy-duty function.

- Body of valve: 10 kg/cm2.
- Seat of valve: 6 kg/cm2 .

3.7 PVC WATER STOP

3.7.1GENERAL

At the expansion joints, PVC water stops shall be provided as shown in the drawings. PVC material should meet the performance requirements given in IS: 12200-1987. The specimen of PVC should be tested before use in accordance with IS: 8543, to the satisfaction of the Engineer before installation. These will be placed at expansion joints as shown in drawings and elsewhere as directed by the Engineer. The PVC water stops shall be 230 mm wide having centre bulb at the middle with serrations on sides and with end grip. The contractor shall furnish complete kit for installing and jointing the water stops at site.

3.7.2 PERFORMANCE REQUIREMENTS

PVC water stops shall comply with IS: 12200-1987 for which performance requirements are as given below. These requirements should be tested with the procedures specified in IS: 8453:

Performance Requirements of PVC Water stops

Sl.No.	Characteristics	Unit	Value
i)	Tensile strength	N/mm²	11.6, Min
ii)	Ultimate elongation	%	300, Min.
iii)	Tear Resistance	N/mm²	4.9, Min.
iv)	Stiffness in flexure	N/mm²	2.46, min.
v)	Accelerated extraction		
	a) Tensile strength	N/mm²	10.5, Min.
	b) Ultimate elongation	%	250, Min.
vi)	Effect of alkali: 7 days		
	a) Weight increase	%	0.10, Max.
	b) Weight decrease	%	0.10, Max.

c)	Hardness change	Point	± 5,
vii) Effect of alkali: 28 days			
a)	Weight increase	%	0.40, Max.
b)	Weight decrease	%	0.30, Max.
c)	Dimension change	%	± 1

The wings of the PVC water stops shall be provided with corrugations or bulbs to achieve good bond. Jointing shall be carried out at site in accordance with the manufacturer's instructions, and to the satisfaction of Engineer.

The water stops shall be well braced and securely fastened in the positions shown on the Drawings. The concrete shall be carefully packed around horizontal or slightly inclined water stops. The edges of horizontally placed water stops shall be bent slightly upwards to facilitate concreting underneath them and to prevent the formation of air pockets. The concreting shall be carried out so that the flow of concrete to the extent possible will be directed parallel to the water stop and in one direction only.

Free sections of built-in water stops shall be protected from shocks and, wherever exposed, from direct sunlight.

3.7.3 **STORAGE**

The water-stops shall be stored in as cool a place as practicable, preferably at a temperature 20°C or less and in no case shall be stored in the open or exposed to the direct sunlight. All rubber/PVC water stops shall be stored so as to permit free circulation of air round them.

All field connections shall be made as directed. The contractor shall take suitable precautions to support and to protect the water-stops during the progress of the works and shall replace or repair at his own expense any water-stops which are damaged before final acceptance of the work.

3.8 **GI WATER STOP**

At construction/expansion joints GI water stops (230mm wide, 18 gauge) shall be provided as per direction of the Engineer. The Contractor shall provide complete kit for installing and jointing the water stops at site.

3.9 **OTHER FACILITIES**

3.9.1 **BOUNDARY WALL**

The Contractor shall construct a boundary wall (height of 2.20 meters above the ground level which shall include barbed wire fencing of an additional 0.4 meters) along the shoreline and boundaries of premises including the provision and installation of one main gate complete in all respect. The boundary wall shall be made with RCC (M20) pillar of 250mm square 3m c/c, panel filled up with first class brickwork. Both sides of the wall shall be plastered.

An entrance gate is proposed for access. The gate shall be of mild steel, size 4m x 2.5m, as per specification, drawing and Engineer.

3.9.2 **SURFACE DRAIN**

Constructing brick masonry open surface drain with bricks of class designation 75 in cement mortar 1:4 (1 cement : 4 fine sand) including earth excavation, 10 cm thick bed concrete 1:5:10 (1 cement : 5 fine sand : 10 graded stone aggregate 40 mm nominal size) and 25 mm thick cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size) for filling haunches including 12 mm cement plaster 1:4 (1 cement : 4 coarse sand) with a floating coat of neat cement inside the drain, its top and exposed side including disposal of surplus earth complete as per standard design with F.P.S. bricks.

Drain Size: 250mm wide & 300mm in average depth. (For connecting washout of OHTs and GLSRs to local drain).

4 SUB SECTION 4: SERVICE RESERVOIRS

4.1.1 EARTHWORK

4.1.1.1 *Scope*

This Specification covers the general requirements of earthwork in excavation necessary for the construction of the Works including structures, roadway, side drains, and water supply lines in accordance with requirements of these Specifications and the lines, grades and cross-section as shown in the Drawings or as indicated by the Engineer. This Specification also includes site grading, filling in areas as required, filling back around foundations, plinths and approach ramps, conveyance and disposal of surplus spoils or stacking them properly as directed by the Engineer 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 sub grade 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 Engineer.

Excavation for structures shall consist of the removal of material for the construction of foundation for buildings, tanks, reservoirs, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines as indicated by the Engineer. The work shall include 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.

4.1.1.2 *Applicable Codes*

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

1. IS: 1200 Method of Measurement of Building Works (Part I).
2. IS: 3764 Safety code for excavation work.
3. IS: 3385 Code of practice for measurement of Civil Engineering Works.
4. IS: 2720 Method of test of soils (All parts)
5. IS: 1498 Classification and identification of soils for General Engineering purposes

4.1.1.3 *Classification of Excavated Material*

- Authority for classification

The classification of excavation shall be similar for all kind of soils or as decided by the Engineer and his decision shall be final and binding on the Contractor. For cutting of rocks, even controlled blasting is prohibited and only pneumatic breakers shall be used.

4.1.1.4 *General*

Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary work, consumable, any and everything necessary, whether or not such items are specifically stated herein for completion of the job in accordance with Specification requirements.

Contractor shall carry out the survey of the site before excavation and properly mark all lines and establish levels for various works such as earthwork in excavation for grading, basement, foundations, plinth filling, roads, drains, cable, trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference / grid lines at intervals as determined by Engineer based on ground profile. These shall be checked by Engineer and thereafter properly recorded.

The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps and reflective sign boards at night for safety.

The contract price quoted shall also include the dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by Engineer, within the lead specified and leveling the same as to provide natural drainage. Rock / soil excavated shall be stacked properly as directed by Engineer. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

4.1.1.5***Clearing***

The area to be excavated / filled shall be cleared as described in sub-section.

4.1.1.6***Timber Shoring***

- Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'Polling Boards'. These shall be of minimum 25 cm X 4 cm sections or as directed by Engineer. The boards shall generally be placed in position, vertically, side by side without any gap, on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 meters spacing, strutted with “Ballies” or as directed by Engineer. The length of the “Ballie” struts shall depend on the width of the trench or pit. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.
- Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by Engineer. It shall be the responsibility of Contractor to take all necessary steps to prevent the sides of excavation, trenches, pits, etc., from collapsing.
- Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only on instructions from Engineer.
- The withdrawal of the timber shall be done very carefully, to prevent collapse, systematically from one end to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.
- In case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm X 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of Engineer. In all other respects, Specification for close timbering shall apply to open timbering.
- In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across sides of excavations / pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut. If, however, Engineer directs any timbering to be left-

in, keeping in mind the type of construction or any other factor, Contractor shall be paid for, at the scheduled item rate, for such left-in timbering.

4.1.1.7***Measurement***

- The Contract unit prices for excavation in BOQ shall be inclusive in full for carrying out the required operation of shoring of excavated trenches including full compensation for all labor, materials, tools, equipment and incidentals necessary to complete the work.

4.1.1.8***Slips and Slides***

- If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If finished slopes slide into the excavated area subsequently, such slides shall be removed.
- Contractor will ensure that the excavated earth/material is not stacked on the sides of the trench which may otherwise cause accident. If any mishap takes place due this reason, it will be sole responsibility of the contractor.

4.1.1.9***Methods, Tools and Equipment***

Only such methods, tools and equipment as approved by the Engineer shall be adopted / used in the work. If so desired by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

4.1.2**CONSTRUCTION OPERATION FOR WATER SUPPLY LINES**

4.1.2.1***Setting out***

- After the site has been cleared, the limits of excavation shall be set out true to lines, curves, slopes, grades and as directed by the Engineer. The Contractor shall provide all labor, survey instruments and materials such as strings, pegs, nails, bamboos, stones, lime, mortar, concrete, etc., required in connection with the setting out of works and the establishment of bench marks. The Contractor shall be responsible for the maintenance of bench marks and other marks and stakes as long as in the opinion of the Engineer, they are required for the work.

4.1.2.2***Excavation***

- All excavations except on hill locks shall be carried out by mechanical equipment unless, in the opinion of Engineer, the work involved and time schedule permit manual work. The work shall be so done that the suitable material available from excavation are satisfactorily utilized.
- While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc.
- The excavations shall be taken out to such widths, lengths, depths, p as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth / width excavated beyond the specified level / dimensions on the Drawings shall be made good at the cost of the Contractor with suitable material of characteristics.
- All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes except that when boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in

an approved manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimize erosion and pounding, allowing for natural drainage to take place. If trees were removed, new trees shall be planted, as directed by the Engineer.

- In works, if any existing structure gets disturbed or loosened, it shall be dismantled and cut to regular shape and re-laid as directed by the Engineer, at the cost of the Contractor.

4.1.2.3***Disposal of excavated materials***

- Unsuitable and surplus material not intended for use within the lead specified above shall also, if necessary, be transported and disposed of up to 8 Km. lead to the dumping site to be identified by the Employer.

4.1.2.4***Filling, Backfilling and site Grading***

General:

i. All fill material will be subject to **Engineer's** approval. If any material is rejected by Engineer, Contractor shall remove the same forthwith from the site at no extra cost to the Owner. Surplus fill material shall be disposed off as directed by **Engineer** after the fill work is completed.

   No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by **Engineer**.

ii. Dewatering of the excavated trench will have to be done as and when required. The contractor will include this in his rates for proper and timely completion of the work.

4.1.2.5***Material:***

i. To the extent available, selected surplus spoils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, 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 moorum or earth to fill up the voids and the mixture used for filling.

ii. If any selected fill material is required to be borrowed, Contractor shall make arrangements for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of Engineer. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish etc. top soil containing salts / sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed off as directed by Engineer. Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his cost.

4.1.2.6***Sand filling in plinth and other places:***

At places backfilling shall be carried out with local sand if directed by Engineer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 2 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until Engineer has inspected and approved the fill.

4.1.2.7***Filling in trenches:***

i. Filling in trenches for pipes shall be commenced as soon as the joints of pipe have been tested and passed. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.

ii. Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centerline of the pipe shall be done by hand compaction with selected approved earth in layers not exceeding 8 cm; backfilling above the level of the centerline of the pipe shall be done with selected earth by hand compaction or other approved means in layers not exceeding 15 cm.

iii. In case of excavation of trenches in rock, the filling up to a level 30 cm. above the top of the pipe shall be done with fine materials, such as earth, moorum etc. The filling up of the level of the centerline of the pipe shall be done by hand compaction in layers not exceeding 8 cm, whereas the filling above the centerline of the pipe shall be done by hand compaction or approved means in layers not exceeding 15 cm. The filling from a level 30 cm. above the top of the pipe to the top of the trench shall be done by hand or other approved mechanical methods with broken rock filling of size not exceeding 15 cm. mixed with fine material as available to fill up the voids.

iv. Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

4.1.2.8***General site grading:***

i. Site grading shall be carried out as directed by Engineer. Excavation shall be carried out as specified in the Specification. Filling and compaction shall be carried out as specified.

ii. Contractor shall protect the earth fill from being washed away by rain or damaged in any other way. Should any slip occur, Contractor shall remove the affected material and make good the slip at his cost.

iii. The fill shall be carried out to such dimensions and levels as indicated on the Drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained

iv. All prices of excavation for all kinds of soil either manually or mechanically, shall be inclusive in the unit prices of BOQ

v. The cost of all other operations shall be deemed to have been covered in the unit prices of BOQ

4.1.2.9***Preservation of Property***

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers or other sub-surface drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any changes. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his expense. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of the Engineer, the actions initiated by the Contractor to replace / restore the damaged objects are not satisfactory, the Engineer shall arrange the replacement / restoration directly through any other agency at the risk and cost of the Contractor after issuing a prior notice to the effect.

4.1.2.10***Finishing Operations***

i. Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

ii. Where directed, the topsoil removed earlier and conserved shall be spread over cut slopes, where feasible, berms and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond.

4.1.2.11 *Works to be Kept Free of Water*

The Contractor shall arrange for the rapid dispersal of water collected / accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangement shall be made in respect of all earth work including excavation for pipe trenches, foundations or cuttings.

The Contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum cross-fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding.

The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

4.1.2.12 *Measurement and payment:*

All works of excavation in foundation for all kind soils/material shall be measured cubic meters for pipe works, building works and road restoration and for leads as specified or directed by the Engineer shall be inclusive in the contract price.

Cost of finishing works and all other operations shall be deemed to have been covered in the price quoted for excavation.

Backfilling, plinth filling, etc. with borrowed earth shall be inclusive in the contract price. The price quoted shall include all operations such as clearing, excavation, lead and transport, fill, compaction, etc. as specified

Payment shall be made as per relevant items in BOQ

Rates

The Contract unit prices for the items of excavation shall be inclusive in contract in full for carrying out the operations required for the individual items including full compensation for:

1. Setting out;
2. Shoring wherever required
3. Transporting the excavated materials and depositing the same on sites of embankments spoil banks or stacking as directed within all lifts and lead. Trimming bottoms and slopes of excavation and finishing etc.;
4. Keeping the work free of water;
5. All labor, materials, tools, equipment, safety measures, testing and incidentals necessary to complete the work to Specifications.

4.1.2.13 *Measurement and Payment for Survey Work*

No extra payment will be made for survey work. Cost of survey work is deemed to have been included in the rates for other items of BOQ.

5 SUB - SECTION5: MECHANICAL WORKS

INTRODUCTION

All the equipment, to be supplied under this contract, i.e. Pumps, Electric Motors, Valves, Chlorinating Equipment of different Units etc. have to be of reputed makes. The equipment of only those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered.

5.1 **CHEMICAL FEEDING PUMPS**

Chemical dosing and metering pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined base plate.

Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self-cleaning action. Ball and seat materials shall be resistant to abrasion.

Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual and electrically or pneumatically controlled stroke positioned. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving step-less adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

The normal operating range of dosing pump shall be not less than 10:1.

(i) **Mechanical Diaphragm:** Diaphragm rigidly coupled to the drive train. Single suction Pumps and discharge valves. Glandless. Accuracy: ± 3% of stoke.

(ii) **Piston Pumps:** Cylinder and piston with packed gland. Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: ± 1% of stroke.

(iii) **Piston Diaphragm Pumps:** Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: ± 2% of stroke.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be 316 stainless steel. Diaphragm materials shall be butyl PTFE, or Hypalon and glands shall be PTFE or Neoprene.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Unless otherwise specified flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

5.2 **VALVES**

5.2.1**GENERAL**

Valves shall be suitable for use with the fluid being conveyed at the temperatures and pressures required for the application. Generally, pressure designation shall not be less than PN1.0.valvesshallhaveintegralflangesdrilledasspecifiedinrelevantlatestISspecificationsorBS:4504.

Throughout erection, the valves shall be supported properly on wooden sleepers, etc. and shall be concreted immediately thereafter, as directed. Before the valves are actually fixed, they shall be cleaned and greased and it should be seen that all parts are in perfect working condition. In the case of air valves, the Contractor shall take special care of the dexine joints and the ebonite and /or vulcanite balls until they are fixed in position. They shall be kept immersed in water in suitable containers.

5.2.2 **GASKETS AND PACKING**

Gaskets shall be of Nitrile rubber and readymade matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.

5.2.3 **NUT, BOLTS, WASHERS**

The Contractor shall provide the jointing material such as nuts, bolts, washers, pig lead, rubber packing, etc.

All bolts, nuts and studs shall be SS 304/316 and shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions. All studs and screws shall be made of SS304/316.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary.

The Contractor shall supply all holding down, 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.

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.

6 SUB - SECTION 6: ELECTRICAL WORKS

6.1 INTRODUCTION

This sub-section details the requirements of electrical works to be provided for the Tube Wells and Control Room at Polytechnic campus.

It is not the intent to specify herein all the details pertaining to the design, selection of material/ equipment, procurement, manufacture, installation, testing and commissioning. However, the same shall be of high standards of engineering and shall comply with all currently applicable standards, regulations and safety codes.

The execution should take care of IE rules, Electricity Board's requirement and other local 0authorities and site condition.

These specifications cover 11 kV/ 0.433 kV substation, transformer, HT control penal, LV switchboards, LV energy efficient motors, LV starters, LV capacitors, HV and LV power cables including submersible and control cables, DC supply system and other allied equipment, etc. along with the specifications for workmanship, laying cables, lighting system, earthing systems, lightning protection etc. It shall be the responsibility of the Contractor to design the electrical system based on the mechanical equipment.

The Contractor shall submit his design calculations/ drawings based on 'Design criteria for electrical equipment/ system' for Engineer's review and approval.

The Bidder shall make his own estimate of sizes, ratings and quantities for substation equipment, all plant items and miscellaneous systems such as earthing, lightning protection, lighting, auxiliary power distribution, etc. It should be clearly understood that the Contract will include all related works and no variation will be allowed for items of works not foreseen or omitted by the Bidder at the bidding stage, except where specifically indicated in the bid documents.

All equipment offered shall comply with the requirements specified in the latest editions of applicable Indian/ International Standards and shall also comply with good engineering practices.

Contractor shall design the electrical system on the basis of 'Design Criteria' to be submitted for Engineer's approval. Contractor shall incorporate any changes/ suggestions in the drawings to suit site conditions and design criteria and standard engineering practice and resubmit for approval to Engineer.

The Contractor shall possess the valid electrical Contractor's license of appropriate class from the concerned statutory bodies governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations.

All types (as applicable) of routine and acceptance tests shall be conducted in the presence of Engineer on all the equipment as per latest applicable IS/IEC at no extra cost. Typical type test reports for other equipment shall be submitted by the Contractor for approval by the Engineer.

All commissioning tests shall be carried out in the presence of Engineer and approval for the same shall be obtained before commissioning and installation. All test reports shall be properly maintained by the Contractor duly approved by the statutory bodies and shall be handed over to the Engineer after completion of the job. All instrument and accessories required for testing and commissioning of the equipment specified herein shall be provided by the Contractor at no extra cost to the Employer.

Liaison with the Electricity Company and other Government organization/ statutory bodies for obtaining Power supply/ other clearance shall be part of the Contractor's scope. After completion of installation work, the Contractor shall arrange for inspection and obtain approval from the concerned statutory bodies. Any fees that are to be paid to such statutory bodies for testing, inspection or calibration shall be paid by the Contractor. Any modification / revision in the equipment / installation of equipment as required by the statutory bodies shall be carried out by the Contractor. All such costs / fees for revisions / modifications shall be deemed to be included in the prices of supply, installation, testing and commissioning of equipment as quoted by the Contractor.

6.2 OPERATING VOLTAGES AND FREQUENCIES:

6.2.1 HT SYSTEM:

(i)	Voltage:	11 kV
(ii)	Frequency:	50 Hz
(iii)	Connection:	3 phase, 3 wire

6.2.2 LT SYSTEM:

(i)	Voltage:	415 V nominal
(ii)	Frequency:	50 HZ
(iii)	Connection:	4 wire
(iv)	Off load transformer voltage:	433 V
(v)	System Earthing:	Solidly earthed
(vi)	415V system maximum fault level:	50 kA

The Tube Wells 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 5 % minus 5% with a maximum combined tolerance of 10%.

6.2.3 CONTROL VOLTAGE, INSTRUMENTATION POWER SUPPLY, AC CONTROL, LIGHTING AND SPACE HEATING:

(i)	Voltage:	110 V	240 V
(ii)	Phases:	1	1
(iii)	Frequency:	50 Hz	50 Hz

6.2.4 DC CONTROL VOLTAGE (FOR HT SWITCHGEAR AND LV ACBS IN LV PCC):

(i)	Voltage:	24 V DC
(ii)	Wires/ Earthing:	2 wire / unearthed

6.3 MAJOR ITEMS

The major items of work for the electrical works, but not limited to, shall be as below:

6.3.1ELECTRIC SUBSTATION AND CONTROL ROOM AT POLYTECHNIC CAMPUS

(i) 11 kV Outdoor substation equipment

(ii) 11 kV Indoor, metal clad switchgear

(iii) 11 kV power cables

(iv) 11 kV cable termination kits for above cables.

(v) 2 Nos. of 1000 kVA capacity of 11/0.433KV ONAN, Dyn11 transformers complete with on line circuit tap changers and fittings accessories as specified

(vi) 415V Motor Control Centers (MCCs)

For operation of 4 Turbine pumpset to be erected in the clear water pump house at polytechnic campus area.

(vii) Capacitor banks connected to each TW circuit to improve the system PF to 0.98 lag.

(viii) LT power and control cables as required for the entire installation.

(ix) Motor starters

(x) Earthing system

(xi) Renovation of existing Lighting system: Both indoor and outdoor lighting covering lighting transformer.

(xii) Cable carrier system

(xiii) Safety equipment as required statutorily and operationally.

6.3.2ELECTRIC SYSTEM AT 24 TUBE WELLS

i. LT Submersible and control cables as required for the entire installation.
ii. Control Penal with provision for operating Electro chlorinator, chlorine solution dosing pump, electric switch gear, instrumentation, power capacitor etc.
iii. Motor starter
iv. Capacitor bank connected to motor circuit to improve the system PF to 0.98 lag.
v. Earthing system
vi. Renovation of existing Lighting system: Both indoor and outdoor lighting.
vii. Cable carrier system
viii. Safety equipment as required statutorily and operationally.

6.3.3ESTIMATION OF LOAD

The following assumptions have to be made to arrive at the estimated load of the different sites.

6.3.3.1 ***Load Factor***

- Main motor : 0.95
- Auxiliary motor : 0.9
- Auxiliary load, valve motors, etc. :0.9
- Lighting load : 1.0

6.3.3.2 ***Diversity Factor***

- Main and auxiliary motor :1.0
- Auxiliary load, valve motors, etc.: 1.5
- Lighting load : 1.2

6.3.3.3 ***Efficiency of LV Motors*** ***: Energy efficient eff1 or eff2***

(**Note**: Energy efficient, high performance motors (minimum eff2 category) shall be provided for optimum utilization of energy.)

6.3.4 PROTECTIONS

The following protections are proposed for various switchboards, transformers, motors and other plant feeders.

(i) ***1***1 kV Switchboard

- IDMT over current and earth fault protection for incomers and bus coupler
- PT fuses failure protection
- IDMT and instantaneous over current and earth fault protection for outgoing transformer feeders
- Transformer auxiliary protection (e.g. WTI, OTI, Buchholz, etc.)
- Transformer auxiliaries for alarm (e.g. MOG, PVR, etc.)
- Restricted earth fault and stand-by earth fault protection for main transformer feeders
- Stand-by earth fault protection for Auxiliary transformer feeders

(ii) LV switchboard

- Over current, short circuit and earth fault protection on ACBs/ MCCBs

(iii) Motors

- Overload protection by thermal (bimetal) relays in all the three phases to trip with single phase preventer (SPP) and short circuit protection in all the three phases through motor protection circuit breakers/ MCCBs Alternatively, microprocessor based motor protection relay shall be used.
- Thermal, locked rotor, short circuit, negative sequence, under voltage, over voltage and earth fault for each motor feeder of rating 90kW and above.

6.3.5 **METERING**

The following metering shall be provided.

(i) 11 kV Switchboard

Multifunction meter (for incomer) containing -

- Ammeter
- Voltmeter
- kW meter
- Frequency meter
- Power factor meter
- Kilowatt hour meter
- kVAR meter
- kVA meter

(ii) LV Incomers

- Ammeters with selector switch
- Voltmeter with selector switch
- kW meter
- Power factor meter
- Kilowatt-hour meter
- Frequency meter

LV Outgoing Feeders

- Ammeter with ammeter selector switch

Multifunction meter shall be equipped with interfacing capability for RS-485 port.

6.3.6 **INDICATING LAMPS**

The following indication shall be provided:

(i) LV Incomers

- Mains ON (red, yellow and blue)

(ii) LV Motor Feeders

- Motor ON, OFF and Trip indication (Red, green and Amber)
- Motor ON, OFF and Trip indication (Red, green and Amber), control supply healthy and trip circuit healthy for breaker feeder.

Neutral earthing resistor on the 11 kV side neutral of the main transformer shall be rated to limit the earth fault current on 11 kV side and shall be sized for 10 second withstand.

All electrical equipment will be rated for 50^0 C design ambient temperature.

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.

The other rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cables, depth of laying, etc. shall also be considered for cable sizing.

Components of luminaries shall be ‘energy efficient low loss’ type. Fluorescent type of luminaries shall be used for pump house area. HPSV or MH luminaries shall be used for Polytechnic campus and other outdoor areas. Industrial type fixtures/ receptacles shall be used.

The values of fault level for designing the electrical system shall be based on transformer capacity, its impedance and system fault level. Fault clearing time for sizing of earth conductor will be taken as one second.

The material of earthing conductor shall be copper. All connections between the earth conductors buried in earth/concrete and between earth conductor and earth leads shall be of brazed type. While sizing the buried earth conductor, a corrosion allowance of at least 20% shall be taken. Plant earthing system shall be designed such that the overall earthing grid resistance is maximum one ohm.

Main earthing conductors outside and inside the building shall be planned in such a manner that various equipment is connected to earthing system by two connections in a reliable manner.

6.3.7 **APPLICABLE 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.

If standards other than IEC are referred, then the Bidder shall enclose English version of the standard with the bid.

In case of conflict between Standards and the specification, these specifications shall govern.

6.3.8 **SITE CONDITIONS**

The bidder shall note the following local conditions while preparing his bid:

Table 18 Local Site Conditions

Description	Value
Altitude	Less than 200 m above Mean Sea Level
Ambient Air Temperature To be considered for design	0°C Minimum 55°C Maximum } Indoor Values

6.3.9**POLLUTION LEVEL AND CREEPAGE DISTANCE**

The installation is classified as Very Heavy Pollution Level (level IV of IEC 60815). However, creep age 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.

6.4 **OUTDOOR SUBSTATION EQUIPMENT**

6.4.1 **GENERAL**

The scope of supply for the outdoor substation consists of galvanized steel (GS) gantry/supporting structure (including civil foundation) fabricated out of structural sections for supporting and fixing various equipment such as disconnectors, lightning arresters, current transformer, voltage transformer, insulators and hardware, Aluminum Conductors Steel Reinforced (ASCR) conductor, etc.

The design, material, construction, manufacture, inspection, testing and performance of substation equipment shall comply with all currently applicable standards, statutes, regulations and safety codes in the locality where the equipment will be installed.

The details of the steel structure and support sections / members shall be subject to approval of structural design calculations to be furnished by the Contractor. Galvanizing shall be as per the details mentioned in this specification.

6.4.2 **SUPPORTING STRUCTURES**

Supporting structures for Circuit Breakers shall be included in the Contractor's scope of supply. The Contractor shall furnish detailed dimensioned drawings indicating weights and all fixing details and relative locations of chassis, operating mechanism box and operating handles etc.

6.4.3 **DRAWINGS AND DATA**

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor after award of contract.

6.5 **HIGH VOLTAGE ISOLATORS**

6.5.1 **APPLICABLE STANDARDS**

Isolators shall conform to the latest applicable standards listed below:

(i)	Isolators	:	IS: 9921 / IEC: 60129, 60694
(ii)	Insulators - High voltage	:	IS: 2544 / IEC: 60273
(iii)	Hot dip galvanizing	:	IS: 2629 / IS: 2633

(iv) Connectors : IS: 5561

6.5.2 DESIGN FEATURES

6.5.2.1 *Construction Features*

(i) Isolator/earthing switch shall be complete with all parts and accessories.

(ii) All similar parts shall be interchangeable.

(iii) Base channels and other structural steel members such as operating pipes, phase coupling rods etc., operating mechanism boxes, bolts, pins etc. shall be hot dip galvanised. All castings except current carrying parts shall be made of malleable iron or cast steel. Gray iron shall not be used in the manufacture of any part. Manual operating handles shall be of galvanised steel.

(iv) Live metal parts shall be of non-rusting and non-corroding metal. Current carrying parts shall be of non-ferrous material such as aluminium or copper. Bolts, screws and pins shall be provided with lock washers, keys or equivalent locking facilities and, if on current carrying parts, shall be made of non-rusting and non-corroding metal such as copper silicon alloy.

(v) The isolator design shall be such that it is free from visible corona discharge in both closed and open positions at the visible discharge test voltages as per applicable standards

(vi) The design of isolator and earth switch shall be such that no lubrication of any part is required except at very infrequent intervals.

(vii) The isolator or earthing switch shall be provided with current carrying contacts on the hinge and jaw ends and all contact surfaces shall be of silver faced copper.

6.5.2.2 *Accessories*

(i) <u>Position Indicator</u>

A mechanical position indicating device shall be provided for each isolator/earthing switch, irrespective of whether the isolating distance is visible or not.

(ii) <u>Earthing Pads</u>

Each pole of the isolator shall be provided with two earthing pads of non-corroding material at opposite ends, brazed to the channel base. Flexible tinned copper earth connectors shall be provided for connecting operating handles of isolators and earthing switches to the earthing system.

(iii) <u>Counter Balance Springs</u>

These shall be provided for counter balancing the isolators to prevent impact at the end of travel both on opening and closing of the isolator/earthing switch. The springs shall be made of non-rusting alloy.

(iv) <u>Name Plate</u>

A weather-proof and corrosion-proof name plate shall be provided on isolators, earthing switches and operating devices. The name plates shall conform to applicable standards.

(v) Adequately rated, renewable type arcing tips shall be provided on the isolators, wherever required, to make and break the magnetizing or line/bus charging currents.

6.5.2.3 *Earthing Switch*

Earthing switch shall form an integral part of each pole of the isolator. Two independent earthing pads each with flexible tinned copper braids and suitable connectors for the specified size of earth conductor lead shall be provided at the hinge end of the switch.

6.5.2.4 *Interlocks*

(i) Isolators and earthing switches shall be provided with padlocking facility to lock them in fully open or fully closed positions. Padlock with keys shall be supplied with the isolator.

(ii) Isolator and earthing switch shall be mechanically interlocked such that it will not be possible to close the earthing switch when the isolator is closed and vice versa.

(iii) Isolator shall be provided with electrical interlocking feature. This shall be in the form of bolt interlock comprising an interlock coil of latch-in type to lock the isolator driving shaft and thus prevent isolator operation in the latch-in condition. It shall be possible to release the latch by energising the interlock coil when certain pre-set conditions of Employer's external interlocking scheme are fulfilled. For this purpose the Contractor shall provide wiring up to the external interlocking contacts both in isolator opening and closing circuits. Further, a separate bypass switch or a similar facility shall be provided on the local control cabinet to facilitate emergency manual operation of isolator. Electrical interlocking arrangement shall be fail-safe type.

6.5.2.5***Insulators***

Insulators used in the assembly of isolators shall be of porcelain and of brown colour. Insulator cap and base shall be of high grade cast steel or malleable steel casting and they shall be machine faced and galvanised.

6.5.3 **OPERATING MECHANISM AND CONTROLS**

(i) The ganging mechanism shall be provided with sufficient adjustment to allow for final alignment of the isolator blades for simultaneous operation. Adjustable stops shall be provided to prevent over-travel in both directions.

(ii) The manual operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided, if necessary, at a height of 1250 mm above grade level. All members necessary for attaching the operating mechanism and operating handles to the supporting structure and foundations shall be supplied as an integral part of the isolator. Rust-proof pins and bearings of the bronze bushing, ball and roller type, shall be furnished. All bearings shall be weather protected by means of covers and grease retainers.

(iii) A weather-proof galvanised sheet steel cabinet with gasket hinged door and padlocking facility shall be provided to house driving mechanism, motor starters, auxiliary switches etc., as applicable. The steel control cabinet (operating mechanism box) shall be dust, weather proof and vermin proof providing degree of protection of IP:54 for outdoor use. This shall comprise of rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2 mm. All doors, removable covers and plates shall be gasket all around with neoprene gaskets. All cabling from operating mechanism and auxiliary contacts to operating mechanism box shall be in the scope of supply of the Contractor and shall be carried out using 650/1100 V grade, 2.5 sq. mm. stranded copper conductor, PVC insulated, armoured, multicore cables or single core cables laid in heavy gauge galvanised steel conduits, unless otherwise specified.

(iv) The auxiliary contacts shall be of silver faced copper. The contacts shall be designed to carry 10 A continuously. All contacts shall be suitable for breaking an inductive current of 0.2 A at 110 V DC.

(v) The operating mechanism design shall be such that during the operation of the isolator, when the moving blades reach the sparking distance, springs take over to give a quick, snap action closing so that the isolator closing is independent of manual efforts. Similarly, the springs must assist during the opening operation to give quick breaking feature.

(vi) Adequate no. of spare terminals shall be provided in the operating cabinet for the purpose of external interlocks.

6.5.4**SUPPORTING STRUCTURES**

Supporting structures for isolators shall be included in the Contractor's scope of supply. The Contractor shall furnish detailed dimensioned drawings indicating weights and all fixing details and relative locations of chassis, operating mechanism box and operating handles etc.

6.5.5DRAWINGS

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor after award of contract.

Assembly

Direct delivery of insulators from insulator manufacturer's works is not preferred and is subject to Employer's approval. Isolators shall be completely assembled at the works to ascertain that all the parts fit correctly.

6.6 LIGHTNING ARRESTORS

6.6.1 APPLICABLE STANDARDS

Lightning arrestors shall conform to the latest applicable standards specified below:

(i)	Lightning arrestors	:	IEC: 60099-4
(ii)	Insulators	:	IS: 2544 / IEC: 60273
(iii)	Large hollow porcelain	:	IS: 5621 / IEC: 60233
(iv)	Connectors	:	IS: 5561
(v)	Hot dip galvanizing	:	IS: 2629 / IS: 2633

6.6.2 DESIGN FEATURES

6.6.2.1*Constructional Features*

(i) Lightning arrestors shall be Gapless metal oxide hermetically sealed type and of self-supporting construction suitable for mounting on steel structures. They shall be provided with pressure relief devices and shall be capable of withstanding the internal pressures developed during various discharges or should safely vent the internal pressures associated with arrester failure without violent shattering.

(ii) All metal parts shall be of non-rusting and non-corroding metal. Bolts, screws and pins shall be provided with lock washers, keys or equivalent locking facilities.

6.6.2.2*Accessories*

The Discharge Counter details shall be as follows:

(i) Self-contained discharge counter, suitably enclosed for outdoor use shall be provided for each single pole unit. The discharge counter shall be visible through an inspection window. The counter terminals shall be so located that incoming and outgoing connections are easily made with minimum possible bends. Suitably sized bypass shunts of copper to facilitate bypassing the discharge counter shall be furnished. The terminal connectors shall permit the connection of these shunts.

(ii) The connection between lightning arrester earth terminal and discharge counter terminal shall be PVC/XLPE insulated for a minimum of 3.6 kV and this insulated conductor shall be supplied along with the arrester.

(iii) A leakage current meter as an integral part of the discharge counter shall be supplied. The counter and the meter shall be so arranged that it is possible to read the leakage current values from ground level. The value of leakage current beyond which the operation is abnormal shall be clearly marked in red colour on the meter.

6.6.2.3***Name Plates***

Each lightning arrestor shall be provided with non-rusting and non-corroding name plate bearing identification as per the applicable standards.

6.6.2.4***Supporting Structure***

Supporting structure for the lightning arrestor shall be included in the Contractor's Scope of Supply. Contractor shall furnish detailed dimensioned drawings indicating weights and all fixing details.

6.6.2.5***Drawings***

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor and get approval before commencement of work at site.

6.7HIGH VOLTAGE CURRENT AND VOLTAGE TRANSFORMERS

6.7.1APPLICABLE STANDARDS

Current and voltage transformers shall conform to the latest applicable standards specified below:

Table 19 Applicable Standards for Current and Voltage Transformers

Current Transformers	:	IS 2705 / BS 7626 / IEC:60185
Voltage Transformers	:	IS:3156/ BS 7625/IEC:60186
Insulating oil	:	IS:335/IEC 60296
Bushings	:	IS:2099/IEC 60137
Large Hollow Porcelain	:	IS:5621/IEC 60233
Insulators	:	IS 2544/IEC 60168
Hot dip galvanizing	:	IS:2629, IS:2633

6.7.2DESIGN FEATURES

(i) Secondary terminals of current and voltage transformers shall be brought out in a weather-proof terminal box. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal box. Glands and lugs for terminating external cable connections shall be provided.

(ii) Terminal and polarity marks shall be indelibly marked on each CT and VT on the associated terminals and these marks shall be in accordance with relevant standards.

(iii) The secondary terminal box for the voltage transformers shall also include necessary HRC fuses for protecting the secondary circuit. Further, for the purpose of fuse supervision on remote panel both terminals of fuse shall be brought out to the terminal box.

(iv) Current and voltage transformers shall be provided with the following accessories:

- H.V. connectors for the 'Lynx' ACSR conductor.
- Two earthing terminals on tanks on opposite sides for the earthing conductors.
- Oil level gauge
- Filling and draining plugs
- Power factor testing terminal

- Facility for lifting bushings and tanks
- Insulating oil required for first filling plus 10% excess. Power factor of the transformer oil shall not exceed 0.005. Insulation oil shall comply with applicable standards.
- Rating and diagram plate as per relevant standards.

(v) Voltage and current transformers shall be given tropicalized treatment for satisfactory operation in hot and humid climate.

(vi) The tank/base and all exposed ferrous parts shall be hot dip galvanised conforming to applicable standards.

(vii) In the case of multi-core CTs, it shall be possible to adjust the tap settings on any core independent of the setting on the other cores, for which purpose these tappings will have to be provided on the secondary windings.

(viii) All CT cores under this Specification shall be of low reactance type.

(ix) No turns compensation shall be used in case of class ‘PS’ CTs.

(x) In case of multi-ratio CTs, the minimum specified requirements in respect of VA, accuracy and Knee Point Voltage (KPV) and maximum secondary resistance specified shall be met at all taps.

(xi) Whenever a VT secondary winding is used for both measurement and protection application, it shall have dual accuracy class of 0.5/3P.

(xii) The end of the primary winding of voltage transformers intended to be earthed shall be brought out through a bushing and earthing connection shall be made outside. This is required to facilitate meggering of the primary winding for which the earth connection has to be removed. The neutral side bushings of the voltage transformers shall be rated for 1.1 kV class.

6.7.3 INSULATORS / BUSHINGS

(i) Insulators/bushings shall conform to applicable standards and shall be made of homogenous vitreous porcelain, the glazing of which shall be of uniform brown or dark brown colour.

(ii) Oil filled insulator/bushings shall he hermetically sealed to prevent ingress of moisture. A cushion of nitrogen gas shall be provided to allow for expansion.

6.7.4 SUPPORTING STRUCTURE

Supporting structure for the Current and Voltage Transformer shall be included in the Contractor’s Scope of Supply. Contractor shall furnish detailed dimensioned drawings indicating weights and all fixing details.

6.7.5 DRAWINGS

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor along with the bid as well as after award of contract.

6.8 INSULATORS AND INSULATOR FITTINGS

6.8.1 APPLICABLE STANDARDS

Insulators and fittings shall conform to the latest editions of standards specified below:

Table 20 Applicable Standards for Insulators and Fittings

(i)	Porcelain post insulators	:	IS: 2544 / BS: 3297 / IEC: 60273
(ii)	Insulators for overhead power lines	:	IS:731/BS:137/IEC:60305,60433

(iii)	Fittings for overhead power lines	:	IS: 2486 / BS: 3288
(iv)	Dimensions of indoor and outdoor porcelain post insulators and post insulator unit	:	IS: 5350
(v)	Hot dip galvanizing	:	IS:2629, 2633

6.8.2 CONSTRUCTION FEATURES

6.8.2.1 *Insulators*

(i) The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed. Insulators shall have compression type glaze with a good luster and of uniform brown colour. The glaze shall be unaffected by sudden changes in temperature and by atmospheric pollution of ozone, acids, alkali, dust etc.

(ii) Under surfaces and grooves shall be shaped for easy cleaning. Shells shall be substantially symmetrical in shape without appreciable warping. Tie wire grooves of pin insulators shall be formed to provide a firm support for the conductor and permit the making of a secure tie.

(iii) Insulators shall be designed to avoid excessive concentration of electrical stresses in any section or across leakage surfaces. Design features which increase radio influence level shall be avoided.

(iv) Each insulator shall have the rated strength marked clearly on the metal cap before galvanising. Each insulator shall also bear symbols identifying the manufacturer, month, and year of manufacture etc.

(v) All metal parts shall be made of good commercial grade malleable iron or open hearth or electric furnace steel, hot dip galvanised conforming to relevant standards. Casting shall be free from blow holes, cracks and such other defects.

(vi) Strain and suspension strings shall comprise of the conventional ball and socket type disc insulators. Individual insulators as well as strings of the same type shall be possible to form either suspension or strain strings using the same disc. The locking clips shall be made of phosphor bronze and shall provide positive locking of the coupling.

(vii) The Contractor shall make available to the Employer, data on all the essential features of design including the method of assembly of shells and metal parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells to adjacent parts provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase insulator life under service conditions.

6.8.2.2 *Hardware Fittings*

(i) Except where otherwise specified, all hardware shall be drop forged from high carbon steel

(ii) All ferrous parts shall be hot dip galvanised conforming to relevant standard

(iii) All clevis fittings and shackles shall be furnished with a high strength high carbon steel galvanised bolt with nut and cotter key.

6.8.3 DRAWINGS

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor before commencement of work at site.

6.9 RELAY AND CONTROL PANEL

6.9.1 APPLICABLE STANDARDS

Relay and control panel shall conform to the latest applicable standards specified below:

Table 21 Applicable Standards for Relay and Control Panel

(i)	Switchgear general requirements	:	IS:13947 (Part1to 5) / BS : 5486
(ii)	Panel wiring	:	IS:5578/11353)/BS:158
(iii)	Factory built assemblies of switchgear and control gear for voltages up to and including 1000 V AC & 1200 V, DC	:	IS:8623/IEC:60439 (Part II & III)
(iv)	Miniature circuit breakers	:	IS:8828;
(v)	HRC cartridge fuses	:	IS:9224/BS:88/IEC:60265-1
(vi)	D type fuses	:	IS:8187
(vii)	Control switches/push buttons	:	IS:6875 (Part I & II)/BSEN:60947/ IEC:60947
(viii)	Current transformers	:	IS:2705/BS:3938
(ix)	Voltage transformers	:	IS:3156/BS:3941/IEC: 60186
(x)	Relays	:	IS:3231, 3842/ BS:142 /IEC:60255
(xi)	Indicating instruments	:	IS:1248/BS:89/IEC:60051
(xii)	AC electricity meters	:	IS:722,8530 /BS:5685/IEC:60145, 60211
(xiii)	Degree of protection	:	IS:13947 (Part I)/BS:5490/ IEC:60947-1
(xiv)	Code of practice for phosphating iron and steel	:	IS:6005 / BS:3189

6.9.2 CONSTRUCTION FEATURES

(i) Relay and control panels shall be completely metal enclosed, free standing, floor mounting type and shall be dust, moisture and vermin proof. The panel enclosures shall provide a degree of protection not less than IP 52.

(ii) All equipment on front of the panel shall be mounted flush or semi-flush with only the flanges projecting. All equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment.

(iii) Control panels shall consist of vertical front panels with equipment mounted thereon and having wiring access from the rear. The doors shall have handles with built-in locking facility.

6.9.3 MIMIC DIAGRAMS

Mimic diagrams shall be provided and shall be screwed on to panels. The material of the mimic strips shall be anodized aluminum or plastic of approved fast cooler and material, which can be easily cleaned. The width of the mimic bus shall not be less than 7.0 mm.

6.9.4 ANNUNCIATORS

Fascia annunciators, when provided, shall have the following essential features and shall be suitable for operation on 24/110 V DC. Fascia annunciators shall be:

(i) Equipment with “Sound Cancel”, “Acknowledge” and “Reset” push buttons common to annunciators on all control panels aligned together and a “Lamp test” push button for each annunciator on individual panels.

(ii) Provided with two lamps connected in parallel on each facia window with series resistors.

(iii) Suitable for normally open initiating contacts of either “hand” or “self” reset type.

(iv) Suitable for annunciating subsequent faults with the specified sequence, immediately after acknowledging the previous fault.

(v) The minimum size of Fascia Window shall be 35 mm x 50 mm.

(vi) Designed for an operating sequence indicated below:

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Sound cancel	Closed or Open	Off	Flashing
Acknowledge	Closed or Open	Off	Steady on
Back to Normal	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

6.9.5 PANEL ACCESSORIES & WIRING

(i) All wiring shall be carried out with 650 V grade, single core, stranded tinned copper conductors with PVC insulation and shall be flame, vermin and rodent proof. The minimum size of the stranded copper conductor used for the panel wiring shall be 1.5 sq. mm.

(ii) Wire terminations shall be made with solder less 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 wiring diagram shall be fitted at both ends of each wire. All wires directly connected to the trip circuit of a breaker or device shall be distinguished by the addition of a red colored unlettered ferrule.

6.9.6 TERMINAL BLOCKS

(i) Terminal blocks shall be 650 V grade, 10 amps rated one piece moulded, complete with insulating barriers, stud type terminals, washers, nut and lock nuts and identification strips. Marking on the terminal strips shall correspond to numbers on the wiring diagrams.

(ii) Terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. Terminal blocks for CT secondary leads shall have short circuiting facility.

(iii) Where duplication of a terminal is necessary, it shall be achieved by solid bonding links.

(iv) At least 10% spare terminals shall be provided on each panel. Also, all spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.

6.9.7 INDICATING INSTRUMENTS AND METERS

(i) Instrument dials shall be white with black numerals and lettering. Knife edge pointers and parallax free dials shall be provided.

(ii) DC ammeters shall be provided with external shunts whenever the current exceeds 5 Amps. The rated voltage drop of the shunts shall be 75 mV.

(iii) Watt-hour meters shall be suitable for measurement of unbalanced loads in 3 phase, 4 wire system. They shall be provided with a separate 3 phase, 4 wire type test blocks for the on-load testing of the meters without disturbing the CT & VT secondary connection.

6.9.8 RELAYS

(i) All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity.

(ii) All protective relays shall be flush mounted at the front with connections at the rear in draw out cases with built-in test facilities, including test plugs. All auxiliary relays and timers shall be supplied in non-draw out cases.

(iii) 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.

(iv) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 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.

(v) 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.

(vi) 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.

(vii) Numerical Relays shall have diagnostic feature with self-check for power failure, Programmable routines, memory and main CPU Failures etc.

(viii) 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 24/110 V DC Control Voltage.

(ix) 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.

(x) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.

(xi) Timer function shall be programmable for ON/OFF delays.

(xii) 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.

(xiii) All relays shall withstand minimum test voltage of 2 KV AC RMS for one minute.

(xiv) Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

6.9.9 CONTROL AND SELECTOR SWITCHES

(i) Control and instrument switches shall be of heavy duty rotary type provided with escutcheon plates clearly marked to indicate the operating position, as well as function of the switch. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

(ii) Circuit breaker control switches shall be three position spring return to neutral type and shall have external red and green indicating lamps. Red lamp shall be wired for continuous supervision of shunt trip circuit with a series resistor.

(iii) Instrument selector switches shall be of the maintained contact (stay put) type.

(iv) Ammeter & Voltmeter Selector Switches shall have four stay put positions. Ammeter selector switches shall have make before break type contacts so at to prevent open circuiting of the CT secondary's when changing the position of the switch.

6.9.10**PUSH BUTTONS**

All push buttons shall have two normally open and two normally closed contacts unless specified otherwise. The contacts shall be able to make and carry 5A at 110 V DC and shall be capable of breaking 1A inductive load at 110 V DC.

6.9.11**INDICATING LAMPS**

(i) Indicating lamps shall be of Panel mounting, LED type. The Lamps shall have escutcheon plates marked with their function with colours as warranted. Lamps shall have translucent lenses with colours as warranted by the application.

(ii) Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Special tools, if any, required for replacing the bulbs and lenses shall also be included.

6.9.12**FUSES**

All fuses shall be of the HRC cartridge plug-in type, provided with visible indication to show that they have fused.

6.9.13**SPACE HEATERS**

Each panel shall be equipped with space heaters to prevent moisture condensation within the enclosure and shall be complete with control switch, thermostat to cut off the heaters at 45°C and fuses for the power supply. Heaters shall be suitable for 240 V, 1 phase, 50 Hz AC.

6.9.14**RECEPTACLE AND INTERIOR LIGHTING**

(i) A 240 V, 1 phase, 50 Hz, AC 3 Pin receptacle shall be provided in the interior of each cubicle with an ON/OFF control switch and fuse for connection of hand lamps.

(ii) An interior illuminating lamp together with the operating door switch and protective fuses shall also be provided.

6.9.15**LABELS**

(i) All front mounted equipment, as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The panel shall also be provided at the top with a label engraved with the panel designation. Lettering for panel designation shall be 6 mm. Labels shall be made of non-rusting metal or 3 ply Lamicoid. The minimum lettering size for device labels shall be 3 mm.

6.9.16**EARTHING**

(i) All panels shall be equipped with an earth bus securely fixed along the inside base of the panels. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included. Provision shall be made to extend the earth bus bar to future adjoining panels on either side. Provision shall also be made on the earth bus bar of the end panels for connecting the earthing conductor.

(ii) All metallic cases/frames of relays, instruments and other panel mounted equipment shall be connected to the earth bus by independent copper wires of not less than 2.5 sq.mm. Suitable clamp connectors shall be used. Soldering shall not be permitted.

(iii) The insulation colour code for earthing wires shall be green.

6.9.17**DRAWINGS AND DATA**

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc. shall be submitted by the contractor after award of contract and get approval before procurement.

6.10**11 KV METAL ENCLOSED SWITCHGEAR**

6.10.1 **APPLICABLE STANDARDS**

Some of the applicable standards are in the table below:

S. No.	Code No.	Title
1	IS: 13118 / BS: 5311/ IEC: 56,694	Circuit breakers
2	IS: 3427 / BSEN: 60298 / IEC: 298	Metal enclosed switchgear
3	IS: 2705 / BS: 7626	Current transformers
4	IS: 3156 / BS: 7625 / IEC: 186	Voltage transformers
5	IS : 5578, 11353	Arrangements for switchgear bus bar, main connections and auxiliary wiring.
6	IS: 2544 / BS: 3279 / IEC: 273	Bus bar support insulators
7	IS: 13947 (Part I) / IEC: 947- I / BSEN: 60529	Degree of protection
8	IS: 3231, 3842 / BS: 142 / IEC: 255	Electrical relays for power system protection
9	IS: 1248 / BS: 89 / IEC: 51	Electrical indicating instruments
10	IS: 9385 / BS: 2692 / IEC: 282	High voltage fuses
11	IS: 722, 8530 / BS: 5685 / IEC: 145, 211	AC electricity meters
12	IS: 613	Specification for copper rods and bars for electrical purposes
13	IS: 6005 / BS: 3189	Code of practice for phosphate iron and steel
14	IS: 9920 / IEC: 129, 265 and 298	Alternating current switches for voltages above 1000V
15	IS: 13703 / BS: 1362 / IEC: 269	Low voltage fuses
16	IS: 3452 / BS: 3676	Toggle switches
17	IS: 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
18	IS: 6875 / BSEN: 60947 / IEC: 947	Control switches

6.10.2**CONSTRUCTION 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.

Instruments, relays 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.

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.

Sheet steel used for fabrication of switchgear, cubicles/boards shall be cold rolled. All panels shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not less than 2.5 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary. All doors, removable covers, gland plates, etc. shall be of at least 2 mm thickness smooth finished, leveled and free from flaws and shall be gasketed all-round the perimeter with neoprene gaskets. All louvers shall have screens and filters. Vent openings shall be covered by fine mesh on the vertical face. The screens and grills shall be made of either brass or galvanized iron wire mesh. . All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All floor mounted panels / boards shall be provided with a channel base frame. Minimum 100 mm ISMC channel are to be used as Base frame with Black enamel paint. It shall be possible to extend the switchboard on both sides. Total height of the switchgear Panel shall not exceed 2600 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 800 mm.

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.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal bus bar 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

The metal-clad switchgear and control gear shall have separate compartments for the following components:

(i) Each set of bus bar.

(ii) Current Transformers.

(iii) Voltage Transformers on incomer side

(iv) Each main switching device.

(v) Cable chamber suitable for heat shrinkable type cable.

(vi) Metering and relaying devices.

Degree of protection: Protection against live part or contact with internal moving parts shall be not less than IP 4X.

The circuit breaker shall have distinct 'service' and 'test' positions. In the 'test' position, the circuit breaker shall be capable of being tested for operation without energizing the power circuits. Four normally open auxiliary contracts shall be provided for each of the service and test limit position switches.

The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.

The Switchgear shall fully house the breaker both in the 'service' position as well as in the 'test' position

Separate removable glands plates with minimum thickness of 3 mm shall be provided for power and control cables. The gland plates for the power cables shall be of non-magnetic material

The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.

6.10.3**PAINTING**

(i) All sheet steelworks shall be phosphate coated in accordance with the following procedure and in accordance with relevant standards for phosphate iron and steel.

(ii) Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.

(iii) Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

(iv) After phosphate, thoroughly rinsing shall be carried out with clean water, followed by final rising with dilute dichromate solution and oven drying.

(v) The phosphate coating shall be sealed by the application of two coats of primer suitable for finishing by powder coating.

(vi) After application of the primer, the fabricated sheet work shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the Engineer.

(vii) The final finished thickness of the coating shall not be less than 100 microns, and shall be more than 150 microns.

(viii) Structure, buses and control wiring troughs shall be so designed and arranged to make future extensions readily feasible.

(ix) Instruments, relays and control devices shall be mounted flush on hinged door of the metering compartment located in the front portion of cubicle. Panel door shall be supported by strong hinges and braced in such a manner as to ensure freedom sagging, bending and general distortion of panel or hinged parts. All auxiliary relays not requiring manual resetting will be mounted inside the LT compartment.

6.10.4**SAFETY INTERLOCKS**

(i) Switchgear shall be provided with following interlocks:

(ii) Operation of an isolator shall not be possible unless the associated circuit breaker is in the 'open' position.

(iii) Compartment door of a breaker or an isolator shall not open unless the associated breaker or an isolator is in 'open' position.

(iv) Caution name plate, 'caution Live Terminals' shall be provided at all points where the terminals are likely to remain live and isolation is possible only at end, i.e. incoming terminals of main isolation.

(v) Circuit breaker cubicles shall be provided with safety shutter operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.

6.10.5**MAIN BUS BAR**

(i) Main bus bar shall be of electrical grade Copper of high conductivity and non- segregated type.

(ii) Bus bar shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct assess or accidental contract with bus bar and primary connections shall not be possible. To provide a seal between adjacent cubicles, bus bar shall be taken through seal-off bushings or insulating pads.

(iii) All bus bar joints shall be thoroughly cleaned and anti-oxide grease shall be applied. Plain and spring washers shall be provided to ensure good contracts at the joints and taps. Wherever aluminum to copper connections is required, suitable bimetallic connectors or clamps shall be used.

(iv) Bus bar shall be rated in accordance with the service conditions and the rated continuous due to short time current ratings specified in the Data Sheet/SLD> maximum temperature of the bus bar and bus bar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 85 deg. Celsius.

(v) Bus bar shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current. Bus bar support insulators shall conform to relevant standards.

(vi) The Bus bar clearance in air shall be suitable for the short circuit levels.

(vii) Bus bar shall not be painted and all performance characteristics specified shall be obtained with unpainted bus bar.

(viii) Bus bar shall be fully insulated by heat shrinkable type sleeving providing full insulation, with mould caps protecting all joints.

6.10.6**GENERAL**

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 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.

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.

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.

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.

6.10.7**OPERATING MECHANISM:**

(i) Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring with limit switch for automatic changing all accessories to make the mechanism a complete operating unit.

(ii) Operating mechanism shall normally be operated from the breaker cubicle itself.

(iii) 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. It shall be located in a position where it will be visible to the operator standing on the front of the switchgear with cubicle door closed. 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.

(iv) 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.

(v) 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.

(vi) 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.

(vii) Circuit breaker control shall be on 24/110 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 50 -110 % the rated control voltage.

(viii) Main poles of the breakers shall be such that unless otherwise specified, the maximum difference between instants of contracts touching during closing shall not exceed half cycle of rated frequency.

(ix) Operating mechanism shall be provided with non-pumping feature, electrically and mechanically. Electrical anti-pumping feature shall be obtained by means of an auxiliary relay.

(x) Main poles of the breaker shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.

(xi) Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker or endanger the operator.

(xii) Under Voltage coil to be provided.

(xiii) Mechanical trip and close devices shall be provided for manual of the breaker. Access to mechanical closing device shall be only after opening the cubicle door. However, the mechanical trip device shall be brought out to the front of the cubicle door.

(xiv) Working part of the mechanism shall be of corrosion resisting material. Bearings, which require grease, shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned and locked to prevent loosening or changing adjustment with repeated operation of the breaker.

(xv) Auxiliary switches mounted on the fixed portion of the cubicles and directly operated from the breaking operating mechanism on each breaker having 4 'NO' and 'NC' potential-free contacts rated for 10 amps. 240V AC and 10 amp (inductive breaker) 30 V DC shall be provided. The contacts shall be in addition to those utilized in the control circuit of each breaker and shall be exclusively meant for the Employer's use in external interlocks and controls.

(xvi) As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply to the motor, at least one open-close-open operating of the circuit breaker shall be possible.

(xvii) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring.

(xviii) Mechanical indicators to indicate 'changed' and 'discharged' condition of spring shall be provided.

(xix) Operating mechanism control:

- The closing and tripping control shall be by a control switch mounted on the cubicle door.
- The mechanical trip and close shall be provided on the breaker in addition to above.

6.10.8**SAFETY INTERLOCKS AND FEATURES:**

(i) Withdrawal or engagement of a circuit breaker shall not be possible unless it is in the open position.

(ii) 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.

(iii) 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.

(iv) 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.

(v) Caution nameplate, "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

6.10.9**EARTHING**

Copper 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.

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.

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.

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.

All instrument and relay cases shall be connected to earth bus bar by means of 1100V grade, green colored, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

6.10.10 **CIRCUIT / BUS BAR EARTHING 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 Bidder shall be clearly detailed in the Bid and shall be subject to Employer'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.

6.10.11 **ANNUNCIATORS**

Annunciator of fascia type, suitable for operation on 30V DC, shall be provided with translucent plastic window for each alarm point. Annunciator fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia light is lighted. Each annunciation window shall be provided with two lamps to provide redundancy against lamp failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All fascia Annunciator points shall be suitable to accept external contacts of either ‘NO’ or ‘NC’ self or hand reset type for initiating the annunciation sequence. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.

For static annunciator 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 annunciator wiring and switching disturbances from the neighboring circuits within the panels / desks.

A “Lamp Test” push button shall be provided for each individual panel’s group of annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

Annunciator shall have following features:

(i) Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.

(ii) Equipped with ‘Sound Cancel’ , ’Acknowledge’ and ‘Reset’ push buttons common to annunciates an all switchgear aligned together and a ‘lamp test’ push button for each annunciates individual panels.

(iii) Provided with two lamps connected in parallel on each fascia window with series resistors.

(iv) Fascia window of minimum size of 35 mm x 50 mm.

(v) During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.

(vi) Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.

(vii) "Alarm Supply Failure" Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply

6.10.12 **INDICATING INSTRUMENTS & METERS**

All electrical instruments and meters shall comply with IEC 60051, 61010 and IS 722, 1248.

All indicating and recording instruments shall be flush mounted in dust proof cases complying with IEC 60068 and dimensions to IEC 61554. All digital instruments shall have interface facilities to communicate data to SCADA system.

6.10.12.1***Indicating Instruments***

Electrical indicating instruments shall be 144mm x 144mm square with 240º scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

Instrument dials shall be white with black numbers and lettering. A red line shall be drawn on each scale to represent rated conditions.

Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.

Instruments shall have accuracy class of 1.0 or better. The design of the scales shall be such that it can read to a resolution corresponding to 50% of the accuracy class index.

Ammeters and current coils of Watt meters and Voltmeters shall continuously withstand 120% of rated current and 10 times the rated current for 0.5 sec., without loss of accuracy. Voltmeters and potential coils of Watt meters and VAr meters shall withstand 120% of rated voltage continuously and twice the rated voltage for 0.5 sec. without loss of accuracy.

Alternatively, instruments can be electronic / digital type with LED 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.

6.10.12.2***Metering Instruments***

(i) Watt-hour meters shall be of the induction type and shall be provided with reverse running stops.

(ii) Watt-hour and Varhour meters shall be of the three phase two element type of accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.

(iii) Watt-hour and Varhour meters 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.

(iv) Meters shall have digital or cyclometer type of registers. They shall read kWh, kVARh or MWh, MVARh as the case may be without the use of additional multiplying factors. Multiplying factors if unavoidable shall be multiples of 10 (ten). Number of digits provided shall be adequate to cover at least 1000 hrs. of operation.

(v) Alternatively, instruments can be electronic / digital type with LED display. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

6.10.12.3***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.

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.

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.

Instrument selector switches shall be of the maintained (stay-put) type. Ammeter and voltmeter selector switches shall have four stay put positions. Ammeter selector switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch.

Lockable type switches, which can be locked in a particular position, shall be provided, if required.

Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

6.10.12.4 ***Indicating Lamps / Pilot Lamps***

Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.

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. Bulbs and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if any, which are required for replacing the bulbs and lenses, shall also be included in the scope of supply.

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.

The basis of colors shall be as follows:

(i)	Red	:	Flow of energy
(ii)	Green	:	No flow of energy
(iii)	White	:	Supervision of power available, relay coil healthy, etc.
(iv)	Amber	:	Disagreement with original condition, 'abnormal' condition or sequence–on' condition.

6.10.12.5***Push Buttons***

Push buttons shall be of momentary contact type with rear terminal connections. The color 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.

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.

6.10.12.6***Space Heaters***

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle. 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 thermostat to cut off the heaters at 35 degree

6.10.12.7***Cubicle Lighting / Receptacle***

Each cubicle shall be provided with interior lighting by means of 18 W 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 phase, 50 Hz, AC supply. A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

6.10.12.8***Power and Control Cable Termination***

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multi-core cables shall be provided. 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 watertight 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.

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.

Cable terminations for HV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.

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.

Necessary number of cable glands shall be supplied for termination of auxiliary power and control cables. Glands shall be of heavy duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.

Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper / aluminum depending on cable conductor and of solder less crimping type.

All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, amour claps, brass glands etc., shall be supplied.

6.10.12.9 ***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.

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 restriping 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.

Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

6.10.12.10***Termination and Ferrules***

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multi core cables terminated on the panels.

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.

All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

6.10.12.11***Control Wiring Terminal Blocks***

Terminal blocks shall be of 1000 V grade 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.

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.

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.

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.

6.10.12.12***Bus Bars***

The Bus bars shall be of electrical grade, high conductivity, copper 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 colors 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 colored, bus bars shall be color coded with colored PVC tape at suitable intervals.

Bus bar 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.

Direct access to, or accidental contact with bus bar and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of bus bar due to insertion of maintenance tools.

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.

6.10.12.13***Current & 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 current ratings of the switchgear. These shall be completely encapsulated.

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.

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.

CTs shall have polarity marks indelibly marked on each transformer and at the associated terminal block. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal block.

VTs shall be of the single phase type and mounted on a draw out trolley. VTs shall be protected on their primary and secondary sides by current limiting fuses with interrupting ratings corresponding to breaker rating. It shall be possible to replace the secondary fuses safely when the switchboard is energized. Alternatively, MCB having auxiliary contact shall be provided. Primary side fuses shall be replaceable only in the de-energized position.

Secondary winding of voltage transformer (VT) shall be rated for a three phase line to line voltage of 110 V.

VTs shall be of the single phase type and mounted on a draw out trolley. VTs shall be protected on their primary sides by current limiting HRC fuses with interrupting ratings corresponding to breaker rating and on secondary side with MCB's. Provision shall be made such that the primary fuses can be handled only in the D-energized position. It shall be possible to replace the secondary fuses safely when the switchboard is energized.

6.10.12.14***Relays***

All Protective relays shall be numerical type. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity.

All protective relays shall be flush mounted at the front with connections at the rear in draw out cases with built-in test facilities, including test plugs. All auxiliary relays and timers shall be supplied in non-draw out cases.

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 control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 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.

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.

6.10.12.15***Transformer differential Protection***

This shall be provided for main transformers. This protection shall trip for all the phase and earth faults inside the zone and shall be stable for all faults outside the zone. This protection shall have restrained inrush-proof feature, which shall never prevent operation for tripping in case a real fault exists within the relay zone during energization of the transformer.

The protection shall be immune to the zero sequence current, which may circulate, during certain conditions through the neutral of only one side of the transformer. It shall be a phase segregated relay of low burden with absolute stability at design short circuit current rating and shall have an operating time of not more than 25 milli sec, at a flow of one side current equal to twice the nominal current. The output of the relay shall have sufficient number of contacts of suitable switching capacity to trip all the circuit breakers which are supposed to be tripped through this protection and initiate the lock-out relay.

The setting of bias and basic setting must be adjustable in steps in order to cover the maximum mismatch between the primary and secondary due to error of the CTs and range of regulation of the tap changer.

This protection should be wired to enable the measurement of differential and stabilization current in service without any possibility of causing open circuits on the secondary side of the current transformers.

6.10.12.16***Over current / Earth Fault Protection***

This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the over current elements and another for the earth fault element.

Phase current range shall cover at least 50-300% of rated current (In) in steps of not more than 10% while the earth current range shall cover at least 5-100% of 'In' in steps of not more than 5%.

The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.

The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.

Over current and earth fault relays shall have separate timers and operation indicators.

The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25 milli seconds and possible to be selected on "blocked" position. Reset time shall be not more than 50 milli seconds for both elements.

The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.

6.10.12.17***Restricted Earth Fault Protection***

The restricted earth fault relay shall be operated from a completely separate core of line and neutral current transformers. The dedicated CTs shall be of class PS and have the same magnetization characteristics with a knee 'emf' value higher than the highest possible setting of the relay. Intermediate CTs for ratio correction are not acceptable. CT sizing shall be matched with the requirements of the relay.

For this protection, 1-phase high impedance relay shall be provided and all the aspects regarding stability of the protection, dimensioning of current transformer, considering the peak short circuit current, etc. and all the auxiliary equipment such as non-linear VDR resistor for voltage limiting, filter for harmonics and DC component suppression and variable shunt resistor for sensitivity adjustment, if required, shall be provided. The total fault clearing time shall not exceed 20 m sec. at 3 x In.

The stability of this protection against out-zone faults shall be confirmed. A calculation to show the proper selection of the relay up to the maximum short circuit of the switchboard shall be submitted.

6.10.12.18***Under voltage relays***

Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.

Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection to SCADA.

6.10.12.19***Motor Protection Relay***

It shall be designed to protect the motor against thermal overload, locked rotor, over current and earth fault protection, under voltage, over voltage, phase reversal and negative sequence.

Thermal setting range shall cover at least 50% to 200% of 'In' in steps of not more than 5 % of 'In'.

Phase current range shall cover at least 5-200% of 'In' in steps of not more than 1% while the earth current range shall cover at least 1-100% of 'In' in steps of not more than 5%.

6.10.12.20***Motor Differential Relay***

This shall be provided for motor ratings greater than 1000 kW. This protection shall trip for all the phase and earth faults inside the zone and shall be stable for all faults outside the zone. This protection shall have restrained starting current feature, which shall never prevent operation for tripping in case a real fault exists within the relay zone during starting of the motor.

The output of the relay shall have sufficient number of contacts of suitable switching capacity to trip the circuit breaker. This protection should be wired to enable the measurement of differential and stabilization current in service without any possibility of causing open circuits on the secondary side of the current transformers.

6.10.12.21***Auxiliary Relays and Timers***

Following auxiliary relays shall be provided on each breaker cubicle:

(i) Trip circuit supervision relay

(ii) Anti- pumping relay

Hand reset type lockout (tripping) relays and timers shall be provided as required in addition to the protection relays given in the single line diagram.

Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage. Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation, high oil temperature, high winding temperature, pressure relief device (PRD) operation etc. shall be provided. Each relay shall have four (4) pairs of self-reset contacts except for Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.

Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self-reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100 ms. The relays shall have hand reset operation indicator.

6.10.12.22 ***Energy monitoring and Management***

Necessary Provisions & features shall be incorporated to enable energy monitoring/energy management for the installation.

6.11**11/0.433KV TRANSFORMER**

6.11.1**CODES AND STANDARDS**

The supply, installation, testing and commissioning of any equipment / materials, etc. shall comply with the latest applicable international / India standards and codes of practices.

The list of some of the applicable Standards is as given below:

(i)	Power Transformer	IS:2026/BS:171/IEC:60076
(ii)	Fittings and Accessories	IS:3639
(iii)	Auxiliary Transformer	IS:1180
(iv)	Loading of oil immersed transformer	IS:6600/BS:CP.1010 /IEC:60354
(v)	Oil	IS:335/BS 148/IEC:60296
(vi)	Bushings for > 1000V, AC	IS:2099/BS:223/IEC:60137
(vii)	Bushings for ≤ 1000V, AC	IS: 7421
(viii)	Degree of Protection	IS:13947 (Part 1) / IEC:60947-1
(ix)	Buchholz Relay	IS:3637
(x)	Electrical insulation classified by thermal stability	IS 1271/BS:2757/IEC:60085
(xi)	Climate Proofing	BS:CP1014

(xii)	Code of Practice for selection ,installation and Maintenance of transformers	IS - 10028

6.11.2**DESIGN FEATURES**

Transformers will be located outdoor and shall be sized for continuous operation and also be rated for satisfactory operation at 50^0C design ambient temperature OCTC type.

6.11.3**CONSTRUCTION FEATURES**

(i) The transformer tank shall be made from high grade plate steel, suitably reinforced by means of stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces and other parts attached to the tank shall be welded. Tank shall be braced to withstand full vacuum as specified by CBIP's latest specification. Suitable guides shall be provided in the tank for positioning the core and coil assembly. The core and coil assembly shall not be cover mounted.

(ii) Adequate space shall be provided at the bottom of the tank for collection of sediment.

(iii) The transformer base shall be designed to permit skidding of the complete transformer unit in any direction, when using plates or rails. The under base shall be detachable unless transport facilities permit a fixed base.

(iv) The material used for gaskets shall be rubberized cork.

(v) The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant and oil insoluble paint. Adequately sized manholes shall be provided for easy inspection and maintenance. All joints which may have to be opened from time to time in the course of operation shall be of a design to permit them to be made easily oil tight in reassembly. Steel bolts and nuts exposed to atmosphere, shall be galvanized. The tank cover shall be suitably sloped so that it does not retain rain water.

(vi) Tank shall be designed to permit lifting, by crane or jacks, of the complete transformer assembly filled with oil. Lifting lugs and eyebolts shall be so located that a safe clearance is obtained between sling and transformer bushings, without the use of a spreader.

(vii) The transformer tank, radiators and conservator shall be designed taking into account the loss of thickness due to shot blasting.

(viii) All taps shall be provided on the HV winding.

(ix) Cable boxes shall have sufficient space for segregating the cable cores and to give adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary cable lugs and armour grips.

(x) All auxiliary wiring from current transformers, buchholz relays, winding temperature indicators, etc., shall be marshaled to a separate weatherproof and vermin proof marshalling box with an independent access cover.

(xi) The marshalling box shall be complete with necessary cable glands and cable lugs. The marshalling box and components shall comply with the requirements specified for control cabinets indicated elsewhere in this specification.

(xii) The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth, so as to minimize interference with communication circuits.

(xiii) The noise level when energized at normal voltage and frequency with fans and pumps running shall not exceed 78dB when measured one meter from edge transformer.

6.11.4 ACCESSORIES AND FITTINGS

Each main power transformer shall have the following fittings and accessories including but not limited to:

(i) A conservator of sufficient volume with:

- Separate compartment for OCTC
- Dial type magnetic oil level gauge with potential free contacts for initiating alarm for low oil level
- Weather-proof dehydrating breathers for both compartments with activated alumina or silica gel as the dehydrating breather
- Shut off valves
- Filling hole, cap and drain valve and isolating valve for conservator.
- Explosion vent with diaphragm Equalizing pipe

The conservator shall be designed to maintain an oil seal up to a temperature of 100^0 C.

(ii) Gas and oil actuated double float Buchholz relay with:

- Necessary shut off valves
- Test cock with pipe connections for sampling
- Potential free contacts for initiation of alarm in case of slow gas formation and trip in case of fast oil and gas surges

(iii) Dial type thermometer with:

- Maximum temperature indicator and its resetting device
- Potential free contacts for initiating alarm on high temperature and trip on very high temperature

(iv) Winding temperature indicator with:

- Necessary sensing, compensating and calibrating devices
- Potential free contacts for initiating alarm on high temperature and trip on very high temperature
- WTI transmitter for remote indication on remote tap changing panel

(v) Detachable type of radiators including but not limited to:

- Shut-off valves and blanking plates on transformer tank at each point of connection of inlet and outlet header
- Top and bottom shut-off valves and blanking plate on each radiator
- Lifting lugs
- Top oil filling plug, 19 mm size
- Air release plug at top
- Oil drain plug at bottom, 19 mm size
- Earthing terminals

(vi) Pressure relief device for transformer tank and OCTC

(vii) Weather - proof marshalling box mounted on transformer tank

(viii) Name plate, rating plate and Diagram plate

(ix) Valves and plugs as below:

- Drain valve
- Filter valve
- Oil sampling valves at top and bottom
- Valves between radiators and tank (in case of detachable radiators)
- Air release plug
- Twin outlets (with plug) for applying vacuum with attachments.

(x) Earthing pads of copper or non-corrodible material for transformer tank (2 places) and radiator banks Inspection manholes as required

(xi) Lifting arrangement for:

- Fully assembled transformer
- Core and coil
- Tank

(xii) Hauling eyes on each face of the transformer

(xiii) Bi-directional flanged wheels

(xiv) Anti-earthquake clamping devices

(xv) Jacking pads

6.11.5**WINDINGS**

The windings shall be of electrical grade copper.

Materials used in insulation and assembly shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be affected under operating conditions.

Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.

Leads from winding to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used where practicable.

Windings shall be subjected to shrinking and seasoning processes so that no further shrinkage occurs during service. Adjustable devices shall be provided to take up possible shrinkage in service. High voltage end - windings shall be suitably braced to withstand short circuit stresses.

Coils shall be supported at frequent intervals by means of wedge type insulation spacers permanently secured in place and arranged to ensure proper oil circulation. To ensure permanent tightness of winding assembly, the insulation spacers shall be dried and compressed at high pressure before use.

Windings shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor would, on edge shall have width exceeding six times the thickness.

All threaded connection shall be locked. Leads from the winding to the terminal board and bushings shall be rigidly supported to prevent it from vibration. Guide tubes shall be used where practicable.

Windings and connections shall be of suitable insulating materials built from flat laminations.

Permanent current carrying joints in the windings and lead shall be brazed or soldered. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil.

Terminals of all windings including unloaded stabilizing windings shall be brought out of the tank through bushings for external connection.

6.11.6**CORE**

The magnetic circuit shall be constructed from high grade, cold rolled, non-ageing, grain oriented silicon steel laminations coated with insulation varnish. The steel laminations shall be of “core” type. Each sheet shall have an insulating coating resistant to the action of hot oil. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand appropriate dielectric test.

All steel sections used for supporting the core shall be thoroughly shot or sand blasted after cutting, drilling and welding.

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 connected to the tank. The core clamping structure shall be designed to minimize eddy current loss.

The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The framework and clamping arrangements shall be securely earthed.

The core and coil assembly shall be dried out and impregnated under vacuum.

6.11.7**TANK**

The transformer tank shall be made from high-grade sheet steel, 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 shot 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.

Tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion the following conditions:

(i) Full vacuum of 760 mm of Hg for filling with oil under vacuum

(ii) Internal gas pressure of 0.35 kg/cm² with oil at operating level

Tank shall be provided with a pressure release device, which shall operate at a pressure below the test pressure for the tank and radiators. The device shall be provided with a device visible from ground to indicate operation. An equalizer pipe connecting the pressure relief device to the conservator shall be supplied. The device shall be provided with potential free contacts for alarm and tripping. Alternatively, a separate pressure relay shall be provided for this purpose.

The tank cover shall be bolted type and not welded, sealed type. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

6.11.8**BUSHINGS**

Bushing on 415 V LV side and on 66/33/11 kV side shall be as per IS 3347 Part I,II and IV respectively. Bushing shall also be as per IS 2099.

Bushings shall be of porcelain. Stresses due to expansion and contraction in any part of the bushing shall not lead to deterioration.

6.11.9 RADIATORS

Radiators shall be designed to withstand the vacuum pressure conditions specified for the tank. They shall be so designed as to completely drain oil into the soak pit and to prevent formation of gas pockets when the tank is being filled.

Transformers of rating above 500 kVA shall be equipped with detachable or separately mounted radiator banks. Radiators for the main transformers shall be with bolted and gasket flange connections. Transformers of rating 500 kVA and below shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

When transformers are provided with separately mounted radiators, flexible joints shall be provided on the main oil pipes connecting the transformer tank to the radiator banks, to reduce vibration and facilitate erection and dismantling. The interconnecting pipes shall be provided with drain plug and air release vents.

6.11.10 OIL

Transformer and associated oil filled equipment shall be supplied of oil plus 10 % extra in non-returnable drums. The oil shall conform to IS: 335. No inhibitors shall be used in the oil. The maker of oil shall be subject to Employer’s approval:

6.11.11 MARSHALLING BOX

The marshalling box shall be tank mounted, weather proof, vermin proof, dust proof, sheet steel (2 mm thick), enclosed and with hinged door having padlock. Door and gland plate shall be fitted with neoprene gaskets. Bottom shall be at least 600 mm from grade level. Top surface shall be sloped. The degree of protection shall be IP65.

Contacts / terminals of electrical devices / relays, etc. mounted on the transformer shall be wired to the marshalling box. Interconnecting wires between the marshalling box and the accessories / devices shall be either PVC insulated wires in GI conduits or PVC insulated, armoured cables together with provision of double compression type, brass cable glands at the marshalling box. The above mentioned cables as well as terminating the cables shall be the Contractor's responsibility.

All contacts for alarm, trip and indication circuits shall each be electrically free, designed for the auxiliary DC supply of 110 V and brought out to separate terminals in the marshalling box. Terminals shall be rated for 10 A. Disconnecting / shorting type terminal block shall be used for CT circuits.

In case of main transformers, provision for remote annunciation shall be provided with two changeover contacts for alarm condition and two changeover contacts for trip condition for each of the following conditions including but not limited to:

(i) Buchholz alarm

(ii) Buchholz Trip

(iii) Oil Temperature high

(iv) Oil Temperature very high

(v) Oil level low

(vi) Pressure relief device operated

(vii) Winding temperature high

(viii) Winding temperature very high

(ix) Conservator oil level low

6.11.12 CABLE TERMINATIONS

Cable boxes shall have sufficient space for segregating the cable cores and for adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary glands, lugs and armour grips.

Air filled cable boxes shall be of adequate dimensions and designed in such a manner that they can be opened for inspection without disturbing the gland plate or incoming cable. Disconnecting chamber shall be provided for disconnecting and moving away the main transformer, without removing the cables or the cable box. Provision shall be made for earthing the body of each cable box.

6.11.13 INTERNAL EARTHING

All internal metal parts of the transformer, with the individual clamping plates; shall be earthed. Core clamps and core bolts shall be insulted from the core by Class B insulation unless other insulation is approved by purchaser.

The top and bottom clamping structure shall be connected to the tank by a copper strap.

The magnetic circuit shall be connected to the clamping structure at one point only, through a link placed in an accessible position beneath an inspection an opening on the tank cover.

When the magnetic circuit is sub-divided by oil ducts or insulated barriers above 0.25 mm thick, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between packets.

Coil clamping rings of metal at earth potential, shall be connected to the adjacent core clamping structure on the same side as the main earth connection.

6.11.14 PERFORMANCE REQUIREMENTS

(i) Transformers shall operate without injurious heating at the rated MVA/ KVA at any voltage within ± 10 percent of the rated voltage of that particular tap in accordance with IS:6600.

(ii) Transformers shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.

(iii) Transformer for two or more limits of voltage or frequency or both shall deliver its rated MVA/KVA under all the rated conditions of voltage or frequency or both; provided an increase in voltage is not accompanied by a decrease in frequency.

(iv) Transformers shall operate below the knee of the saturation curve at 110 percent voltage to preclude Ferro resonance and non-linear oscillations.

(v) Transformers shall be capable of operation continuously, in accordance with the applicable standard loading guide at their rated MVA/KVA and at any of the specified voltage ratios. Under these conditions, no limitations by terminal bushings, on-load tap changers or other auxiliary equipment shall apply.

(vi) The neutral terminal of windings with star connection shall be designed for the highest over current that can flow through this winding.

(vii) The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate wave form distortion and any possibility of high frequency disturbances reaching a magnitude as to cause interference with communication circuits.

(viii) The Engineer reserves the right to reject the transformer if the same does not meet the specification requirement subject to tolerances as per IS: 2062. The rejected transformers shall be replaced by transformers complying with the requirements to this specification at the Contractor's cost.

(ix) If the commissioning of the project is likely to be delayed by the rejection of a transformer, as mentioned under (viii) above, the Engineer 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.

(x) Operating Under Overloads - It shall be possible to operate the transformer as per loading guide IS: 6600 up to overloads of 150%. There shall be no limitations imposed by bushings, tap changers, auxiliary equipment, etc. to meet this requirement.

(xi) 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 Central Board of Irrigation and Power (CBIP) manual for transformer ratings less than or equal to 2000 kVA.

6.11.15**TESTS**

All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.

The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works.

(i) Heat run test.

(ii) Oil pressure test.

(iii) Vendor shall submit the short circuit withstand test certificate for the transformer.

(iv) All routine tests including the followings:

- Temperature rise test on one transformer of same capacity
- Measurement of resistance of windings at principal and extreme taps
- Ratio at each tap, polarity and phase relationships
- Measurement of impedance voltage at principal and extreme taps
- Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110 % rated voltage
- Measurement of efficiency and regulation at ½, ¾ and full load
- Measurement of insulation resistance
- Induced over voltage withstand test
- Separate source voltage withstand test
- Magnetic balance test
- Pressure test for the tank

Type test certificates shall be provided for verification. Whenever two nos. or more identical transformers are being offered, type tests on one of them shall be carried out, including heat run test.

All auxiliaries and accessories such as temperature indicators, Buchholz and pressure relays shall be tested as per the applicable standards and test certificates shall be furnished to the Engineer for approval.

6.11.16 LOSSES

The transformers shall be of "Low- loss' design. The No-load Losses and load losses shall be declared by the manufacturer. The same shall be guaranteed without further tolerance increments.

6.11.17 REJECTION

The Engineer may reject the transformer if anyone of the following conditions arises during testing:

(i) Any of the quantities / parameters of transformers subject to tolerances are outside the tolerances given in the applicable standards or such tolerance as guaranteed in the Contractor's bid.

(ii) Winding and / or top oil temperature rise exceeds the specified / guaranteed value.

(iii) Transformer fails to withstand any of the dielectric tests.

(iv) No- load loss exceeds the guaranteed value by 20% or more.

(v) Load loss exceeds the guaranteed value by 20% or more.

(vi) Impedance value exceeds the guaranteed value by $\pm$ 10 % or more.

(vii) Oil or winding temperature rise exceeds the specified value by 5°C.

(viii) Transformer fails on impulse test.

(ix) Transformer fails on power frequency voltage withstand test.

(x) Transformer is proved to have been manufactured not in accordance with the specification.

Additional tests shall be conducted to locate the failure and after rectification, all tests shall be repeated to prove that the rebuilt transformer meets the specification in all respects, all at the Contractor's expense.

The Engineer reserves the right to have the transformer replaced or repaired by the Contractor within reasonable period to Engineer's satisfaction at no extra cost to the Employer. The Contractor shall also bear the costs, including but not limited to, incurred by the Employer in re-inspection / re-testing such as travel and incidental expense, etc. The Contractor shall note that any delay in completion time due to such repair / replacement shall be subject to liquidated damages as specified in the Conditions of Contract.

6.11.18 MISCELLANEOUS

The following items shall also be included in the Contractor's scope for each transformer:

(i) Supply, installation and commissioning of interconnecting cables between transformers mounted accessories, marshalling box, OLTC and remote panel in the electrical room along with associated compression type brass cable glands, lugs, etc.

(ii) Ten percent extra oil, in addition to that required for first filling of complete transformer, in non-returnable drums

(iii) A 10 liters can of paint for touching up the external surface after erection, and

(iv) Terminal clamps / connectors suitable for connecting to specified sizes of conductor / tube / cable.

6.11.19 DESIGN CRITERIA

The transformer size shall be determined from the estimation of the simultaneous maximum demand based on the power rating of all main and auxiliary motors and other loads and their operating / running periods.

Appropriate values of load factor, diversity factor, power factor and efficiency shall be considered for each type of load. Improvement in power factor due to capacitors shall not be considered. Five percent (5%) contingency shall be added to the simultaneous maximum demand thus calculated and the next standard size of transformer as per IEC shall be selected.

Two such transformers shall be provided for 100 % redundancy at each site. The design calculations for transformer sizing shall be subject to the approval of the Engineer.

6.11.20**PAINTING**

The interior of all transformer tanks and other oil filled chambers and internal structural steel work shall be cleaned of all scale and dust and surface shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish. Steel surface exposed to the weather shall be thoroughly cleaned and applied a priming coat of zinc chromate. The second coat shall be of oil and weather resistant nature, preferably of distinct color from the prime finishing coats. The final coat shall be of glossy oil and weather resisting non fading epoxy paint of specified shade.

All exposed bolts, nuts and washers shall be of galvanized steel unless otherwise approved.

Metal parts not accessible for painting shall be made of corrosion-resistant material. Machine finished and bright surfaces shall be coated with a suitable compound and wrapped.

Interior surfaces of mechanism chambers and knocks shall receive three coats of paint after proper cleaning the final coat shall be of a light colored anti-condensation paint.

6.12**415 V SWITCHGEAR PANEL**

6.12.1**CODES AND STANDARDS**

The design, construction, manufacture and performance of equipment shall conform to latest applicable International/BIS standards and comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

Some of the relevant Standards are specified in the table below:

Title	Code No.
Switchgear general requirements	IS: 13947/BS: 5486/IEC: 60947
Factory Built assemblies of SWGR and Control gear for Voltages up to including 1000V AC and 1200V DC	IS: 8626/BS: 5486/IEC: 60439
Air Break Switches	IS: 13947-P3/BSEN: 60947/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: 269-1
Contactors	IS: 13947/BSEN: 60947-4IEC: 60947-1
Starters	IS: 13947/BSEN: 60947-4/IEC: 60292-1 to 4
Control Switches / Push Buttons	IS: 6875/BSEN: 60947/IEC: 60044
Current Transformers	IS: 2705/BS: 7626
Voltage Transformers	IS: 3156/BS: 7625/IEC: 60044, 60186
Indicating Transformers	IS: 1248/BS: 89/IEC:60051
Making and Identification of Conductors and Apparatus terminals	IS: 11353/BS: 159
AC Electricity Meter	IS: 7252,8530/BS: 5685/IEC: 145, 211

Title	Code No.
Selection Installation and Maintenance of Switchgear and Control gear.	IS: 10118
Degree of protection	IS: 13947/IEC: 60947-P1/ IP: 52
Code of practice for phosphating 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
Bus Bar	IS: 613
Relays	IS: 3231/IS: 3842/BSEN: 60947-5-1/ IEC: 60255
Push Buttons	IS: 6875/BSEN : 60947/BSEN : 60037/IEC: 60037

6.12.2**FEATURES OF CONSTRUCTION**

The switchgear shall be metal enclosed, dust proof, modular type suitable for indoor floor mounting and shall have following features:

(i) Height shall not exceed 2300 mm. Height of Switches, pushbuttons shall not exceed 1800 mm and shall not be less than 700 mm.

(ii) Degree of Protection shall be IP54.

(iii) Shall be Single or double front execution and draw out type

(iv) Shall have designation labels both on front and rear sides

(v) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

(vi) The switchgear shall be divided into distinct vertical sections each comprising:

- A completely metal enclosed bus bar compartment running horizontally.
- Individual feeder modules arranged in multi-tier formation. It is essential that the modules are integral multiples of the basis unit size to provide for flexibility in changes, if any, at site.
- Enclosed vertical bus bar serving all modules in the vertical section. For safety isolation of the vertical bus bar, insulating barrier with cut-outs shall be provided to allow the power stab contracts to engage with vertical bus bar.
- A vertical cable alley covering the entire height. The cable alley shall be minimum 300 mm wide for motor control modules and 500 mm wide for circuit breaker controlled modules.
- A horizontal separate enclosure for all auxiliary power and control buses, ad required, shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap- off connections from these buses shall be arranged separately for each vertical section.

(vii) The switchgear shall be easily extendable on both sides by the addition of vertical sections after removing the end covers.

(viii) Operating device shall be incorporated only in the front of switchgear.

(ix) Each shipping section shall have metal sheets at both ends.

(x) Cable alley shall be provided with suitable hinged doors.

(xi) Rear of single front switchgear shall be provided with removable panels with captive screws.

(xii) All doors shall be with concealed type hinges and captive screws

(xiii) Each vertical section shall be equipped with 240 V, single phase, 50Hz space heater controlled by thermostat

(xiv) Each switchgear cubicle shall be provided with the interior lighting with a 20 W fluorescent tube with on/off switch.

(xv) A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for connection of hand lamps.

(xvi) Interchangeability

All identical equipment and corresponding parts shall be fully interchangeable without and modifications.

6.12.2.1***Sheet Metal Work***

The switchgear frame shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel.

Frames shall be enclosed by sheet steel of thickness not less than 2.5 mm, smoothly finished, leveled, and free from flaws. Doors and covers shall be made of sheet steel of thickness not less than 2 mm. Stiffeners shall be provided wherever necessary.
All panel edges and door edges shall be reinforcement against distortion by rolling, bending or by the addition of welded reinforcement members.
Cuts-outs shall be true in shape and void of shape edges.
The complete structure shall be rigid, self- supporting, free from vibration, twists and bends.

6.12.3 **MAIN AND AUXILIARY BUSES**

6.12.3.1***Main Buses and Taps***

Switchgear shall be provided with three phase or three phase and neutral bus bar.

Bus bar shall be of uniform cross section throughout the length of the switchgear, and up to the incoming terminals of feeder circuit breaker / switch.

The bus bar shall be made of high conductivity copper.

Bus bar shall be provided with at least the minimum clearance in air as per applicable standards for a 500 V, 3 phase system.

All bus bar, bus-taps shall be insulated with close fittings sleeve of hard, smooth, dust and dirt free plastic insulation of high dielectric strength (450 V/ mil) to provide a permanent high dielectric non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing and in fast colors to indicate phases. The joints shall be insulated in such way as to provide for accessibility of contract bolts for maintenance. The dielectric strength and properties shall hold good for the temperature range of 0 deg. C to 90 deg. C. If the insulating sleeve is not colored bus-bars shall be colors – coded with colored bands at suitable intervals.

Bus bar shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents for the associated switchgear. Busbar supports shall be made of glass reinforced moulded plastic materials or DMC/SMC.

Separate supports shall be provided for each phase of the bus bar. If a common supports is provided for all three phases, anti-tracking barriers shall be incorporated.

Bus bar joints shall be complete with high tensile steel bolts and Belleville washers and nuts.

Bus bar shall be thoroughly cleaned at the joint locations and suitable contract grease shall be applied just before making a joint.

6.12.3.2 ***Auxiliary Buses***

Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specified requirements. The materials of control power supply buses shall be electrolytic copper. The material for space power supply shall be same as that for the main power buses.

6.12.4 **PAINTING**

All sheet steel work shall be phosphate in accordance with the following procedure and in accordance with applicable standards.

Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing and running water, rinsing with slightly alkaline hot water and drying.

After Phosphate, thorough, rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed by the application of two coats of primer suitable for finishing by power coating.

After application of the primer, the fabricated sheet steel work shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the Engineer.

Each coat of primer, the fabricated sheet steel work shall be subject to epoxy based powder coating. Shade of powder coating is subject to approval by the Engineer.

The final finishing thickness of paint film on steel shall not be less than 100 microns, and shall not be more than 150 microns.

Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

6.12.5 **MOTOR PROTECTION CIRCUIT BREAKERS (MPCBS)**

MPCBs shall be 3 phase devices suitable for direct connection to system having fault level of 50 kA rms. MPCBs shall be complete within built bi-metal overload protection, short circuit protection and protection against single phasing.

Bi-metal overload protection shall have range suitable for motor FLC. These shall be class 10 (normal duty) for normal applications such as pumps, agitators etc. and class 20 (heavy duty) for long time starting equipment such as centrifugal blowers.

The protections shall provide at least one potential free output alarm contact for use in control circuitry alarm and signal to SCADA system.

6.12.6 **SWITCHES AND FUSES**

(i) 415 V air-break switch shall be of the load break, fault make, group operated type. 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 and d-c systems, the switches shall be of the two pole type.

(ii) Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contact 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.

(iii) 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.

(iv) 415 V switches and fuses shall be provided with the following interlocks so that :

(v) The fuses are not accessible unless the switch is in fully open condition

(vi) It is not possible to close the switch when the fuse cover is open, but an authorised 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.

(vii) 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.

(viii) Earthing and neutral lines in main supply circuits shall be of solid silver plated copper and be of the bolted pattern.

(ix) Fuses and links functionally associated with the same circuit shall be mounted side by side.

6.12.7 **MINIATURE CIRCUIT BREAKER (MCB)**

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.

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.

6.12.8 **CONTACTORS**

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.

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 contactor shall be provided with single phasing preventer (SPP).

Motor starters shall be complete with auxiliary relays, timers and necessary indications.

6.12.9 **SPACE HEATERS**

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 thermostat to cut off the heaters at 350 C.

6.12.10 SAFETY ARRANGEMENTS

All 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 labelled to facilitate testing.

6.12.11 INSTRUMENTS AND METERS

Electrical indicating instruments shall be 110 mm square with 240º scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers. Instrument dials shall be white with black numbers and lettering .Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current. Watt hour meters shall be of the induction type and shall be provided with reverse running stops. Instruments shall have an accuracy of Class 1.0. These shall be digital type.

6.12.12 PUSHBUTTONS AND INDICATOR LIGHTS

Push buttons, selector switches and indicating light shall be heavy duty type.

Push buttons shall have a momentary contact. Selector switches shall be rotary operated type with totally enclosed silver plated contacts. Indicating Light shall be cluster LED type.

6.12.13 CABLE CONNECTIONS

Adequate space shall be provided with in the unit to allow for the termination of all cables. The manufacturer shall state the maximum conductor size that can be accommodated at the termination points of each external circuit.

The terminal blocks provide shall be located so as to provide ease of access. Terminal blocks provided shall be grouped by cable designation and shall be segregated according to circuit voltage and field destination. This requirement shall prevail even where contract drawings show different.

If specified on the soft starter specification sheet, the unit shall be provided with metal cable glands and generously dimensioned glands plate(s). Sufficient distance shall be allowed between this plate(s) and the termination points, to avoid sharp bends of the cables.

6.12.14 WIRING

Wiring shall be installed in wire ways or shall be neatly grouped in packs by using non- metallic wiring cleats. Wiring groups shall be supported. Wire ways shall not be filled to more than 40% of their cross sectional area. Interconnecting wiring between equipment located in front and rear of panels shall be noted inside the enclosure.

6.12.15 MAIN CIRCUITS WIRING:

All wiring shall be clearly grouped and be adequately protected. The internal wiring shall be carried out with 650/1100V grade, PVC insulated, stranded conductor wires and able to withstand a flash test at 2.5 kV for 1 minute (excluding electronic components). Each conductor shall be sized to suit the current rating of the protective device and the minimum size of conductor for power circuits shall be 4 Sq.mm copper or equivalent size aluminum conductor. Main supply should be kept as far as possible from the motor cable.

6.12.16 CONTROL CIRCUIT WIRING:

All control circuit wiring shall be nearly loomed or enclosed in panel wiring trunking and shall be of the insulated stranded copper conductor and be able to withstand a flash test at 2.5 kV for 1 minute (excluding electronic components). All wires should be shielded and should be at least 1.5 mm^2

All wires shall be connected to terminal individually and clearly identified at both ends in accordance with the wiring diagram (s). Wires shall be formed of continuous lengths between termination points.

Connection shall be the non-loosening type.

Terminals in current measuring circuits shall be of special purpose with suitable bridging links and measuring facilities.

6.12.17 PANEL EARTHING

Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

Earth bus bars shall be of copper 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.

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.

All the metals parts of the complete unit, which are not intended as electrical conductors, shall be effectively and permanently bonded. Sufficient means shall be provided for connecting the complete unit permanently to the earthing system.

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.

Motor and mains cables should be shielded and the shielding should be fixed and grounded as close to the soft starter as possible. The motor shielding should be connected to ground at both ends.

The controller should be mounted on unpainted flat sheet steel, with anti-corrosion treated contactor. Painted steel can be used on condition that good electrical contact is ensured between the mating and mounting surfaces.

Panel mounted units shall contain an earth bar, to which internal earthing conductors shall be terminated.

6.12.18 RATINGS PLATES AND LABELS

The panel shall have a rating plate permanently fixed to the front of the equipment giving the following minimum information.

(i) Rated voltage and frequency

(ii) Rated output capacity

(iii) Standard to which equipment conforms

(iv) Month and year of manufacture

(v) Manufacturers name and address

(vi) Degree of ingress protection

6.13415 V SWITCH BOARD ACCESSORIES

6.13.1THERMAL OVERLOAD RELAYS

All the over load relays used for the protection of three phase induction / synchronous motors shall be complete with a three elements, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with rating of the motor.

Thermal overload relays shall be hand reset type.

'Stop' push button of the starter and hand reset device shall be separate from each other.

Overload relay hand reset push button shall be brought out on the front of the compartment door.

Overload relay shall be provided with least one 'NO' and one 'NC' or one change –over contract.

6.13.2SINGLE PHASING PREVENTERS

The relay shall be suitable for application to protect reversible and non-reversible motors. The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and rpm of the motor. The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited. The single phasing preventers should be current sensing type.

6.13.3MOULDED CASE CIRCUIT BREAKERS

Moulded case circuit breaker (MCCBs) or air circuit breaker (ACB) shall be provided for use in lieu of switch fuse for the motor controls for higher kW rating where MPCBs are not available. MCCB shall be provided if rating/ load requirement does not exceed 400 Amps, otherwise A.C.B. shall be provided.

The MCCBs shall conform to BSEN: 60947-2 and the latest application standards.

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 in AC circuits shall be of triple pole construction arranged for simultaneous three poles manual closing and opening and for automatic instantaneous tripping on short circuit. The ON, OFF and TRIP positions of the MCCBs shall be clearly indicated and visible to the operator when mounted as in service. Front of board operating handle shall be provided.

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 (I_{CS}) equal to the ultimate short-circuit capacity (I_{CU}).

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 temperature compensated.

The MCCBs shall be provided with the following features:

- Common trip bar for simultaneous tripping of all poles
- 2 NO + 2 NC auxiliary contacts

MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locker rotor currents of values associated with protective relays setting of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20milliseconds.

MCCBs terminal shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

6.13.4 **AIR CIRCUIT BREAKER**

Air Circuit Breaker (ACB) shall conform to IS/IEC-60947; BS EN 60947.

ACB shall be triple pole, electrically operated, draw-out type suitable for operation 415 V, 50 C//S A.C. supply. It shall be fully interlocked horizontal withdraw-out type version with hinged door. It shall be provided of positively earth frame, automatic safety shutters with pad locking facility, ON/OFF indication, silver faced moving contacts and arcing contact.

All contacts subjected to arching should tipped with arc resistance materials, inter phase barriers should be incorporated.

Isolating contact of silver plated, multi-finger, spring loaded type should be provided.

Micro based release, which shall be self-powered and true RMS sensing type with comprehensive protection, shall be provided to offer protection against overload and short circuit and ground fault. It shall be consisting of multi-state LED to indicate power ON condition, test mode and with individual fault annunciation through LEDs

The breaker should be inter-locked to prevent access to live parts unless the circuit is dead.

The breaker should not be disconnected from the isolating contacts or re-engaged with the contact unless breaker is in the open position.

The breaker must be tripped before the door can be opened to gain access to the racking door is open until 'ISOLATED' position is reached.

Main contacts should be shrouded automatically by a safety shutter preventing in advertent contact with isolating contact in with-draw position.

6.13.5 **CURRENT TRANSFORMERS**

Current transformer shall be of the dry type resin cast. Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second.

Unless otherwise specified, the minimum performance requirements of current transformers are as follows:

Measuring CTs- 10VA, accuracy class 1.0 and an instrument safety factor of less than 5.

Protective CTs- 15VA, accuracy class 5p and an accuracy limit factor of 10.

Test links shall be provided in both secondary leads of the CTs to easily carry out current measurement tests.

All current transformers shall be earthed through a separate earth link on the terminal block to permit easy measurement of the current transformer insulation resistance.
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 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.

6.13.6 **VOLTAGE TRANSFORMERS**

Voltage transformers shall be of dry type cast resin.

Unless otherwise specified, the minimum performance requirements of voltage transformers are as follow:

(i) Measuring VTs - 25 VA per phase and accuracy class 1.0

(ii) Protective VTs - 25 VA per phase and accuracy class 3.0

All secondary windings of voltage transformers including open delta windings shall be rated for 110 V per phase.

Voltage transformers shall have a continuous over- voltage factor of 1.2 and short time over-voltage factor as follow:

(i) 1.5 for 30 seconds in case effectively earthed system.

(ii) 1.9 for 8 hours in case of non-effectively earthed system.

Voltage transformers shall be complete with suitable rated primary, secondary and tertiary fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. HRC Fuses shall be provided on each sub circuit. It shall be possible to replace Voltage transformers without having to de-energize the main bus bar. The terminals of VT secondary and tertiary windings which are required to be connected to earth shall be earthed by an isolating link without a fuse.

It shall be possible to replace voltage transformer fuses easily without having to de-energise the main bus-bars.

6.13.7**RELAYS**

The following clauses shall apply to the protective relays. Relays shall be:

(i) Numerical type with communication facility.

(ii) Enclosed in dust proof flush mounting draw out type cases.

(iii) Accessible for setting and resetting from the front.

(iv) Provided with positive acting hand-reset flat indicators visible from the front.

Access to setting devices shall be possible only after the front covers are removed. Access to resetting devices shall be external to the case. Auxiliary relays shall be rated to operate satisfactorily between 70% and 110% rated voltage. Each relay shall be provided with at least two separate voltage free contracts.

6.13.8**INDICATING INSTRUMENTS AND METERS**

Electrical indicating instruments shall be of minimum 96 mm square size, suitable for flush mounting. All instruments shall be generally of the same pattern and appearance throughout which perform similar duties shall be of uniform type and manufacture. Indicating Instruments shall be digital type preferably and shall have class 1.0accuracy. Watt hour meters shall be electronic type with LED display.

6.13.9**INDICATING LAMPS**

Indicating lamps shall be:

(i) Cluster LED type

(ii) Provided with series as required

(iii) Provided with translucent lamp covers of colors “red ‘green’ and ‘Amber’ as required in the control wiring diagrams. Cover shall comply with BSEN 60037.

(iv) Bulbs and lenses shall be easily replaceable from the front.

6.13.10 CONTROL AND SELECTOR SWITCHES

Control and selector switches shall be:

(i) Of the rotary type.

(ii) Adequately rated for the purpose intended (minimum acceptable rating is 10) A continuous at 240 V AC and 1 A (inductive break) 220 V DC.

(iii) Provided with escutcheon plates clearly marked to show the positions.

Control Switches shall be:

(i) Of the spring return to normal type.

(ii) Provided with pistol grip type handles.

Selector switches shall be:

(i) Of the maintained contract stay put type. Switches in ammeter circuits shall have mark-before- break type contact.

(ii) Provided with oval handle.

6.13.11 PUSH BUTTONS

Push buttons shall be:

(i) Of the momentary contact, push to actuate type rated to carry 10 A at 240 V AC a 1A (inductive breaking) at 220 V DC.

(ii) Fitted with self-reset, 2 NO and 2 NC contacts.

(iii) Provided with integral escutcheon plates marked with its function.

(iv) ‘Start’, ‘Open’, ‘Close’ push buttons shall be green in color.

(v) ‘Stop’ push button shall be red in color.

(vi) All other push button shall be black in color.

(vii) ‘Emergency stop’ push button shall be of the lockable in the pushed position type and rotate release and shall be shrouded to prevent accidental operation.

6.13.12 CONTROL TRANSFORMER

Each bus selection in the MCC shall be provided with a control transformer 415/110v, single phase, and dry type and of adequate VA rating to cater to loads of control circuitry of the feeder connected to that bus. The transformers shall be adequately protected on the primary side by an MCCB and on the secondary side an MCB.

The secondary of the control transformers shall be taken to a control bus to be run throughout the length of the MCC.

6.13.13 WINDOW TYPE ALARM ANNUNCIATORS

The alarm annunciation scheme wherever specified in control wiring drawings shall incorporate the following features:

(i) Visual indication of the fault by means of steadily lit alarm windows.

(ii) Audible alarm on the occurrence of the fault.

(iii) Red facia units to differentiate trip alarm from non-trip alarms.

(iv) Acknowledgement of occurrence of fault, incorporating audible alarm cancellation features.

(v) Resetting the scheme after the faults has been cleared.

(vi) Facility to test the healthy condition of the lamps automatically excluding units indicating existing faults.

(vii) Prevention of mal-operation of the scheme when the push buttons are pressed incorrectly or in a wrong sequence.

(viii) Initiation of the complete sequence of audiovisual alarms in the event of a new fault occurring at the time of accepting an existing fault.

(ix) Suitable for operation on DC supply with a voltage variation between 80% and 110% of the rated voltage.

(x) Suitable for operation for fleeting (15milli sec. duration) as well as the persistent faults.

(xi) Facility for a separate audio visual alarm to indicate: “Alarm supply failure”.

(xii) Facility for duplicating the audio-visual alarm at a second location.

(xiii) Window alarm enunciators shall incorporate the following construction features:

- Flush mounted fascia units, each of which is provided with two lamps and a series resistor and a ground glass plate in front of the inscription.
- Plug in relays mounted behind the fascia units.

(xiv) The alarm annunciation scheme shall comprise the following equipment’s:

- A fascia complete with relays for each fault.
- A common alarm bell.
- ‘Accept’ ‘reset’ and ‘lamp test’ push Buttons.
- Alarms supply failure, ‘Accept’ and ‘reset’ push buttons.

6.14**MOTOR STARTERS**

The selection of starters shall be made according to the rating of the motor used with the equipment the selection shall be done as follows:

(i)	Up to 5 kW	:	Direct On Line Starter
(ii)	Above 5 kW & up to 100 kW	:	Star-delta Starters (Automatic type)
(iii)	Above 100 kW	:	Soft Starters

All starter feeders shall have individual ammeter with selector switch.

At least 15% spare starter modules of each type and kW rating subject to a minimum of 1 No. shall be provided on each bus section of the MCC.

6.14.1 **DIRECT ON-LINE STARTERS (DOL):**

Direct on-line starters module shall be suitable for Class AC 3 utilization category suitable for type-2 coordination, as specified in applicable standards. Each DOL starter feeder shall be complete with the following:

(i) Motor Protection Circuit breaker (MPCB) with built in Overload relay and Single phasing preventer

(ii) Contactors

(iii) ON-OF-TRIP indication lamps,

(iv) Start-Stop-Reset push button

(v) Local/Remote set switch

(vi) Auto/Off/Manual set switch as per requirement

6.14.2 STAR-DELTA STARTERS:

Automatic Star-Delta starter module shall comprise of three sets of contactors one for the line, one for the star point and one for the delta, and a timer relay to automatically change the connections from star to delta.

Star-Delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized, timer contract de-energizing the star contactor, and delta contactor closing.

Start-delta starter shall be suitable for Class AC 3 utilization category suitable for type-2 coordination as specified in applicable standards.

Each starter feeder shall be complete with following:

(i) MPCB/MCCB as appropriate with built in Overload relay and Single phasing preventer
(ii) 3 nos. Contactors
(iii) ON-OF-TRIP indication lamps,
(iv) Start-Stop-Reset push button
(v) Local/Remote set switch
(vi) Auto/Off/Manual set switch as per requirement
(vii) Electronics Timer with Relay

6.14.3 SOFT STARTER:

Soft starter panel module shall be indoor type; metal clad with separate metal enclosed compartments for:

(i) Control, metering and current transformers for differential protection.
(ii) Shorting (by pass) arrangement
(iii) Power cable termination
(iv) Push button with indicating lamps

The enclosure of the soft starter shall have a rigid construction with adequate supports. All the construction details shall be as specified for LT switchgear and panel.

The soft starter including all its components, protection and indication devices shall be mounted in one support or frame. The materials of construction shall be properly prepared and treated against corrosion.

The soft starter module shall be suitable for floor mounting and free standing type, or mounting inside a panel.

The degree of protection shall be as specified on the soft starter specification sheets and reference should be made to IEC529 for degrees of protection standards.

The controller must have a minimum of 100 mm free space above and below the unit and 50 mm to the left and right of the unit to permit good air flow for cooling purposes. When forced cooling is provided it shall cause extra pollution on the controllers electronic card.

Starter shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 3.0 times the full load current of the motor.

The cable compartment shall house all power cable connections along with associated cable terminations.

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.

Caution name plate with inscription “Caution - Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, e.g. incoming terminals of main disconnecting switch.

Starting of motor shall be either from soft starter panel located near to motor or shall be from motor module or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

6.14.3.1 ***Electrical Supply***

The soft starter shall be suitable to operate on the mains supply system as specified in the general requirement specification for electrical equipment.

6.14.3.2***Performance***

(i) Maximum current rating: The soft starter shall have a nominal current of 1.3 times the full current of the controlled motor for standard duty applications. (Standard duty applications are those which do not exceed 230 seconds at 3 times the motor nominal current per hour including starting, stopping or braking.)

- For severe duty applications the soft starter shall be derated to suit the requirements of the application. The manufacture is to state the maximum nominal current ratings of the soft starter.
- In the case of the ambient temperature exceeding 40^{o} C around the soft starter, the soft starter should be derated by 1.2 % for each degree C over 40^{o} C up to 60^{o} C maximum.

(ii) Current Limit Range: The manufacture shall specify the current range of his proposed soft starter

(iii) Operating characteristics: The soft starter shall comply to the following operating characteristics:

(iv) Allow the output limit current to be adjusted from 150 to 700% of the normal current rating of the soft starter.

(v) Allow adjustable acceleration times up to 60 seconds

(vi) Digital outputs for switching reversing contracts on the motor

(vii) Integrated thermal overload protection

6.14.3.3***Assemblies***

When mounted in an enclosure, the soft starter shall be provided with a suitably rated incoming AC Magnetic Circuit Breaker, suitable for isolation. A thermal magnetic Circuit breaker should be in the case where the soft starter is completely by passed using a bypass contactor.

An AC contactor should be located on the incoming side of the soft starter. This contactor should be of an AC3 type contactor for use on motor circuits.

An external operator handle is to be attached to the isolator. The drive display module is to be located remotely from the controller on the door of the panel.

A bypass contactor, should be supplied and connected so that the AC soft starter energies this contactor at the required time in the start cycle. If possible, thermal protection should still be connected through the soft starter, if this is possible, a thermal magnetic circuit breaker should be used, as discussed above.

6.14.3.4***Soft Starter Protection***

The protection should be provided as specified on the Soft starter Specification Sheet. The manufacture should supply details of all protection devices on the proposed equipment.

Fuses should be supplied for type 2 co-ordination. These should be of the fast acting type for protection of the thyristors.

6.14.3.5***Motor Thermal Protection***

Thermal overload protection should be integrated in the soft starter and should be accurate to a maximum ambient temperature of 45°C. This thermal protection should be adjustable according to thermal class of the application.

6.14.3.6***Start Time Too Long***

The soft starter should supply protection start times exceeding the programmed start time in the case of overloads at starting.

6.14.3.7***Temperature Exceeding 45°C***

If the temperature exceeds 45^{0}C around the motor, the provision for external protection via thermostat probes integrated into the motor and feed back into the soft starter, is to be made available as an input to the soft starter.

6.14.3.8***Indications and Alarms***

A fault history for the soft starter protection functions shall be provided for fault indication and fault tracing. Fault indication shall be displayed in plane test on an alphanumeric display required fault indication shall be in accordance with soft starter Specification Sheet.

6.14.3.9***Operation Controls:***

The soft starter should be provided with local and remote control functions.

6.14.3.10***Local Control:***

A control panel shall be mounted on the front of the enclosure provided with operation functions in accordance with the soft starter Specification Sheet.

6.14.3.11***Remote Control:***

Provisions shall be included in order for the soft starter to be controlled remotely in accordance with the soft starter specification sheet. Necessary terminals for the input and output functions shall be provided.

When the control function is changed from local to remote or the reverse the adjustments of the soft starter shall be maintained.

The following functions shall be provided:

(i) Offloading and downloading of present parameters to the PC.

(ii) Locking and unlocking parameter settings to prevent unauthorized access.

6.15**POWER CAPACITORS**

6.15.1**CODES AND STANDARDS:**

Title	Code No.

Title	Code No.
Shunt capacitors for power systems	IS: 2834 / BS: 1650
Internal fuses and internal overpressure Disconnectors for shunt capacitors	IS: 12672
Metal enclosed switchgear	IS: 3427 / BSEN: 60298 / IEC: 60298
Specification for copper rods and bars for electrical purposes	IS: 613
Code of practice for phosphating iron and steel	IS: 6005 / BS: 3189
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS: 2021
Current transformers	IS:2705/BS:7626
Arrangement for switchgear bus bar, main connections and auxiliary wiring	IS:5578/IS:11353
Degree of protection	IS:13947 – Part (I)/IEC:60947-1
Load break switches	IS:9920, IEC:129, 265, 298
Series reactor	IS:5553
Porcelain post insulators	IS:2544

6.15.2**DESIGN FEATURES**

The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation accessories and shall be metal enclosed, indoor floor mounting and free standing type.

Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

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

The capacitors bank may comprise of suitable number of single phase units in series rack shall be such that failure of one or more units shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units.

The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers shall be provided in the cubicle to ensure proper ventilation. Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.

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 IS: 2834.

Bushings may be either of glass or porcelain and shall be joined to the case by solder-welded or other method which ensures an adequate and permanent seal

Each unit active parts shall be non-inflammable dielectric immersed in suitable impregnant, self-cooled, and hermetically sealed. The impregnant shall be non-PCB (Poly chlorinated Biphenyl) oil.

Each unit shall satisfactorily be operated at 135% of rated kVAr including factors of over voltage harmonic current and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above the rated voltage, excluding transients.

Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

A weather-proof and corrosion-proof name plate shall be provided on each capacitor unit. The nameplate shall contain the information set out in IS: 2834.

6.15.3 SERIES REACTORS

The capacitor banks shall be provided with series reactors. The reactor design shall be such that they will not be over loaded due to harmonics in the supply system. The reactor shall be:

(i) Indoor type

(ii) Completely sealed unit

(iii) Either dry type or non-inflammable dielectric immersed in case of indoor units

(iv) Designed to have a linear V-I-characteristic up to 150% of rated capacitor current

(v) Designed to have temperature rise within limits as specified in IS: 2026

6.15.4 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 disconnected only the faulty unit shall leave the rest of the units undisturbed. A blown fuse shall give visual indication so that it may be detected during periodic inspection. The fuse blowing time shall coordinate with the pressure built up within the unit to avoid explosion.

6.15.5 TEMPERATURE RISE:

The temperature rise above the specified ambient of any part of the capacitor and associated equipment shall not exceed the maximum permissible temperature limit as specified in IS: 2834 or its latest amendment.

6.15.6 TEST AND TEST REPORTS

All tests shall be conducted in accordance with the latest edition of IS: 2834 and in addition to any other tests specified elsewhere in these specifications.

6.15.7 RATING PLATE:

The following information shall be given on the rating plate of each capacitor unit:

(i) Reference to IS

(ii) Manufacturer's name and or trade mark

(iii) Manufacturer's Identification Number

(iv) Rated output in kVAr

(v) Rated Voltage

(vi) Rated Frequency in Hertz

(vii) Upper Limit of temperature category

(viii) No. of phases

(ix) Connection Symbol

(x) Discharge Device

(xi) Type of Dielectric

(xii) Reference to Self Healing design

(xiii) Total Weight

(xiv) Type of Impregnant

6.16 POWER AND CONTROL CABLES

6.16.1 CODES AND STANDARDS:

Title	Code No.
PVC insulated cables (for voltage up to 1100V)	IS: 694
HRPVC and PVC insulated cables heavy duty	IS: 1554
Low frequency cables and wires with PVC insulation and sheath	IEC: 60189-1 and IEC: 60189-2
Submersible Cables	IS:694-1990
Cross linked polyethylene insulated PVC sheathed cables	IS: 7098
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
Method of test for cables	IS: 10810
Specification for drums of electric cables	IS: 10418
Specification of PVC insulated cables for electricity supply	BS: 6346
Specification for PVC insulation and sheath of electric cables	BS: 6746
Mild steel wires, strips and tapes for armouring of cables	IS: 3975
Recommended current ratings for cables PVC insulated and PVC sheathed heavy duty cables	IS: 3961(par-II)
Aluminum conductors for insulated cables	IS: 1753
Methods of testing weight, thickness and uniformity of coating on hot dipped galvanized articles	IS: 2633

6.16.2DESIGN REQUIREMENTS OF CABLES

Cables shall be capable of satisfactory performance when installed on trays, trenches, ducts, and when laid directly in the ground. Cables shall be capable of operating satisfactorily under a power supply system voltage variation of 10%, frequency variation + 5% and a combined variation of + 10%. The size of cables to be used in various electrical equipment's shall be in accordance with the following design criteria. Minimum size shall be 6 sq.mm copper for power cable, 2.5 sq.mm copper cable for small power rating equipment up to 2.2 kW motors and 1.5 sq.mm copper for control.

In assessing the rating of any cable or wire, the following factors shall be taken into account:

(i) Supply voltage and frequency

(ii) Maximum voltage drop permissible

(iii) Type and magnitude of load

(iv) Fault level and duration related to circuit protection relays and fuses

(v) Circuit over current protection

(vi) Route length and disposition of cables

(vii) Ambient temperature

(viii) Method of installation

All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45^0C. The design current of any circuit shall exceed the full load current of the supplies device by at least 10%. For cable sizing the following factors shall be taken into consideration:

(i) Full load current

(ii) Derating factor (overall) under the conditions of laying as 0.6

(iii) Total voltage drop from LT of the transformer to MCC bus as 2% and from MCC to individual load (motor) as 3 %

(iv) For lighting circuits, the voltage drop at the farthest end shall not exceed 5%

(v) Short circuit current and its duration as applicable viz. effective let through energy the cable is required to withstand

Cables shall normally be laid under the following conditions:

(i)	In air	:	Ambient temperature of 47^o C
(ii)	In ground	:	Ground temperature of 35^o C
(iii)	Depth of laying in ground	:	600 mm for LT Cables
(iv)	Thermal resistivity	:	120 deg. Cent cm/watt
(v)	In trays	:	Single layer touching

The cable shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.

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 energization. HV and LV cables shall be sized for a fault clearance time of 0.5 seconds for the incoming feeders and 0.16 seconds for switchboard feeders controlled by circuit breaker.

6.16.3 CABLE CONDUCTORS

Copper conductors shall be used for cables of sizes up to 35 Sq mm. Aluminum conductors shall be used for cables of above 35 Sq mm. Cores of cross-sectional area greater than 1.5 mm^2 shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm^2.

6.16.4 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_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

6.16.5 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.

The Bidder 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, the contractor shall obtain Employer’s approval for the drum lengths.

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 Employer’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.

6.16.6 GENERAL

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

6.16.7 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

6.16.8 CABLE RACKS AND TRAYS

(i) Cable racks/trays shall be fabricated from standard structural steel members

(ii) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanized.

6.16.9 GALVANISING

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

(i) Fabricated Steel

Thickness less than 2 mm, but not less than 1.2 mm	340 gms./sq. m
Thickness less than 5 mm, but not less than 2 mm	460 gms/sq. m
Thickness 5 mm and over	610 gms/sq. m

(ii) Fasteners

Up to nominal size M10	270 gms/sq. m
Over M10	300 gms/sq. m

Galvanising shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.17 HV POWER CABLES GRADE XLPE INSULATED CABLES

6.17.1 DESIGN AND CONSTRUCTION

6.17.2 GENERAL

The design and construction of electrical power and control cables shall be in accordance with the codes and standards as specified.

All electrical power and control cables shall have colored cores as follows:

Cable Type		Power and Control Cables
(i)	Single core	Red or Black
(ii)	Two core	Red and Black
(iii)	Three core	Red, Yellow, Blue
(iv)	Four core	Red, Yellow, Blue, Black
(v)	Five cores	Red, Yellow, Blue, Black , Green white numerical printed on

The black sheath is for the neutral and the other colors are for the phase conductors.

For multi-core cables (i.e. above 4 cores) for control applications, the core numbers shall be printed each cable core for identification (i.e. nos. 1, 2, 3, 4, 5, 6, 7…upward).

All cables shall be suitable for operation under the following conditions:

(i) Directly buried in ground.

(ii) Run in buried PVC, concrete or all steel ducts.

(iii) Runs fastened to cable rack or tray in open air.

The cables shall be capable of continuous operation at highest system voltage as specified with maximum conductor operating temperature of 90^0 C and maximum temperature under fault condition of not more than 250^0 C.

6.17.3**CONDUCTOR:**

The conductors shall be of stranded, high purity copper/ annealed high conductivity copper conductors laid up and rendered smooth and free from defects likely to injure the insulation and conforming to IS: 8130.

6.17.4**INSULATION:**

The conductor screen, XLPE insulation and insulation screen shall be extruded in one operation by 'Triple Extrusion' to ensure prefect bonding between the layers. The core identification shall be with colored strips of red, yellow and blue or by printed numerals to identify the phase conductors.

The thickness of insulation shall be decided based on the permissible electrical stress (less than 3 KV/mm)

6.17.5**INSULATION SCREEN (OVER INDIVIDUAL CORE):**

The insulation screen shall consist of two parts.

Nonmetallic, semi-conducting compound extruded directly over insulation and fully bonded. A layer of semi conducting fabric tape shall be provided over the extruded layer to give bedding to the metallic part of screen.

6.17.6**INNER SHEATH:**

For all cables having two or more cores, inner sheath shall be applied over laid cores either by extrusion or by wrapping. The inner sheath shall be applied as circular as possible and to fit closely on the laid up cores so that it can be removed without damage to the insulation.

The inner sheath shall be of vulcanized rubber/proofed or plastic tap and shall not be harder than PVC used for insulation. This shall conform to requirement of types ST-2 of IS: 5831. The thickness of sheath shall be not less than 0.7 mm

6.17.7**BINDER TAPE:**

Binder tape shall be provided above metallic screen.

6.17.8**WATERPROOFING:**

By means of suitable non-woven waterproofing tape under the metallic screen and plastic laminated tape or aluminum laminated tape above to the binder tape.

6.17.9**ARMOURING:**

Armoring shall be applied over inner sheath, where specified and shall be of galvanized steel strip as per IS 3975. The armor shall be applied as closely as possible with left hand direction of lay. For cables having diameter over the inner sheath less than 13 mm, the armor shall be of galvanized round steel wires or galvanized steel strips. The dimensions and resistance of armor shall be as per IS 1554 part I.

6.17.10**OUTER SHEATH:**

Extrude PVC over the metallic screen/armor shall be provided which shall conform to Type process ST2 compound. To protect the cable against rodent and termite stack, suitable chemicals shall be added into the PVC compound of outer sheath. In addition common covering for the three cores, fillers etc. shall be provided. The dimension of insulation, armor and outer sheathing shall be governed by values given in Table 1, 3 and 4 if IS: 7098 Part II.

6.17.11**SEALING AND COILING**

Both ends of every length of cable shall be sealed properly immediately after tests at manufacturer's premises.

The cables shall be rolled on suitable wooden or steel drums. The drum shall be marked with following:

(i) Make.
(ii) Cross sectional area of the cable with no. of cores.
(iii) Voltage grade and type of cable.
(iv) Lengths of cable, weight of cable drum including cable.
(v) Direction of rotation of drum by arrow marking.
(vi) ISI certification mark.
(vii) For all cut lengths of cables which are to be delivered to the Employer, approved sealing caps of correct size shall be supplied and properly mounted immediately after the respective cable length is cut.

6.17.12**INSPECTION AND TESTING:**

Performance and acceptance tests for electrical power and control cables shall be carried out at manufacturer's works which shall be witnessed by the Employer/Engineer deputed by the Employer shall be accepted. Copies of type test certificates, as per relevant standards, shall be furnished by the Contractor along with the bid.

The required tests on the cables shall include but not limited to the following:

(i) High Voltage Test.
(ii) Conductor Resistance Test.
(iii) Armor Resistance Test.
(iv) Thickness of Insulation.
(v) Test for Flame Retardance.
(vi) Insulation Resistance Test.

6.18**1100 V GRADE XLPE INSULATED POWER CABLES**

Cables shall be insulated with XLPE insulation. The inner sheath over laid up cores shall be XLPE and outer sheath over the armor shall be extruded PVC compound type ST-1. The voltage rating shall be 1100V and conforming to the latest IS. The cables shall be of copper conductor, stranded grade H4 class 2 as per IS 8130.

6.18.1**1100 V GRADE PVC INSULATED CONTROL CABLES**

Cables shall be insulated with PVC. The inner sheath over laid up cores and outer sheath over the armor shall be extruded PVC compound type ST-1. The voltage rating shall be 1100 V and confirming to the latest IS: 1554 Part-I. The cables shall be of annealed copper conductors with a minimum size of 1.5 sq. mm.

6.18.2 TELECOMMUNICATION CABLES:

The cables shall meet the following requirements:

(i)	Conductor	:	Solid, tinned, annealed copper
(ii)	Insulation	:	PVC insulation Type-A as per IS:5831
(iii)	Twisting	:	The insulated conductors shall be twisted together to form twisted pairs or quads, these shall be stranded in concentric layers to form the cable core. The cable thus formed shall be tightly lapped with outer wrapping tapes. The interstices of insulated cable core shall be completely filled with viscose compound
(iv)	Overall screening	:	With 0.075 mm Aluminum tape or 0.013 mm melinex tape, overlap not less than 30%
(v)	Other details	:	A suitable non-magnetic rip cord shall be laid longitudinally under the sheath. The armouring shall be of galvanized steel wires or galvanized single steel strip. The inner PVC sheath shall be of Type-A. The outer PVC sheath shall be of Type ST-1.

6.19 SUBMERSIBLE CABLES

6.19.1 SCOPE

Submersible Cable shall be ISI marked three core flexible flat PVC insulated and PVC Sheathed joint less cable conforming to IS 694:1990 (amended up to date) to be used with the submersible pumping sets inside and outside water for working voltage up to and including 1100 volts. These cables are to be used as cables suitable for outdoor use having bunched plain high conductivity copper conductor conforming to IS: 8130-1984 (amended up to date) and insulated and sheathed with PVC compound conforming to IS; 5831-1984 (amended up to date).

6.19.2 MATERIAL OF CONSTRUCTION

6.19.2.1 *COPPER CONDUCTOR*

The bunched conductor shall be composed of plain annealed high conductivity copper wires complying with Class 5 of Copper Conductor as per IS 8130-1984 (amended up to date). The nominal max. Diameter of wires and corresponding minimum number of wires in a strand and maximum allowable resistance shall be as follows:

Table 22 Copper Conductor Criteria

S. No.	**Size of cable in sq. mm**	**Maximum dia. & corresponding wires in a core**		**Max. resistance of conductors at 20^{o} centigrade (ohms/km.)**
		Maximum dia. in mm	**Minimum No. of wires in core**	
1	1.5	0.26	29	13.30
2	2.5	0.26	47	7.98

3	4.0	0.31	53	4.95
4	6.0	0.31	80	3.30
5	10.0	0.41	76	1.91
6	16.0	0.41	122	1.21
7	25.0	0.41	190	0.78
8	35.0	0.41	266	0.554
9	50.0	0.41	379	0.386

NOTE: The cross sectional area of every core should be same as per prescribed size of cable (when calculated on the basis of diameter of each wire & number of wires in a core).

6.19.2.2***INSULATION & SHEATH***

The insulation shall be of PVC compound conforming to the requirement type `A' of IS 5831:1984 (Specification for PVC insulation and sheath of electric cable) (amended up to date). The sheath shall be of PVC compound conforming to the requirement of type ST-I of IS: 5831-1984 (amended up to date). Cores shall be identified by different coloring of PVC insulation. Color of cores shall be identified by Red, Yellow and Blue and the color of sheath shall be Black only. Three cores shall be laid side by side. Average thickness of insulation shall not be less than the nominal value (ti) mentioned below and the smallest of measured values of thickness of insulation shall not fall below the nominal value ti mentioned below by more than (0.1 mm + 0.1 ti).

The sheath where applicable, shall be applied by extrusion. It shall be applied over the laid up cores. It shall be so applied that it fits closely on the laid up cores and it shall be possible to remove it without damage to the insulation. The thickness of sheath determined by taking the average of a number of measurements, shall not be less than the nominal value (ts) specified below, and smallest of the measured values shall not fall below the nominal value(ts) specified below by more than 0.2mm + 0.2 ts.

S. No.	**Size of cable (mm^2)**	**Nominal thickness of insulation (mm) (t_i)**	**Nominal thickness of sheath t_s (mm)**
1	1.5	0.6	0.9
2	2.5	0.7	1.0
3	4.0	0.8	1.1
4	6.0	0.8	1.1
5	10.0	1.0	1.2
6	16.0	1.0	1.3
7	25.0	1.2	1.5
8	35.0	1.2	1.6
9	50.0	1.4	1.7

6.19.3**TESTING**

6.19.3.1***ACCEPTANCE TESTS***

The following tests shall constitute acceptance tests:

Table 23 Acceptance Test

S. No.	Test	Test method as per
(A)	Annealing Test (for copper)	Part No.1 of IS:10810
(B)	Conductor Resistance Test	Part No.5 of IS:10810
(C)	Test for thickness of insulation and sheath.	Part No. 6 of IS:10810
(D)	Tensile strength and elongation at break of insulation and sheath.	Part No. 7 of IS:10810
(E)	Insulation resistance test	Part No. 43 of IS:10810
(F)	High Voltage Test	Clause 16.3 of IS: 694 The cable shall withstand without breakdown an ac voltage of 3 kV (rms) or a dc voltage of 7.2 kV applied for a period of 5 minutes for each test connection.
(G)	Flammability test	Clause 16.5 of IS: 694 & Part No. 53 of IS: 10810 (The period of burning after removal of flame shall not exceed 60 seconds and the unaffected (uncharged) portion from the lower edge of the top clamp shall be at least 50mm).

6.19.3.2***ROUTINE TESTS***

The following shall constitute routine tests;

a) Conductor resistance test, and

b) High voltage test.

1. TYPE TEST

The following tests shall constitute type tests:

Table 24 Type Test

S. No.	Type Test	For Requirements, Ref	Test Method
a)	Tests on Conductor		
	i) Annealing Test (for copper)	IS 8130: 1984	As per Part 1 of IS: 10810
	ii) Resistance Test	IS 8130: 1984	As per Part 5 of IS: 10810
b)	Test for overall dimensions and thickness of insulation and sheath	10, 13, 14 Table 1 to 5 of IS 8130: 1984	As per Part 6 of IS: 10810
c)	Physical tests for insulation and sheath		
	i) Tensile strength and elongation at break	IS 5831: 1984	As per Part 7 of IS: 10810

S. No.	Type Test	For Requirements, Ref	Test Method
	ii) Loss of mass test	IS 5831: 1984	As per Part No.10 of IS:10810
	iii) Ageing in air oven	IS 5831: 1984	As per Part No.11 of IS:10810
	iv) Shrinkage test	IS 5831: 1984	As per Part No.12 of IS:10810
	v) Heat Shock test	IS 5831: 1984	As per Part No.14 of IS:10810
	vi) Hot deformation	IS 5831: 1984	As per Part No.15 of IS:10810
d)	Insulation resistance	IS 5831: 1984	As per Part No.43 of IS:10810
e)	High voltage test (Water immersion test)	16.2 of IS 694	As per Part No.45 of IS:10810
			i) ac test
			The core(s) shall be carefully removed from a sample approximately 3 M long from the finished cable. They shall be so immersed in a water bath at 60 ± 3 degree C that their ends protrude at least 200mm above the water level. After 24 hours, a voltage of 3 kV (rms) shall be applied between conductors and water. This voltage shall be raised to 6 kV (rms) within 10 seconds and held constant at this value for 5 minutes. If the sample fails in this test, one more sample shall be subjected to this test, which should pass.
			ii) dc test
			The cores which have passed the preliminary test mentioned above shall be subsequently tested with a dc voltage of 1.2 kV in the same water bath at the same temperature. The conductors shall be connected to the negative pole and water to the positive pole of dc supply by means of a copper electrode. The core shall withstand this dc voltage test for 240 hours without breakdown. The voltage shall be applied continuously, but if there are any unavoidable interruptions during the 4 hours period, that period shall be increased by the time of interruptions. The total of such interruptions shall not exceed 1 hour otherwise the test shall be started again.

S. No.	Type Test	For Requirements, Ref	Test Method
f)	Flammability test	16.5 of IS 694	As per Part 53 of IS: 10810
g)	Cold bend test for diameter <= 12.5mm	IS 5831:1984	As per Part No.20 of IS:10810
h)	Cold impact test for diameter more than 12.5mm	IS 5831:1984	As per Part No.21 of IS:10810
i)	Additional ageing test	16.6 of IS 694	**Ageing of Sample** A sample, 6m long of the finished cable shall be suspended in a heating chamber and exposed to a temperature of 80 ± 2 degree C during a period of 168 hours. Immediately after this, the sample shall be placed in a bath of boiling water for a period of 8 hours and in a water bath at 25^{o} C for 16 hours. This procedure shall be repeated on 5 successive days. The ends of the sample shall protrude at least 200mm above the water level. Testing and Evaluation A sample, 5m long, taken from the conditioned sample shall be tested for high voltage test in accordance with clause 16.3 of IS 694:1990. The test has however, to be carried out on the finished cable and in a water bath at 60 ± 3 degree C. The remaining conditioned sample shall be submitted to cold bend and cold impact test as appropriate.

The contractor shall produce above test certificates from the manufacturer with each lot of cables brought to site.

6.The cable shall carry following information and contained in label attached to pump set:

a) Reference to IS 694

b) Manufacturer's Name, Brand Name of trade mark.

c) Type of Cable and Voltage grade.

d) Number of Cores.

e) Nominal core sectional area of conductor.

f) Length of Cable.

g) Cable code (yy)

h) Year of Manufacture.

i) No. of wires in a core

The manufacturer shall identify throughout the length of Cable the Manufacturer's name or trade mark by means of embossing on the cable. The distance between any two consecutive printing or embossing should not be more than one meter. The cable shall also be marked with standard mark.

6.20CABLE TRAYS

6.20.1MOUNTING – GENERAL NOTES

Unless otherwise specially mentioned on the relevant drawings, all cable tray mounting works to be carried out as per notes given here.

Cable tray mounting arrangement type shall be marked on the layout drawing. Assembly of cable tray mounting structure shall be fabricated, supplied, erected and painted by the electrical sub-contractor. Civil sub-contractor will provide plate inserts in floor slabs at 1000mm spacing for cable tray mounting structure.

Cable tray mounting structure shall be welded to the plate inserts or to the structural beams. Wherever embedded plates and structural beams are not available for welding the cable tray mounting structure, the Contractor shall supply the MS plate and fix it to floor slab by anchor fasteners of minimum dia. 16mm having holding power of 5000 kg .

The spacing between cable tray mounting structures shall be 1000mm for horizontal straight runs of cable tray. The minimum loading on a support arm shall be 120kg/M of the cable run.

Width of the horizontal arms of the mounting structures to be same as the tray widths required in cable layout drawings plus length required for welding to the vertical supports (maximum tray width will be 900mm) except where shown otherwise:

(i) Spacing between horizontal support arms of vertical cable tray runs: 300 mm.

(ii) Minimum clearance between the topmost tray tier and structural member: 300 mm.

(iii) Minimum vertical clearance below the bottom of the lowest cable tray tier and any structural member: 300 mm.

The length of the vertical supporting members, for horizontal cable tray runs, will be to suit the number of cable tray tiers required in the cable layout drawings. Cable trays will be welded to tray mounting supports.

All structural steel supplied by the Contractor and exposed surface of embedded steel for cable tray mountings and shall be painted as follows:

(i) **For indoor installatio**n: One coat of red oxide zinc chromate primer and two coats of synthetic enamel paint.

(ii) **For outdoor installations:** Painting with coats epoxy based paint.

Where any cut of holes are made or welding is done on finished steel work these steel work shall be painted by the manner specified above.

6.20.2FABRICATION WORK

MS channels/angles of requisite size shall be used for cable tray supports, push button station mounting frames, panel frames etc. The fabricated work shall be provided with two coats of zinc rich red oxide primer and 2 coats of enameled paint of approved color. The scope of fabrication work includes supply of necessary hardware viz. anchor fasteners, MS base plate etc.

6.20.3CABLE TRAYS – CONSTRUCTION NOTES

Cable trays of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows etc. shall be hot dip galvanized from 12 gauge (2.5 thick) mild steel sheets. Cable trays covers shall be fabricated from 16 gauge (1.70 mm thick) MS sheets.

The cable trays to be supplied in standard lengths of 2500 mm and clear inside width of trays shall be as follows:

(i) Perforated type trays : 150,300,450 and 600 mm

(ii) Ladder type trays : 300,450, 600 and 900 mm

The spacing of rungs for ladder type of trays to be 250 mm unless otherwise noted.

All finished cable trays and accessories etc. shows are typing not cover the entire range of the same. Fabrication of accessories shall be free from sharp edges and corners, burrs and unevenness.
The details of accessories etc. shows are typical and do not cover the entire range of the same fabrication of accessories not covered here shall be done with the help of relevant project drawings.

6.20.4 **CABLE TRAYS – INSTALLATION NOTES**

Unless otherwise specifically mentioned, all cable tray mounting works shall be carried out as per approved drawings. The type and size of tray to be used will be as mentioned in the individual layout drawings.
The maximum size of cable tray when used in trenches shall be of 600 mm width.
Cable trays shall be welded to the mounting/ carrier structures. Vertical trays (raceways) and all outdoor cable trays shall be provided with removable 16 gauge painted MS sheet covers.
Each continuous laid out length of cable tray shall be earthed at minimum two places by MS flats of minimum size 25mmx3mm (unless otherwise noted) to the main earthing grid, the distance between points shall not exceed 10 meters.
The following shall be checked before laying the cables on trays:

(i) Check for proper painting and identification nos. of the tray

(ii) Check for continuity of power and control cable trays over the entire route

(iii) Check that all sharp corners, burrs and waste materials have been removed from the tray

6.20.5 **CABLE – INSTALLATION NOTES**

6.20.5.1 ***General:***

These notes in general cover cables up to and including 66kV rating
Electrical installation work shall comply with all currently applicable statues, regulations and safety modes in the locality /country where the installation is to be carried out.
Installation of cable shall include, unloading , storing , laying , fixing, jointing, termination, supply of glands and lugs and all other work necessary for completing the job.
Cables will be installed in trenches, trays, racks, conduits, and duct banks or directly buried. The actual cable layouts will be shown on the relevant project drawings. Any changes, if necessary, after obtaining prior approval of the Purchaser/Engineer shall be carried out at site by the Contractor and shall be clearly marked by him on project drawings and forwarded for approval of the Employer.
Cable to each circuit shall be laid in continuous length, cable jointing, and splicing shall be done after obtaining site Engineer's permission.

6.20.5.2 ***Outdoor Cable Installation***

Outdoor cables, for interplant cabling, shall be laid in built up RCC trenches, unless approved otherwise by the Engineer. Cable trays of adequate width and multi-tier formation as required for cabling shall be installed in cable trenches. Adequate walkway space of minimum 500 mm width shall be provided inside the cable trenches for the purpose of cable installation and future maintenance / inspection. Adequate slope shall be provided to the cable trench bottom to drain away rain water accumulated inside the trench. Trench top, however, shall be leveled throughout. Precast RCC covers with lifting facility shall be provided to cover the built up trenches.
In specific cases allowed by the Engineer, cables shall be directly buried in ground as follows:

(i) Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150mm. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench shall then be backfilled with the excavated soil and well rammed in successive layer of not more than 300mmm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than50 mm in the center and tapering towards the sides of the trench.

(ii) Cable route markers shall be provided at every 20 meters. At least one marker shall be provided if the length of the buried cable is less than 15 meters. Buried cables in trefoil formation shall be bound by plastic tapes of 1mm dia. Nylon cord every 750 mm.

(iii) Joint markers at each joint location shall identify joints in directly buried cables.

(iv) In each outdoor cable run, some extra cable length shall be kept at a suitable point to enable a straight through joint to be made should the cable develop fault at a later date.

(v) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in RCC Hume pipes of minimum length 1000mm subject to an overlap of minimum 50mm.For road crossing, the pipe for the cable shall be buried at not less than 600mm unless otherwise noted in the drawings.

6.20.5.3***Cables in Trays - on Racks***

Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. HT cables shall be laid in top trays and cables of subsequent voltage grades in lower tiers of trays.
Minimum distance between HT and LT power cable shall be 500mm, between HT power and control cable shall be 500mm and between LT power and control cable shall be 300mm. The sizing of cable tray shall provide a minimum 25% spare capacity. The tray shall be run at least 150mm clear of mechanical services.

6.20.6**TERMINATION CLAMPING AND MISCELLANEOUS DETAILS**

Cable entry to motors, push button stations and other early electrical devices shall be from the bottom as far as possible or from the sides. Top entry shall be avoided particularly for outdoor equipment.
Identifications tags made from aluminum sheet shall be attached to each end of each cable by means of GI binding wire. Tags shall be additionally put at an interval of 30 meters on long runs of cables and in pull boxes.
All cable terminations shall be solder less crimping type. The crimping tools shall be adequate for lug sizes.
Each cable entry into a terminating box shall be made through a suitable gland.

6.21 **TESTING AND COMMISSIONING OF CABLES**

Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the meggers for the cables of different voltage grades shall be as indicated below:

Table 25 Voltage rating of meggers for cables

Voltage grade of cable	Megger Rating
1.1 kV	500v
3.3kv,6.6kV and 11kV	1000v
22kv and 33kv	2.5kv Motorized Megger

6.21.1**TESTING OF CABLE INSTALLATION**

DC test voltages after installation (before commissioning) (REF IS: 1255-83)
DC test voltages for cables is 1.5 times rated voltage.
In each test, the metallic sheath /screen /armor should be connected to earth.
Continuity of all the cores, corrections of all connections as per writing diagrams, correctness of polarity and phasing of power cables and proper earth connection of cable gland, cable boxes, armour and metallic sheath shall be checked.

6.21.2**INSPECTION AND TESTING:**

6.21.2.1***General:***

The cables shall be tested in accordance with the IS: 1554/7098. The tests shall include:

(i) Test for conductor

(ii) Test for thickness of insulation

(iii) Test for laying up

(iv) Test for thickness of laying up

(v) Test for thickness of inner sheath

(vi) Test for armouring

(vii) Test for thickness of outer sheath.

6.21.2.2***Test Equipment's:***

Contractor shall ensure to use calibrated test equipment having valid calibration test certificate from standard laboratories traceable to National Standards.

6.21.2.3***Pre-commissioning tests at site:***

After successful installation of LV cables, the cables shall be tested at site performing following tests: LV cables- Insulation resistance test.

6.22**LIGHTING SYSTEM**

6.22.1**LIGHTING GENERAL**

(i) The Lighting system shall include the following items.

- Lighting fixtures complete with Lamps and accessories
- Lighting system equipment
  - Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system
  - Lighting fixture supports, street lighting poles and flood light towers
  - Main Lighting distribution board, lighting panels.
  - Multi core cables for street, boundary and flood lighting.

(ii) DC Emergency Lighting shall be provided for Control rooms of Switchyards, Switchgear and Control room of Pump houses.

Electrical installation work shall comply with all currently applicable standards, statues, regulations and safety codes in the locality/ country where the installation is to be carried out. Installation of lighting system shall be carried out generally as per the instructions in this document and typical drawings and relevant project layout drawings to be furnished by the Contractor.

The scope of installation shall include storing, unpacking, fixing of all items associated with lighting system, laying and fixing conduits, wiring, termination, testing, commissioning and all other work items necessary for completing the job. The supply of all mounting accessories hardware ,consumables like fixing saddles at the fixture fixing/suspension points, connectors, jointing ferrules, all fixing brackets, screws and studs and earthing wires shall be deemed to be include in the scope of installation work.

Lighting panel, distribution boards, fixtures, fans, receptacles, switches, shall be located as per the Employer approved layout drawings. Any changes if necessary after obtaining prior approval of the Employer, shall be carried out at site by the Contractor and shall clearly marked him on the project drawings and forwarded to for purchaser's approval.

The required conduits for lighting wiring shall be suitably routed at site by the Contractor with due considerations to a neat layout and ease of maintenance.

Unless specifically noted otherwise, lighting panels, light control switches and receptacles shall be installed at the following mounting heights from finished floor / ground levels:

(i) Lighting panels: 1200 mm to bottom of the panel

(ii) Light control switches: 1200 mm

(iii) Receptacles units: 500 mm for indoor and 1000 mm for outdoor.

6.22.2 CODES AND STANDARDS

The design, manufacture and performance of equipment shall conform to the latest standards specified below:

6.22.3 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 reflectors	:	IS: 1777
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
Luminaries for street lighting	:	IS:10322 Part 5
Water tight electric lighting fittings	:	IS:3553/ BS:4533,5225(I)
Bayonet lamp holders	:	IS:1258/BSEN:1184/IEC:60061
Edison screw lamp holders	:	IS:10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS:3323
Starters for fluorescent lamp	:	IS:2215/BSEN 60155
Holders for starters for tubular fluorescent lamps	:	IS:3324/ BSEN 60400
Ballast for use in fluorescent lighting fittings	:	IS: 1534 (Part 1)/BSEN 60920& 60921
Transistorized ballast for fluorescent lamps	:	IS:7027
Ballast for HP mercury vapour lamp	:	IS:6616
Capacitors for use in fluorescent HPMV & LP sodium vapour discharge circuits	:	IS:1569/ BSEN 61048 & 61049 /IEC: 60586
Vitreous enamel reflector for tungsten filament lamp	:	IS:8017
Tubular fluorescent lamps	:	IS:2418 (Part –1) /BSEN 60081 IEC:60081
High pressure mercury vapor lamps	:	IS:9900/BS:3677/ IEC:60188
Tungsten filament general electric lamps	:	IS:418/IEC:60432
Cast acrylic sheets for use in Luminaries	:	IS:7569
Screw less terminal and electrical connections for lighting fittings	:	IS:10322
High pressure sodium vapor lamps		IS:9974
Emergency lighting units		IS:9583
Ignition proof enclosures, dust-tight for Electrical Equipment		IS:11005
Luminaries		IS:10322 (Part I to V)

6.22.4 LIGHTING SYSTEM EQUIPMENT

Arrangement for bus bar, main connections and auxiliary wiring and marking	IS:5578/ 11353/BS:159
Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V	IS:2675/ BSEN 60439
General requirements for switchgear and control gear for voltages not exceeding 1000 V	IS:13947
Code of practice - installation and Maintenance of switchgear	IS:10118/BS:6423, BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages up to and including 1000 V AC and 1200 V DC	IS:8623/BS-5486/ IEC:60439
Miniature air break circuit breakers for AC circuits	IS:8828/ BSEN 60898
HRC cartridge fuse links up to 650 V	IS:9224/BS:88/ IEC:60269
'D' Type fuses	IS:8187
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 electrical wiring	IS:3837/BS-31
Flexible steel conduits for electrical wiring	IS:3480
Rigid non-metallic conduits for 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 steel poles	IS:2713
Specification for copper rods and bars for electrical purposes	IS:613
Code of practice for phosphating iron and steel	IS:6005/ BS:3189
Fittings for rigid steel conduits for electrical wiring	IS:2667

6.22.5 LIGHTING FIXTURES (LUMINARIES)

(i) Luminaries 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.

(ii) The Luminaries shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

(iii) Connections between different components shall be made in such a way that they will not work loose by small vibration.

(iv) For each type of Luminaries the Contractor shall furnish the utilization factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

(v) All Luminaries 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.

(vi) The Luminaries 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.

(vii) Fluorescent type, mercury vapour and sodium vapour type Luminaries shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters, re-wirable fuse and fuse base. These shall be mounted as far as possible in the luminaries housing only. If these cannot be accommodated integral with the Luminaries 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.

(viii) Fluorescent type Luminaries with more than one lamp shall be provided with capacitors connected in lead-lag circuit for correction of stroboscopic effect.

(ix) Each luminaries shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/400 V, 1 core, PVC insulated copper/aluminum conductor wires up to 4 sq.mm in size. In outdoor areas the termination at the luminaries shall be suitable for 1100 V, PVC insulated, copper/aluminum conductor, armored 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.

(x) Mounting facility and conduit knock-outs for the luminaries shall be provided.

(xi) Earthing

- Each luminaries shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
- 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.
- All metal or metal enclosed parts of the luminaries/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

(xii) Painting/Finish

- All surfaces of the Luminaries/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
- When enamel finish is specified, it shall have a minimum thickness of 50 microns for outside surface and 38 microns for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
- The luminaries housing shall be stove-enameled/epoxy stove-enameled-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.
- The finish of the luminaries shall be such that no bright spots are produced either by direct light source or by reflection.
- External control gear box provided for housing accessories shall be painted or galvanized.

- Flame Proof Fittings: These fittings shall be suitable for installation in hazardous areas containing ethane (CH_5), CO, H_2S and CO_2 gases shall be suitable for zone I application.

6.23 INDUSTRIAL LUMINARIES

6.23.1 FLUORESCENT LUMINARIES

(i) The luminaries shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thickness and complete with all control accessories mounted on it. The finish shall be vitreous enameled.

(ii) Luminaries shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.

(iii) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaries shall be in the lower hemisphere.

(iv) The luminous output of the luminaries with reflector shall not be less than 75% irrespective of type of reflector used.

6.23.2 INCANDESCENT/ MERCURY VAPOUR/ SODIUM VAPOUR LUMINARIES

6.23.2.1 *Bulk Head Luminaries*

(i) The luminaries shall be of robust construction, with cast aluminum/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.

(ii) The luminaries shall be suitable for incandescent lamp up to 150 watts, for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

6.23.2.2 *High and Medium Bay Luminaries*

High and medium bay luminaries shall be with cast aluminum housing, anodized aluminum mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.

(i) The luminaries shall be suitable for mercury vapour lamps up to 1000 watts and sodium vapor lamps up to 400 watts. The control gear accessories shall be mounted integral with the luminaries.

(ii) High bay luminaries shall be used when the mounting height is above 8m while medium bay luminaries shall be used when the mounting height is around 6 to 8m.

6.23.3 FLOOD LIGHT LUMINAIRE

6.23.3.1 *General purpose flood light luminaire*

(i) Flood light luminaries shall be of weather proof construction with cast aluminum housing, anodized aluminum mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.

(ii) 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.

(iii) For focusing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.

(iv) The Luminaries shall be suitable for single and dual mercury vapor or sodium vapor lamps up to 400 watts, incandescent lamps up to 1000 watts or halogen lamps up to 1000 watts. When mercury vapor or sodium vapor lamps are specified, the same shall be mounted in a separate sheet metal enclosed/cast aluminum weather proof control gear box.

(v) The luminaries shall be provided with cable gland on the canopy in down ward direction for cable connection.

(vi) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.

(vii) It shall be possible to replace the lamp from the canopy without opening the front glass.

6.24 OUTDOOR LANTERN LUMINARIES

6.24.1 POST TOP LANTERN

(i) Top lantern Luminaries shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

(ii) The luminaries shall have cast aluminum 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.

(iii) The luminaries shall be suitable up to 200 W incandescent lamp, 125 W mercury vapour lamps or 70 W sodium vapor lamp.

6.24.2 SUB-STATION LANTERN

(i) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.

(ii) The luminaries shall have cast aluminum housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodized aluminum 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.

(iii) The Luminaries shall be suitable up to 200 watts incandescent lamp, 125 W mercury vapor lamp or 70 W sodium vapour lamp.

6.24.3 STREET LIGHTING LUMINARIES

6.24.3.1 *Fluorescent Luminaries*

(i) Street lighting fluorescent luminaries shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.

(ii) The luminaries 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.

(iii) The luminaries shall be suitable for 1 x 40 watts or 2 x 40 watts fluorescent tubes and for mounting heights up to 4m.

6.24.3.2 *Mercury vapour and sodium vapour luminaires*

(i) Street light mercury/sodium vapour luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc.

(ii) The luminaries shall be of semi-cut off with cast aluminum housing, acrylic or prismatic cover, polished aluminum reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

(iii) The luminaries shall be suitable up to 400 watts mercury or sodium vapour lamps and for mounting heights from 4 meters to 12 meters.

6.24.3.3 *Portable Emergency Light Luminaries*

(i) Emergency light of Installite luminaries shall be indoor type for providing emergency light during failure of normal AC supply.

(ii) The luminaries shall be with CRCA sheet steel enclosure, complete with metallised 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 luminaries.

(iii) The luminaries shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaries shall pick-up automatically and on restoration of A.C. supply the luminaries shall switch off automatically.

(iv) The luminaries shall be suitable for incandescent lamp up to 40 W or fluorescent lamp up to 20 W.

6.24.4 ACCESSORIES FOR LUMINARIES

6.24.4.1 *Reflectors*

(i) The reflectors shall be made of CRCA sheet steel/aluminum/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaries.

(ii) The thickness of steel/aluminum shall comply with relevant standards. Reflectors made of steel shall have vitreous enameled finish. Aluminum used for reflectors shall be anodized/epoxy stove enameled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.

(iii) 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.

(iv) 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.

6.24.4.2 *Lamp/Starter Holders*

(i) 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.

(ii) Lamp holders for the fluorescent 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.

(iii) Lamp holders for incandescent, mercury vapour and sodium vapour lamps shall be of Edison Screw (E.S.) type.

(iv) 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.

6.24.4.3 *Ballasts*

(i) The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy duty type copper wire wound, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of ±10% of 240 V. End connections and taps shall be brought out to a suitable terminal block rigidly fixed to the ballast enclosure. Ballasts shall be free from hum and such of those which produce hum shall be replaced by Contractor free of cost.

(ii) Ballasts shall be mounted using self-locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non-combustible enclosures.

(iii) Separate ballast for each lamp shall be provided in case of multi lamp luminaires, except in the case of 2 x 20 Watts luminaries.

6.24.4.4***Starters***

(i) Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitors.

6.24.4.5***Capacitors***

(i) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

(ii) The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 0.95 lag or better.

(iii) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnant and ingress of moisture.

6.24.4.6***Lamps***

(i) Lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/electrodes shall not break under such circumstances.

1. Incandescent lamps

(i) General Lighting Service (GLS) lamps shall be tungsten filament incandescent type. The filament shall be coiled coil type rated for 230/250 volts, Single phase A.C.

(ii) Lamps shall be with Edison Screw type metal lamp caps to prevent pilferage.

(iii) Lamps shall be milky white for diffused, soft, glare free lighting and rated up to 100 watts.

2. Fluorescent Lamps

(i) Fluorescent lamps shall be low pressure mercury vapour type with low wattage consumption and high efficiency and longer burning life (about 2500 hours).

(ii) Lamps shall be of white light type suitable for operation on 240 V, single phase A.C. in standard lengths of 2, 4 and 5 feet and ratings up to 65 watts.

(iii) Lamps shall be provided with features to avoid blackening of lamp ends.

3. High Intensity Discharge lamp

These lamps include high pressure mercury vapor lamps and high pressure sodium vapor lamps.

(i) High pressure mercury vapor lamps shall be with quartz discharge tube, internal coated shell, quick restrike time (of within 5 minutes) and with burning life (about 5000 hours) in standard ratings up to 1000 watts.

(ii) High pressure sodium vapor lamps shall be with polycrystalline translucent, coated discharge tube, coated shell, quick restrike time (of within 5 minutes) and with burning life (about 10,000 hours) in standard ratings up to 400 watts

6.25**LIGHTING SYSTEM EQUIPMENT**

6.25.1**MAIN LIGHTING DISTRIBUTION BOARD AND LIGHTING PANELS (AC & DC)**

6.25.1.1***Constructional Features:***

(i) 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.

(ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketted all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units 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.

(iii) 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.

(iv) 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.

(v) 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.

(vi) Two earthing terminals shall be provided to suit the earthing conductor.

(vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognized phosphating 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.

6.25.1.2***Bus bar:***

(i) Bus bar shall be of copper conductor of hard drawn (HD) and high conductivity. Bus bar shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints.

(ii) Bus bar shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.

(iii) Bus bar shall be adequately sized for the continuous current rating such that the maximum temperature of the bus bar, bus bar risers/droppers and contacts does not exceed 85° C under site reference ambient temperature.

(iv) The bus bar, bus bar connections and bus bar 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.

(v) 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 bar. If a common support is provided for all three phases, anti-tracking barriers shall be incorporated.

(vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase bus bar. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase bus bar. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

6.25.1.3***Panels/Boards' Component Equipment***

6.25.1.3.1 Switches/Miniature Circuit Breakers (MCB)

(i) Switches/MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards.

(ii) 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/220 V D.C.

(iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility.

(iv) The connections between switch and fuse shall be insulated and all live connections shall be shrouded.

6.25.1.3.2 Fuses

(i) Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80 kA at 440 V. Fuses up to 63A for distribution systems of medium short circuit levels may be of HRC cartridge screw-cap, D type, having a certified rupturing capacity of not less than 46 kA at 440 V and 16 kA at 250 V D.C.

(ii) Fuses shall be provided with visible indication to show that they have operated.

(iii) Cartridge fuses shall preferably be mounted in moulded plastic carriers. If fuse-carriers are not provided, insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

6.25.1.3.3 Indicating Instruments and Meters

(i) Whenever required, 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.

(ii) Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.

(iii) Watt-hour meters shall be of direct reading electro-dynamometer type complete with cyclometer type dials and reverse running stops.

(iv) Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.

(v) Potential fuses shall be provided at the tap-off point from the bus bar for the voltmeters.

6.25.1.3.4 Instrument Transformers

(i) 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.

(ii) 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.

(iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

6.25.1.3.5 Indicating Lamps

Indicating lamps shall be of the filament type and low watt consumption. Lamps shall be provided with series resistors.

6.26 INTERNAL WIRING

(i) 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 aluminum/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.

(ii) Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

(iii) 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.

(iv) Terminals for circuits with voltage exceeding 125 V shall be shrouded.

(v) Terminals shall be numbered and provided with identification strip for identification of the circuit.

(vi) Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

(vii) Unless otherwise stated, the mode of wiring will be as follows:

- 250/440 V PVC insulated flexible one core wired used for indoor lighting wiring shall be laid in rigid PVC conduits.
- Outdoor lighting cables shall be directly buried in ground at a minimum depth 600 mm or routed in the available cable trenches. Cables crossing road /rail shall be laid in RCC hume pipes.
- Size of wire shall be chosen to limit voltage drop to within 5%. Minimum area of conductor shall be 1.5sqmm copper, unless otherwise stated and density not to exceed 2.5A mm^2.
- Generally not more than 8 to 10 points shall be wired in one circuit.
- For the purpose of calculating connected loads of various circuits a multiplying factor of 1.25 will be assumed to the rated lamp wattage for mercury vapour and fluorescent lamp fixtures to take into account loses in the control gear.
- A loading of 100 watts and 500 watts will be assumed to single phase 5 amps and 15 amps receptacles respectively.

6.26.1LABELS & DIAGRAM PLATE

(i) 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.

(ii) Labels shall be made of non-rusting metal, 3-ply lamicoid or engraved PVC

(iii) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

6.26.2LIGHT CONTROL SWITCHES

(i) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Phase, and 50 Hz supply.

(ii) Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

(iii) The size of enclosure 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 box shall be covered with perspex/insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

6.26.3 RECEPTACLE UNITS

(i) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanized 18 gauge steel enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

(ii) The receptacle units shall be suitable for 240 V, 1 phase - N, 50 Hz/415 V, 3 Phase - N, 50 Hz supply as required.

(iii) Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in “ON” position.

(iv) Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in “ON” position.

(v) The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

6.26.4 LIGHTING WIRES

(i) The wires for wiring in lighting system shall be 250/440 V, 1/C, PVC insulated, unarmoured with stranded copper conductors.

(ii) The minimum area of conductors shall be 1.5 sq.mm for light fittings and 5A Receptacles and 2.5 sq.mm for receptacles rated 15 A and above.

(iii) The wires shall be colour coded white for phase/positive of D.C. and black for neutral/negative of D.C.

6.26.5 CONDUITS

(i) Rigid steel/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.

(ii) Steel conduits shall be seamed by welding and hot dip galvanized. They shall be supplied in standard lengths of 5 m.

(iii) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

(iv) The conduits shall be supported by means of saddles as follows:

- Spacing between saddles not to exceed 1m in addition saddles shall be located on either ends of couples /bonds or similar fittings /accessories. In such cases the saddles shall be located at a distance not exceeding 300mm from the fittings/ accessory.
- Wires belongings to different phases hall not be run in the same conduit. However more than one conduit , consisting of phase and neutral wires, of the same phase can be run in the same conduit, for every phase wire a separate neutral wire shall be run.

6.26.6 JUNCTION BOXES

(i) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc.

(ii) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.

(iii) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, and HRC fuses as required.

(iv) 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.

(v) The boxes shall be painted with one shop coat of Red oxide zinc chromate primer followed by a finishing coat of paint.

6.26.7 LIGHTING POLES AND FLOOD LIGHT POLE MOUNTING

(i) Lighting poles for street lights and flood lights shall be of stepped tubular steel poles construction as per applicable standard. These poles shall be coated with bituminous preservative paint 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 aluminum paint shall be applied.

(ii) Unless otherwise specified, poles, shall be painted with red lead oxide primer and two coats of aluminum paint.

An aluminum ladder of required height 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.

(iii) 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 attached drawings.

6.26.8 CEILING FANS

Unless otherwise specified, all ceiling fans shall be installed not less than 2.75m above the floor level. In rooms having fluorescent lamp lighting fixtures and ceiling fans, the fans shall be installed with their blades at least 100 mm above the lighting fixtures.

Ceiling fans shall be 1200 mm sweep in size complete with electronic regulator. Domestic exhaust fans shall be installed in admin block and laboratory and heavy duty industrial exhaust fans in HT/LT panel rooms and transformer rooms. The fans shall be complete with mounting frame. The fan opening shall be covered by netted louvers to prevent the access of birds

6.26.9 LIGHT FIXTURE EARTHING

Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 12 SWG GI wire (unless otherwise specified) run along the entire length of the conduit between the fixture and the corresponding lighting panel where it will be connected to the station earth. The earth wire of each conduit length shall be efficiently fastened to the conduit at regular intervals of not more than 750 mm.

6.27 OUTDOOR LIGHTING SYSTEM

All outdoor areas will be provided with AC lighting and the same will be available as long as AC supply is healthy.

Outdoor lighting shall be done with swaged steel tubular electric poles of adequate height at every 25 meters to give the required illumination levels.

6.27.1 ILLUMINATION LEVELS

The illumination levels to calculate the no. of lighting fixtures for various areas shall be considered as follows:

Area	Illumination Level (Lux)
Pump house	250 lux

Battery room	150 lux
Machinery service area	150 lux
Office/conference room	400 lux
Switchgear rooms	250 lux
Plant control rooms	400 lux
Chemical/general stores	150 lux
Chemical room	200 lux
Cable basement	100 lux
All other indoor areas	150 lux
Outdoor platforms and walkways	50 lux
Building entrances	100 lux
Outdoor Plant and pumping station areas	20 lux
Switchyard and transformer yard:	
a. General	10 lux
b. On equipment	30 lux
Roads (Secondary)	10 lux

The illumination system shall be so designed that the uniformity factor is of acceptable level and that the glare is within limits. The ratio of maximum to minimum illumination levels shall not exceed 20 in outdoor area.

The following values of ‘light loss factor’ shall be considered for design:

(i) Indoor air-conditioned area : 0.8

(ii) Other indoor areas : 0.7

(iii) Outdoor area : 0.6

The Contractor shall furnish detailed design calculations, uniformity factors, and ratio of maximum to minimum illumination levels, ratio of average to minimum illumination levels, glare values, etc. for approval. Detailed characteristics of various types of fixtures including photometric curves and tables shall also be furnished for review.

6.27.2**OUTDOOR LIGHTING**

6.27.2.1***Street Light Pole:***

Outdoor lighting shall be done with swaged steel tubular electric poles as per relevant IS Specifications and of adequate height to suit road width and an approximate spacing of 25 m. the installation scope includes excavation required for pole, construction of 600 x 600 mm concrete base for pole etc., earthing of pole, junction box and luminaire and laying of 3 x 2.5 AYY cable from junction box to luminaire from inside of the pole.

The street light pole erection shall be complete with:

(i) 1 no: street light pole of adequate height.

(ii) 1 no: 150W HPSV street lighting luminaire.

(iii) 2 no: 50mm dia. GI conduit sleeves for incoming and outgoing cables up to junction box.

(iv) 1.5 M long 20mm dia. Galvanized MS rod earth electrode for earthing of each 5th street lighting pole.

(v) Loop-in-loop-out type weatherproof Junction box with terminal blocks suitable for terminating 4 x 16 mm^2 GI stranded wires.

(vi) The lighting cable shall be laid underground at a depth of minimum 600 mm below ground level with a protection of sand and bricks as per IS specifications.

6.27.2.2***Street Light Luminaries:***

The fitting shall be outdoor weather proof type and shall be integral type and have a reflector of stove enamel type with heavy duty gauge deep drawn aluminum housing finished in white stoved enamel paint inside and grey hammer tone outside fitted with a 3 pin/E-27 porcelain lamp holder suitable for 150W/ 250W HPSV lamp

The protective cover shall be transparent clear acrylic cover, hinged with a suitable neoprene gasket on the lamp reflector housing with toggles to make the luminaries dustproof, weatherproof and insect-proof.

The control gear housing shall be cast aluminum (LM6) alloy hinged with a sheet aluminum cover finished in stoved enameled grey hammer tone outside and zinc chromate inside.

Heavy duty polyester filled copper ballast, power factor improvement condenser, lamp and mains connector block and an earthing terminal shall be assembled on a detachable tray suitable for 1 no 15W/ 250W HPSV lamp.

“U” clamps are to be provided on to the control gear housing with 2 nuts for firm gripping to the supporting pole bracket of maximum angle at which can be installed.

6.27.2.3***Receptacle Units:***

Decorative and industrial type receptacle units of 5/15A, 15A, 30A single pole / three pole (SP/TP) with switches/ MCBs shall be confirming to latest IS 3854 and sockets conforming to IS 1293. The units shall be suitable for mounting on stove enameled sheet steel boxes generally conforming to IS: 5133 Part-I.

5/15A, 5 pin convenient switch socket outlets with indication lamp and fuse mounted on a PVC surface mounting box shall be installed in administration block and laboratory area. Wiring from lighting panel to each socket is covered in point wiring.

15A single phase industrial sockets with 15A SP MCB and 2 earthing terminals shall be installed in rest of the area. 3 x 4 sq. mm. AYWY cable shall be laid on wall from lighting panel to socket along with earth wire.

6.27.2.4***Drawing and Data:***

As part of the proposal, the Contractor shall furnish relevant descriptive and illustrative literature on lighting fixtures, accessories and receptacles that includes:

(i) Dimensional drawings.

(ii) Mounting details, cable entry and weight.

(iii) Assembly details.

(iv) Wiring connections.

(v) Light absorption and utilization factors.

6.28 BATTERY CHARGING AND DC POWER DISTRIBUTION SYSTEM

6.28.1 APPLICABLE STANDARDS

The battery charger and DC 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.

Title	Code. No.
Basic climatic and mechanical durability tests for components for electronic and electrical equipment	IS: 9000
Environmental tests for electronic and electrical equipment	IS: 9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	IS: 5921
Transformer and inductors (power, audio, pulse and switching0 for electronic equipment	IS: 6297
Printed wiring boards	IS: 7405
Environmental requirements for semi-conductor devices and integrated circuits	IS: 6553
Terminals for electronic equipment	IS: 40047
Factory built assemblies of switchgear and control gear for voltage up to and including 1000 V AC and 1200 v DC	IS: 8623/BS: 5486/IEC: 60439
Air break switches	IS: 13947 (part-3)BSEN: 60947-3
Miniature circuit breakers	IS: 88238/BSEN: 60898
HRC cartridge fuses	IS: 9224/BS: 88
Contractors	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-(part I)/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 code	IS: 6619
Specification for copper rods and bars for electrical purposes	IS: 613

6.28.2 REQUIREMENTS:

The power supplies will operate from 240V AC and produce a 30V DC output voltage at full load current:

(i) Voltage Regulation: 0.02% for 10% mains voltage variation

(ii) Load regulation: 0.3% from zero to full load conditions

The power supply shall incorporate an over voltage protection circuit, the components of which shall be independent of the voltage regulating circuit.

Following items shall be covered in the Contract:

(i) One no. 48 V Nickel Cadmium type Battery (Minimum capacity of Battery – 200AH)

(ii) Two nos. Float-cum-boost chargers for 48 V batteries

(iii) DC distribution board.

All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

6.28.3**BATTERY CHARGER**

(i) Battery charger shall be combined float-cum-boost type.

(ii) The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.

(iii) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The Bidder shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

(iv) The float charger shall be designed for supplying :

- The D.C. loads shall be continuous load and short-time overload.
- The trickle charging current of the battery.

(v) The boost charger shall be designed for supplying the boost charging current of the battery.

(vi) 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.

(vii) 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,

(viii) Performance

- Float Charger

  The D.C. output voltage during float charging shall be stabilized within ±1% of the set DC bus voltage. Manual control shall be used if auto mode fails.

- Boost Charger

  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.

(ix) 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.

(x) The D.C System shall be unearthed.

6.28.4 CHARGER PANEL AND D.C. DISTRIBUTION BOARD

(i) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.

(ii) 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.

(iii) 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.

(iv) Bus bars shall be of copper 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

(v) 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.

(vi) 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.

(vii) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.

(viii) 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.

(ix) Ground terminals with isolating links shall be provided.

(x) Cable glands shall be provided to suit the incoming and outgoing cables.

6.28.5 COMPONENTS/ACCESSORIES

(i) 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, stricker 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 phase 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 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) 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) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.
- One (1) Double pole DC ON/OFF rotary switch for float charger output.
- One (1) pilot lamp with series resistor to indicate float charger DC ‘ON’ condition.
- Annunciation System for the following shall be provided:
  - AC Supply Failure.
  - Rectifier Fuse Failure.
  - Surge Circuit Fuse Failure.
  - Filter Fuse Failure.
  - Load Limiter Operated.
  - Charger Trip.
  - Battery on Float.
  - Battery on Boost.

6.28.6POWER ELECTRONIC COMPONENTS

(i) Diode and thyristors shall be of monocrystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.

(ii) 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.

(iii) 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.

(iv) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.

(v) The diodes or thyristor banks shall be natural air cooled.

(vi) The diodes or thyristors shall be protected against overvoltage 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.

6.28.7BATTERY DESIGN FEATURES

(i) Battery offered shall be Nickel Cadmium (Ni-Cad) Type. The battery shall conform to the latest applicable standards specified below:

Specification for vented type	:	IS 10918
Nickel Cadmium Batteries		

(ii) 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.

(iii) 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.

(iv) 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.

(v) 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.

(vi) Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

(vii) Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

- Battery racks
- Porcelaine insulators, rubber pads, etc.

- Set of inter-cell, inter-tier and inter-bank nickel coated copper connectors as required for the complete installation.
- Electrolyte for first filling + 10% extra.

(viii) 1 set of accessories for testing and maintenance shall also be provided suitable for all the battery banks.

•	(a)	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
•	(b)	One	-	Filler hole thermometer fitted with plug and cap and having specific gravity correction scale.
•	(c)	Three	-	Pocket thermometers
•	(d)	Two	-	Cell lifting straps
•	(e)	One set each of	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors Spare vent plugs Spare nuts and bolts Suitable set of spanners

(ix) 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.

(x) It shall be the responsibility of the Contractor to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication, annunciation, etc. and emergency lighting. 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.

(xi) 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

6.28.8**MAKING:**

Unit shall be provided with a name/rating plate made of corrosion resistant material fixed to a AH capacity non-removable part. At a minimum the following information shall be indelibly marked:

(i) Year of manufacture.

(ii) Name of manufacture.

(iii) Type and serial number of unit.

(iv) Nominal input current/voltage.

(v) Nominal output current/voltage.

(vi) IP classification according IEC: 60529.

(vii) Cell number.

(viii) Type of Electrolyte.

(ix) Phase or pole markings of AC and DC supply terminals.

All other name plates shall be laminated phenolic type (white-black-white) and engraved through to the black lamination. The edge of all nameplates shall be beveled at 45 degrees. These name plates to be attached with self-tapping screws.

Compartments and their component shall be provided with, but not limited to, the essential data as required (e.g. tag numbers, ratings, etc.).

Terminals shall be properly clearly identified for easy identification by the operator.

The capacity of the battery shall be given based on an equivalent 5 hour discharge time.

6.28.9**RATING PLATES AND NAMEPLATES:**

All components (switching devices, MCBs, instruments etc.) shall be fitted with a rating plate in accordance with relevant requirements. All functional units shall be clearly labeled to diagrams.

Rating plates shall be made of corrosion-resistant material and have indelible inscriptions.

Enameled plates are not acceptable.

Each outgoing feeder shall be provided with nameplates, mounted on the front of a non-removable part.

Lettering shall be minimum of 5 mm in height. The edge of all nameplates shall be beveled at 45 degrees. The first and second lines shall describe the service with the item number centered on the third line. Nameplates shall be attached to their respective doors with nuts, bolts, and washers. Self-tapping screws shall not be used. Nameplates shall correspond with the description and tag numbers as shown on the one line diagram.

The nameplates shall be black non-deteriorating material (e.g. Reposal or Traffolite) and shall permit inscriptions with characters in white.

6.28.10**RECTIFIER**

6.28.10.1***Battery "Float" Charge Operation:***

The rated output current of the rectifier shall be the current corresponding to the maximum load in KVA divided by the normal DC system voltage, plus the current required charging the battery from end cell voltage in 10 hours.

The rectifier steady- state Dc output voltage variations shall be controlled to within plus 1% and minus 1% of the set value. This corresponds to the battery float-charge voltage during load variations between zero and the rated output current of the DC supply unit and during steady-state input voltage and frequency variations referred to in.

During transient input voltage depressions up to 20% of nominal voltage, the rectifier DC output voltage variations shall be controlled to a value that will at least prevent the initiation of battery discharge.

Facilities for on-line adjustment of the set value of float-charge voltage shall be provided. A suitable potentiometer shall be provided on panel front for this purpose.

The DC output current of the rectifier, when operating under constant limiting conditions, shall be controlled to within plus 2% and minus 2% of the set value.

The RMS value of the voltage ripple, with the battery connected, shall not exceed 3% of the nominal DC system voltage.

6.28.10.2***Battery "Rapid" Charge Operation (Boost Charging):***

The "rapid"-charge cycle shall be according to a constant current/constant voltage characteristic.

The duration of the "rapid"-charge operation shall be automatic and after the elapsed time, will re-instate the rectifier output voltage to that corresponding to continuous float- charge operation.

When operating under constant current-limiting conditions, the DC output current of the rectifier shall be controlled to within plus 2% and minus 2% of the set value.

When operating under constant output voltage conditions, the voltage shall be controlled to within plus 1% and minus 1% of the set value.

The applied set value of the rapid-charge voltage and the duration for which it is applied to the battery shall restore the battery to 100% of its nominal ampere hour capacity within the specified 6-hour period.

Facilities shall be provided for on-line adjustment of the set of voltage applied to the battery, by a potentiometer provided at the front of the panel.

6.28.10.3***Battery Discharge Operation:***

The battery voltage and capacity shall be such as to supply a direct current corresponding to a load specified in data sheet while maintaining an output voltage within the permissible tolerances indicated in the data sheet.

The following battery discharge requirements shall be fulfilled:

(i) Under the prevailing climatic conditions including the minimum ambient temperature specified.
(ii) By a battery which is in a partially charged condition.

6.29**AUXILIARY EQUIPMENT**

6.29.1**INDICATIONS AND ALARMS:**

The following indication equipment shall be provided on the cabinet door:

(i) AC "mains Supply failure"

(ii) Rectifier "charge failure"

(iii) Rectifier "High DC float Voltage"

(iv) Alarm contact to main alarm system.

(v) Rectifier "Low DC float voltage"

(vi) Charger on boost.

(vii) Charger on Float

(viii) Earth Fault

(ix) Over temperature(Shut down)

(x) Overload

(xi) Reverse polarity (tripping)

Indications shall be provided with in-built test facilities. Alarm indications shall have manual reset facilities. They shall have a built-in memory to retain indication upon total supply failure.

6.29.2**MEASUREMENT:**

The following measuring instruments shall be provided:

(i) DC voltmeter measuring rectifier output voltage (with selection switch to measure positive to negative, positive to earth and Negative to earth Voltage).

(ii) DC ammeter, with zero at mid-scale, measuring battery current.

(iii) DC ammeter measuring rectifier output current.

(iv) AC Voltmeter measuring input voltage.

(v) AC ammeter measuring input current.

(vi) Voltmeter for battery voltage.

The accuracy of all measuring instruments shall be not less than that according to class index 1.5 of IEC publication 60051.

6.29.3PROTECTION AND CONTROL

The following protective and control equipment shall be provided as a minimum requirement:

(i) Rectifier AC mains contactor with on/off control circuit switch and fuses

(ii) Rectifier AC mains supply monitoring assembly

(iii) Manually operated float-charge/rapid –charge selector switches mechanically interlocked with the DC supply unit.

(iv) Manually rapid-chare time control relay

(v) Adjust rapid-charge time control relay

(vi) Rectifier DC output circuit fuses

(vii) Battery circuit fuses.

(viii) Auto/manual selector switch

(ix) Float/ boost

(x) Input side Filter to reduce harmonica on the mains side

(xi) Potentiometer to set float and boost voltage in ‘Auto’ model (*)

(xii) Potentiometer to vary float and boost voltage in “manual” model (*)

(xiii) Range to be determined by Contractor based on battery requirements.

The AC mains supply monitor shall operate to open the rectifier AC mains supply contactor in the event of AC supply voltage depressions, or three-phase AC supply unbalance, that would otherwise impair the performance of the DC supply unit, and shall automatically reclose the contactor on restoration of AC supply voltage.

Rectifier output and battery circuit fuses shall be in accordance with IEC publication 60269-2. The rating of rectifier output and battery circuit fuses shall be coordinated such that the battery supply to the load is maintained in the event of rectifier bridge short circuits. The rectifier shall have the necessary equipment to ensure soft/slow starting upon connection of the mains supply, to limit the in-rush current from the mains supply.

In addition the DC supply unit shall incorporate all the necessary control equipment to fulfill the performance requirements of this specification, and to protect the unit its compound from excess current under all operating conditions, selectively operating protective device shall be incorporated as required to safeguard the unit and its components from the consequences of internal and external short circuits, over voltages and main or control circuit malfunctions, how so ever caused.

6.29.4EARTHING

A copper main earth bar shall be fitted along the whole width of the cubicle. This bar shall be bonded to the enclosure of the unit. Within the cubicle an earthing bolt M10 shall be mounted. Metallic enclosure of all components shall be connected to the earth bus by independent PVC insulated copper conductor.

A high resistance shall be connected between Positive and negative poles of the system and the centre points of the resistance shall be earthed through an earth fault relay, designed to indicate whether the earth fault exists on the Positive or Negative pole of the system. The value of resistance connected across the poles shall be such that in the event of a fault on either Pole the earth fault current does not exceed rated mA.

6.29.5**DC-EARTHING**

The DC system is free from earth; therefore an earth fault detection system must be applied.

6.30**INDUCTION MOTORS**

6.30.1**DESIGN REQUIREMENTS**

The motors shall generally conform to IS: 325 or relevant equivalent internationally approved standards and shall be energy efficient type (Eff 1). Additionally the specific requirements mentioned in the following clauses shall also be met.

6.30.2**PERFORMANCE AND CHARACTERISTICS**

- Motors shall be capable of giving rated output without reduction in the expected life span, when operated continuously under the following supply conditions:
  - (i) Variation in supply voltage ± 10%
  - (ii) Variation in supply frequency ± 5%
  - (iii) Combined voltage and frequency variation ±10%
- Motors shall be suitable for full voltage direct-on-line starting for motor ratings less than or equal to 5 kW, motor ratings greater than 5 kW and less than or equal to 50 kW shall be suitable for Star-Delta starter, motor ratings greater than 50 kW and less than or equal to 100 kW shall be suitable for Auto Transformer starter and motor ratings greater than 100 kW shall be suitable for Soft starter.
- The motors for the driven pumps/equipment shall have sufficient rating to operate the pump at any point from shut-off head to run out point specified without overloading. In addition the motor shall have an allowance as under:
- The Power rating of the motor shall be the larger of the following:
  - (i) 20% higher than the power input required to the pump at duty point at a speed corresponding to the frequency of 50Hz.
  - (ii) 15% higher than the maximum power input required to the pump through the entire range of head capacity curve.
  - (iii) In the case of other equipment, other than pumps, if not mentioned specifically under its specifications, it shall be 20% higher than maximum power required to the equipment through the entire range of working.
- Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage.
- Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition.
- The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than 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 motors which is inclusive of 20% tolerance.
- 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 condition 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.

- The three phases shall be segregated by metal barriers within both line and neutral terminal box.
- The earthling pads 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 holes drilled at 40mm centers, tapped & provided with suitable bolts and washers for connecting the earthling strip.
- At least six resistance type temperature detectors for the stator winding each having D.C. resistance of 100 ohms at 0 degrees Celsius, embedded in the stator winding at locations where highest temperatures may be expected, shall be provided. The material of the RTD's shall be platinum.
- At least one vibration detector for the stator winding, embedded in the stator winding at location where vibration may be expected, shall be provided. Compression-type piezoelectric type accelerometers, velocity transducers or proximity transducers shall be applied to the vibration detection system.
- Motors shall have space heaters suitable for 240V single phase 50Hz AC supply. These shall be placed in easily accessible position in the lower part of motor frame. Provision shall be made to measure temperature of bearing by inserting hand held temperature measuring device.
- 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.
- Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

6.30.3 INSULATIONS

- 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 hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

- Motors shall be given power house treatment. This comprises an additional treatment to the winding over and above the normal specified treatment. After the coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and bakings shall be applied to the assembly.

6.30.4 CONSTRUCTIONAL FEATURES

- The motor construction shall be suitable for easy disassembly and reassembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.
- Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
- The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

6.30.5 TERMINAL BOX

- Terminal boxes shall be of weather proof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

- The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

6.30.6 ACCESSORIES

Two 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.

6.31 SUBMERSIBLE TYPE INDUCTION MOTOR

The submersible type motor shall conform to IS: 325/ IS: 9283 and submersible

Cable shall conform to IS: 9968.

Motor should be capable of giving rated output under following supply conditions:

(i) Variation in supply voltage: +/- 10%

(ii) Variation in supply frequency: +/- 5%

(iii) Combined voltage and frequency variations: +/- 10%

Motor shall be suitable for full voltage DOL and / or Star-delta starting. The enclosure of the motor shall be IP: 68. The guaranteed performance of the motor shall be met with tolerance specified in IS: 9283.

Minimum three number thyristors in series are to be provided to sense the stator winding temperature.

6.32 EARTHING

6.32.1 GENERAL

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 armor of multicore cables shall be earthed at both ends. Metallic sheaths and armor 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 copper flat and gates by flexible lead to earthed post. Each Continuous laid length of cable tray shall be earthed at minimum two places by copper Flats to earthing system; the distance between the earthing points shall not exceed 30m.

Earthing and lightning protection system shall be provided to ensure equipment safety, personnel safety and to facilitate designed operation of protective devices during earth fault conditions in the associated system.

Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

The scope includes measurement of electrical soil resistivity (during dry season) at site, supply of earthing conductors, earth electrode pits, lightning protection system and their installation including associated civil work as per the specifications and approved drawings, to the satisfaction of the Engineer. The scope of works shall also comprise designing the earthing and lightning protection systems as per the applicable standards and specific design basis listed below:

(i) Average value of soil resistivity as measured for different electrode spacing, at site. (From 2 to 100 Meter or more in steps of 5, 10 Meter. At least 20 nos. readings shall be taken over the plant area, each in two different directions)

(ii) Permissible values of step and touch potentials based on weight of human being as 70 kg and Earth fault current of 40 kA for 1 seconds

(iii) Gravel with surface resistivity of 3000 ohm-m

(iv) Depth of burial of earth conductors of 600 mm below ground level

(v) Ground resistance with only electrodes of maximum 1 ohm.

(vi) Ground resistance of earthing grid of maximum 1 ohm

(vii) Corrosion allowance of at least 20 %

(viii) Earthing conductor material shall be copper and electrode shall be of minimum 20 mm diameter and 3 m long.

Earthing system design and calculations shall be subject to Engineer approval.

The Contractor shall install bare earth conductors as required for the system and individual equipment earthing. All the work such as cutting, bending, supporting, drilling, brazing / soldering, clamping, bolting and connections to structures, equipment frames, terminals or other devices shall be in the Contractor's scope. All hardware and consumables such as fixing cleats / clamps, anchor fasteners, lugs, bolts, nuts, washers, brazing electrodes, flux, bituminous compound, anti-corrosive paint, etc. as required for the complete work shall be included by the Contractor.

Tap connections (earthing leads) of more than 500 mm long, from main earthing grid to equipment shall be embedded in the floor by the Contractor together with associated civil work such as chipping / chasing, concreting and surfacing, etc. The concrete cover over the conductor shall not be less than 50 mm.

The scope of installation of earth conductors in outdoor areas, buried in ground shall include excavation in earth up to 600 mm depth and 400mm width, laying of conductor at 600 mm depth, brazing as required of main grid conductor joints as well as riser's up to 500 mm above ground at required locations and backfilling. Backfilling material to be placed over buried conductor shall be free from stones and other mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the trench and compacted. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside. Earthing conductors in outdoor areas shall be laid 1500mm away from buildings. The scope of installation of earth conductors in outdoor areas buried in ground, shall include excavation of earth up to 600 mm depth, brazing / welding of main grid conductor, joints as well as risers of length 500 mm above ground at required locations and then backfilling.

Wherever earthing conductor crosses underground service duct and pipes, it shall be laid 300 mm below them. If the distance is less than 300 mm, the earthing conductor shall be bonded to such service ducts / pipes.

The scope of installation of electrodes shall include installation of electrodes in constructed earth pits, and connecting to main buried earth grids. The scope of work shall include excavation, construction of the earth pits including all materials required for treatment (salt, charcoal, chemicals, etc.), placing the electrode and connecting to main earth grid conductors.

The work of embedment of earthing conductor in RCC floors / walls along with provision of earth plate inserts / pads / earth risers shall be done by the Contractor preferably before the floors / columns / walls are cast. The embedded conductors shall be connected to reinforcing rods wherever necessary.

The scope of installation of earthing leads to the equipment and risers on steel structures / walls shall include laying the conductors, brazing / cleating at specified intervals, brazing to the main earth grids, risers, bolting at equipment terminals and coating brazed joints by bituminous paint.

Earthing and lightning protection system conductors along their run on walls / columns, etc. shall be cleated at an interval of 750 mm.

Main earthing conductor shall be buried below the trench at crossing points.

Metallic frames of all electrical equipment shall be earthed by two separate and distinct leads and then connected with earthing system.

Neutral of a transformer shall be earthed to two separate earth electrode pit by two separate earth leads.

Crane rails shall be connected to the earthing system.

An earthing mat shall be provided under the operating handle of the disconnector. Operating handle of the disconnector and the supporting structure shall be bonded together by a flexible connection and connected to earth grid.

Metal pipes and cable conduits shall be effectively bonded and earthed by earthing clamps efficiently fastened to the conduit at both ends.

Neutral connection shall never be used for equipment earthing.

A separate earth electrode shall be provided for each lightning arrester and for each lightning conductor down comer.

Cable sheaths and screen shall be bonded to the earthing system.

Armour of multicore cables shall be bonded to earthing system at both ends, while that of single core cables shall be earthed at source end only. The size of conductor for bonding shall be appropriate with the system fault current.

Conduits, fixtures, junction boxes, etc. shall be bonded to the earthing system by 16 SWG diameter copper wire looped from lighting panel earth bus onwards. Outdoor lighting poles, junction boxes, etc. shall be earthed by 12 SWG copper wires.

Street light pole and junction box shall be earthed with 12 SWG copper wires tapped off from the earthing conductor to be laid along the street lighting cable.

All metallic parts such as transformer, fence, gate, etc. shall be properly earthed.

Wherever earthing conductor passes through walls, galvanized steel pipe sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor, by suitable water-proof compound. Water stops shall be provided wherever earthing conductor enters the building from outside below ground level.

All connections in the main earth conductors buried in earth / concrete shall be brazed type. Connections between main earthing conductor and earth leads shall also be of brazed type. Connection between earth leads and equipment shall be by two bolts.

All electrical equipment shall be connected to the earth bus at two points except the lighting fittings and junction boxes where single earthing shall be provided. Equipment in hazardous areas shall be earthed in two places.
Overall earthing system resistances shall be measured and recorded in the presence of site Engineer during the dry season.
Resistance of each earth electrode with electrode isolated from the system.
Combined earth resistance of the installation measured at the substation, switch room and any other point as directed by the site Engineer.
The method of testing shall be as per IS: 3043. The Contractor shall prepare the test report and submit to the Engineer. The effective earth resistance of the system shall be less than one ohm.
The 415 volts neutral shall be solidly earthed by means of two separate and distinct connections to the earth using conductor of appropriate size. Each connection shall be connected to an

independent earth interconnected between themselves and the main earthing grid to form an earthing ring. The neutral earthing leads shall be kept away from the transformer tank and protected inside wire mesh enclosure to prevent accidental contact.
Terminal joints in the equipment shall be bolted. The earthing conductors running underground shall be laid approximately 600 mm below the grade level.
Removable test links shall be provided near the earth pits to facilitate testing of earth pits.

All paint, scale etc. shall be removed before earthing connections are made. Anchor bolts or fixing bolts shall not be used for earthing connections.

Installation of lightning conductors on the roof of buildings shall include laying, anchoring, astening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying, fastening / cleating / brazing of the down comers on the walls / columns of the building and connection to the test links to be provided above ground level.

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.

Lightning protection system down-conductors shall not be connected to the conductors of safety earthing system above ground level. The lightning protection system for the structures shall be installed by forming a grid of exposed continuous earth conductors and taking down-comers along the walls/supports of the structure and terminating the same at earth pits. A separate earth electrode shall be provided for each lightning arrester and for each lightning conductor down comer. The lightning protection system earth pits shall be inter-connected to form the safety earthing grid provided for the building / structure. The safety earthing grid shall be connected to the mains grid of the switch yard.

The lightning protection air termination rods and / or horizontal air termination conductors shall be fixed in a firm manner. The necessary accessories such as cleats, clamps, brazing materials, bolts, nuts, shall be supplied by Contractor.

Air termination systems shall be connected to earthing system by down conductors. There shall not be any sharp bends, turns and kinks in the down conductors.

All joints in the down conductors shall be of brazed type. All metallic structure within 1 meter of down conductors shall be bonded to lightning protection system.

Every down conductor shall be provided with a ‘test link’ mounted on wall / column at about 1000 mm above ground level housed in a 16 SWG GS enclosure. The test joint shall be directly connected to the earth electrode.

The lightning protection system shall not be in direct contact with underground metallic service ducts, cables, cable conduits and metal enclosures of electrical equipment. However, all metal projections, railings, vents, tanks, etc. above the roof shall be bonded together to form a part of roof grid.

Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. In addition, no intermediate earthing connection shall be made to lightning arresters and transformer, who’s earthing leads shall be directly connected to electrode pit.

6.32.2**APPLICABLE 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/ANSI / IEE Std. 80 and 142, IEC 61024
Code of Practice for the Protection of Building and	:	IS:2309

allied structure against lightning

Hot dip galvanizing	:	IS:2629, 2633, 4759
Structural steel	:	IS:2062 & 808
Welding	:	IS:816

All electrical equipment must be efficiently double earthed in accordance with the requirement of IS: 3043 and relevant regulations of the local Electric Supply Authority.

6.32.3**EARTHING CONDUCTOR**

The electrical installation shall wherever 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:

(i) Conductors above ground shall be copper flat;

(ii) Conductor buried in the ground or embedded in concrete shall be copper, rod /flat. Allowance shall be made for reduction in the cross section of the copper over the design life of the earthing system;

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.

Earth electrodes where used shall be of heavy duty galvanized mild steel 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.

Each earth electrode pipe shall be welded at the top to a copper 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 Engineer.

Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

After the earth installation has been completed the Contractor shall demonstrate to the Engineer 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.

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.

The lightning protection shall be provided by the contractor as per code of practice for lightning protection – IS: 2309.

6.32.4**EARTH PITS**

The number of earth pits will depend upon soil resistivity and the voltage of the system. The earth pit together with the electrode shall be constructed as per IS: 3043. The minimum distance between two earth pits shall not be less than twice the length of the electrode. A bolted assembly link shall be provided in connection between earth electrode and the main earth conductor. GI pipe for watering shall be included in the earth pit.

Treated earth pits shall comprise of treatment material such as salt and charcoal or any other conductivity enhancing compound. Treatment material placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in 150 mm thick uniformly spread and compacted layers. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

Earth electrodes shall be fabricated from minimum 20 mm diameter, 3m long, copper rod or 40 mm diameter, 3m long GI pipe. The minimum spacing between adjacent electrodes shall be 6 m. Design and constructional details of electrode pit shall be subject to the Engineer approval.

Electrodes shall, as far as practicable, be embedded below permanent moisture level.

Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil works such as excavation / drilling and connection to main earth grid. Earth electrode pit marker shall be provided.

Treated earth pits shall be treated with suitable treatment material mentioned above, if average electrical resistivity of soil is more than 20 ohm meter.

6.32.5INSTRUMENTATION 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 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 radially from the same earth point.

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. 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.

SPDs associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer’s recommendations.

6.32.6GALVANIZING

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:

(i)	**Fabricated Steel**	
	Thickness less than 2 mm, but not less than 1.2 mm	**340 gms/sq.m**
	Thickness less than 5 mm, but not less than 2 mm	**460 gms/sq. m**
	Thickness 5 mm and over	**610 gm / sq.m**
(ii)	**Fasteners**	
	Up to nominal size M10	**270 gms/sq.m**
	Over M10	**300 gms/sq.m**

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.32.7 TESTING OF EARTHING SYSTEM

Resistance of all earth electrode and total resistance of each group shall be tested to prove that the value do not exceed that specified in the codes of practice or regulations and recorded. Earth pit resistance shall not be more than 1 Ohm.
The continuity of earthing and resistance of each earthing connection to the equipment shall be tested and recorded.

6.33 SAFETY REQUIREMENTS

6.33.1 SCOPE

This section covers the requirements of items to be provided in the sub-station for compliance with statutory regulations, safety and operational needs.

6.33.2 REQUIREMENTS

Safety provisions shall be generally in conformity with the relevant Indian Standards and IE Rules and Regulations. In particular the following items shall be provided:

(i) Insulation Mats: Insulation Mats conforming to IS: 5424-1969 shall be provided in front of main switch boards and other control equipment as specified.

(ii) First Aid Charts and First Aid Box: Charts (one in English, one in Hindi, one in Punjabi), displaying methods of giving artificial respiration to a recipient of electrical shock shall be prominently provided at appropriate place. Standard First Aid Boxes containing materials as prescribed by St. John Ambulance brigade or Indian Red Cross should be provided in each sub-station.

(iii) Danger Plate: Danger plates shall be provided on HV and MV equipment. MV danger notice plate shall be 200mm x 150mm made of mild steel at least 2 mm thick vitreous enameled white on both sides and with inscriptions in signal red colour on front side as required.

(iv) Fire Extinguishers: Portable CO2 conforming to IS: 2878-1976 dry chemical conforming to IS: 2171-1976 extinguishers shall be installed in the sub-station at suitable places as specified.

(v) Fire Buckets: Fire buckets conforming to IS: 2546-1974 shall be installed with the suitable stand for storage of water and sand.

(vi) Necessary number of caution boards as “Man - on - Line” “Don’t switch on” etc. shall be available in the sub-station.

(vii) Key Board: A key board of required size shall be provided at a proper place containing castel key, and all other keys of sub-station and allied areas.

6.33.3 SAFETY EQUIPMENT

Following safety equipment shall be provided at the specified locations:
Sand Bucket Extinguishers:
Two sand buckets of adequate capacity shall be installed in the transformer yard at accessible locations:

(i) Dry CO_2 Fire Extinguishers: Dry carbon dioxide type portable fire extinguishers, of minimum 5 kg capacity, shall be provided in each panel room and laboratory.

(ii) Insulating Anti–Skid Rubber Mats: 11kV grade anti-skid rubber mats shall be provided in front of 11kv switchgear panels throughout the length of the switchgear.

(iii) 1.1 kV grade anti–skid rubber mats shall be provided in front of all LT switchgear throughout the length of the switchgear.

(iv) Shock Treatment Charts: 2 nos. shock treatment charts in English and local language (Hindi and Punjabi) as per relevant standards shall be provided in each panel room at an approachable locations

(v) Danger Plates: “DANGER “plates indicating relevant voltage grade written in English and local language (Hindi and Punjabi) shall be provided at all accessible sides of the following locations-11kv switchgear room, Transformer yard and all LT panel rooms.

(vi) A set of 33 kV grade hand gloves and earthing rods.

(vii) All electrical installations shall be duly approved by Chief Electrical Inspector to Government (CEIG) and other statutory authorities. The Contractor shall bear the cost of the same.

6.34INSTALLATION AND COMMISSIONING OF ELECTRICAL EQUIPMENT

Before commissioning any switchgear panel, circuit breaker, motor starters etc. the following points must be checked and ensured for safe energizing of the switchboard:

(i) That the erection of equipment to be commissioned is complete in all respect with its auxiliaries and all other mountings including earthing.

(ii) That all the openings in floor inside or outside the cubicle panels have been sealed off.

(iii) That all the cubicles panel doors, gaskets are intact and no other opening exists for vermin entry.

(iv) That all the metering instruments have been checked and calibrated.

(v) That all control circuit fuses are of proper rating and showing continuity.

(vi) That all the indication lamps are healthy in position.

(vii) That the mechanical parts of breaker closing and tripping mechanism have been checked and lubricated and circuit breakers have been tested for contact level, contact pressure and resistance and buffers are free and fully lubricated.

(viii) That air vent pipe of CB is free and spots / shutter mechanism is okay.

(ix) That auxiliary contact have been checked for cleanliness and adequate contact pressure and auxiliary contacts in series with tripping circuit open with opening of breaker.

(x) That the polarity test and ratio test of all the PTs and CTs is over.

(xi) That the high voltage test of circuit breaker, bus bar and outgoing and incoming cables have been conducted and are satisfactory.

(xii) That all the protective relays have been tested for primary and secondary injection tests. All thermal overloads relays and the contactor coils and operation of all the current and voltage operated relays have been tested.

(xiii) That the simulation tests for all protective, alarm and annunciation relays are okay and all the relays have been properly set. That the manual closing and tripping have been tried against shock and bouncing of the mechanism.

(xiv) That IR has been recorded for bus bar, circuit breakers, incoming and outgoing cables, control wiring, and potential transformers. Joints resistance of high capacity bus bar has been recorded and found to be satisfactory.

(xv) That firefighting equipment like CTC, CO2 or soda ash extinguishers are kept ready for use.

6.35EMERGENCY EQUIPMENT (GENERAL)

6.35.1FIRE EXTINGUISHERS

The Contractor shall provide minimum one CO_2 fire extinguishers (10 kg) at each of the TWs outside the Polytechnic campus area and two fire extinguishers each in the two control rooms in Polytechnic campus area.

6.35.2 FIRST AID KITS

Complete first aid kits shall be provided one at each TW and control room. The first aid kit shall consist of all materials, medicines necessary for treatment of cuts, wounds, burns bad effects of inhalation of chlorine, bad effects on skin due to contact of chemicals acids etc. Following materials in general in sufficient quantities shall be provided.

- Medical cotton, sterile cotton pads.
- Cotton Bandages, elastic bandages.
- Pair of scissors, packet of new shaving blades.
- Sticking plaster for medical use.
- Band-aid strips.

Following chemicals/medicines shall be provided in sufficient quantities:

- Tinctures iodine and mercury chrome.
- Burnol ointment.
- Bottles of spirit and of Dettol.
- Toilet soaps.

To be procured under medical advice

- Tablets for bad-effects of chlorine inhalation.
- Skin lotions and ointments for burns, acid effects.
- Eye drops for soothing effects.

6.35.3 FIRE EXTINGUISHER AND FIRST AID KITS SHALL BE PROVIDED AT THE END OF THE COMMISSIONING PERIOD.

6.35.3.1 *Spillage and Leakage*

- Chemical preparing, dosing and transfer equipment shall be designed and arranged so that any leakage and spilling can be controlled and cannot enter ducts, channels, etc., and have a corrosive impact on pipes, cables or other equipment of the plant.

At all lubrication or greasing points grease trays or pans shall be provided to collect excessive lubricant or spillage onto the equipment or into water.

6.35.3.2 *Spare Parts*

The spare parts shall be new, unused and strictly interchangeable with the parts they are intended to replace. They shall be treated and packed for long storage under the climatic conditions prevailing at the site. The packing shall be clearly and durably labeled giving full details for the identification of the contents. All cases, containers and other packages containing the parts are liable to be opened for such examination as the Engineer-in-Charge may require and packing shall be designed to facilitate opening and thereafter re-packing.

7 SUB-SECTION 7: INSTRUMENTATION AND CONTROLS

INTRODUCTION

This sub-section of the specifications defines the general requirements for the design, supply, installation, inspection and testing of the Instrumentation, Controls, and associated materials to be installed at different Tube Wells and Control Room at Polytechnic campus. For selection of field instruments or anything related to instrumentation, the Contractor shall follow the specifications contained herein.

Irrespective of the detailed specifications of the respective items detailed in other sub-sections, the Contractor shall be required to provide all equipment, accessories, cabling, earthing, providing necessary transducers/sensors, system hardware/software, programming logic etc. to achieve the functional requirements described in the Bid Documents. The civil and electromechanical work associated with installation of the instrumentation equipment shall also be in the Contractor's scope.

7.1 REFERENCE STANDARDS

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

Table 26 Reference Standards

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, ISO 3511/I-1977	Symbolic representation for process measurement control Functions and instrumentation. Basic requirements
BS EN 837-1:1998	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS 3680 (Various)	Measurement of liquid flow in open channels.
BS 3693:1992	Recommendations for design of scales and indexes on analogue indicating instruments
BS EN 60770-1:1999, IEC 60770-1:1999	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS 5308 (Various)	Instrumentation cables
BS EN 60529:1992	Specification for degrees of protection provided by enclosures (IP code)
BS ISO 11631:1998	Measurement of fluid flow. Methods of specifying 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 conditions. Climatic conditions
BS 6739:1986	Code of practice for instrumentation in process control systems: installation design and practice
BS 1553 (Various)	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-37.1-1975 - (R1982)	Electrical Transducer Nomenclature and Terminology
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
IEC 61158-2	Communication Protocols
BS EN 50081	Electromagnetic Compatibility
ISO 3511	Process measurement control functions - instrumentation symbolic representation.
IEC-8705101	Modbus Protocol Conversion

7.2 **DOCUMENTS TO BE SUBMITTED**

7.2.1 **GENERAL SUBMISSIONS**

The Contractor shall make submissions to the Engineer of all design drawings, schedules and complete documentation relating to instrumentation, control systems provided under this Contract along with catalogues and data sheets from respective manufacturers.

7.2.2 **CERTIFICATES**

(i) Manufacturers' works tests.
(ii) Pre-installation checks.
(iii) Pressure-testing schedules.
(iv) Instrument loop test check sheets.
(v) Installed instrument performance tests.
(vi) System tests.
(vii) Statutory certificates of compliance (such as hazardous area equipment).

7.2.3 **OPERATION AND MAINTENANCE INSTRUCTIONS**

(i) Composite manual describing the functional and operation of each piece of equipment.
(ii) Composite manual for testing and servicing every system and individual item.

7.3 **INSTRUMENTATION EQUIPMENT**

Unless otherwise specified, all functions shall be transmitted electrically and all analogue signal-transmission systems shall be in accordance with IEC 60381 – 1/BS 5863: Part 1 or equivalent and shall use a signal of digital or 4mA to 20mA dc. Where possible, measuring systems shall be designed so that any necessary power supply is taken from the appropriate instrument panel.

Transmitting devices shall have integral indicators to monitor the output signal or connections suitable for use with a portable test meter, and shall be capable of meeting the performance requirements specified in the appropriate part of BS EN 60770-1 or equivalent. For the important and critical processes the transmitting devices, such as pressure, temperature and level gauges, shall have a reference gauge installed locally for easy reference for the operation and maintenance staff. The transmitters shall be provided with LCD meters.

Equipment mounted in enclosures shall be suitable for continuous operation at the maximum internal temperature possible in service, due account being taken of internally-generated heat and heat dissipated by other plant. All components shall be rated adequately and circuits shall be designed so that change of component characteristics within the manufacturers' tolerances shall not affect the performance of plant. All equipment shall be designed to operate without forced (or fan) cooling.

Field mounted instruments shall be mounted such that they are easily viewable and easily accessible for maintenance.

Instruments not mounted in panels shall be supplied complete with all brackets, stands, supporting steelwork and weatherproof enclosures (separate from the instrument cases) necessary for securing them in their working positions and affording complete protection at all times including periods of servicing, adjustment, calibration and maintenance.

7.4 **INDICATING INSTRUMENTS AND METERS**

All instruments and meters shall be flush mounted and generally of the same pattern and appearance throughout and those which perform similar duties shall be of uniform type and manufacture.

Indicating instruments shall be fitted with an externally accessible zero adjuster. They shall have no parallax error and their normal maximum reading shall be approximately 60% full scale deflection.

Ammeters in motor starter circuits shall be capable of withstanding the starting current and shall have a compressed overload scale. The ammeter shall have an adjustable and sealable red pointer set to indicate normal full load current. The ammeter physical size shall be in keeping with the size of the starter concerned. The minimum size to be used is 0.25 DIN.

Indicating instruments shall comply with IS 1248, BS 89 or IEC 60051 and shall be of industrial grade accuracy.

Kilowatt-hour meters shall comply fully with IS 722 or BS 5685 Class 2 and shall have industrial grade accuracy (±2.5%). Three element units shall be used for 3 phase 4-wire systems. Two element units shall be used for 3 phase, 3-wire systems.

7.5 **INDICATOR LIGHTS**

Indicator lights shall be not less than 20 mm diameter and shall be panel mounted types with metal bodies adequately fastened so that the lamps shall be capable of replacement from the front of the apparatus without disturbance to the lamp holder or panel wiring. Lamp holders shall be keyed into panels to prevent rotation. Lens colors shall comply with BS EN 60037 as follows:

- Power On — White*
- Running — Green

- Tripped/Alarm Red
- Status (Open, Closed, Etc.) Blue
- Ready To Start Blue
- Warning (No Imminent Danger) Amber

Note: *White may be used where doubt exists as to which other colour to use.

The lights shall be under-run to give long life either by use of a resistor to limit voltage to 90% normal value or by using higher voltage lamps.

The indicating lamps on control panel shall be cluster of LED's.

7.6 **PUSH BUTTONS**

Colours of pushbuttons shall generally comply with IS 6875, BSEN 60947, 60037 or IEC 60073 and in particular shall be as follows:

- Stop, Emergency Stop Red
- Start Green
- Jogging/Inching Black
- Reset (When Not Also Acting As A Stop) Blue
- Lamp Test Blue
- Override/Alarm Accept Yellow

7.7 **INSTRUMENTS SPECIFICATION**

GENERAL

Instrumentation system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. All electronic components shall be adequately rated and circuits shall be designed so that change of component characteristics shall not affect plant operation.

All instrumentation equipment shall be new, of proven design, reputed make, and shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment's shall be designed to withstand tropical rain. Wherever necessary space heaters, dust and water proof cabinets shall be provided. Instruments offered shall be complete with all the necessary mounting accessories.

Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.

No custom made hybrid type integrated circuits shall be used.

Unless otherwise stated, overall accuracy of all measurement systems shall be ±1% of measured value, and repeatability shall be ±0.5%.

Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 80% of the full scale range.

On resumption of the supply following a power failure the instruments and associated equipment shall start working automatically.

The instruments shall be designed to permit maximum interchangeability of parts and ease of access during inspection and maintenance.

Unless otherwise stated, field mounted electrical and electronic instruments shall be weatherproof to IP-65.

The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail but in any case not less stringent than those conditions detailed in the Project Requirements. Instruments shall be resistant to corrosion in the atmosphere in which they are expected to operate.

Lockable enclosures shall be provided for all the field mounted instruments.

All field instruments, and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Engineer for approval before any labels are manufactured.

All coated parts of sensors shall be made out of non-corrosive material capable of working with chlorine content of required ppm.

For all instruments installed in the field, surge protection devices (SPD s) shall be provided at both ends of the connecting cable for protection against static discharges / lightning and electromagnetic interference.

Individual pair screened, overall screened, armored cables shall be used for analogue signals and armored, and overall screened cable shall be used for digital signal cables.

7.7.1 **FLOW MEASURING SYSTEMS**

Flow measuring system shall consist of flow sensor / transducers, flow computer, flow transmitter, digital flow indicator and integrator and any other item required to complete the system.

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 in underground/above ground pipelines.

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 in accordance with the requirements of the flow meter manufacturer and in line with applicable standards. Contractor shall finalize the exact location of flow transducers in consultation with Engineer.

The flow transmitter shall be suitable for field mounting and shall accept input from the flow transducer. It shall process the input signal and provide 4-20 mA DC output proportional to flow rate. Flow transmitters shall have LED display to indicate instantaneous flow rate. The flow range shall be adjustable.

A zero span adjustment facility shall be provided for flow transmitter and indicator.

The following standards shall be followed:

(i) BS EN 24185 - Measurement of fluid flow in closed conduits - Weighing Method.

(ii) BS ISO 12765 – Measurement of fluid flow in closed conduits – Methods using transit-time ultrasonic flow meters

(iii) ISO 8316 – Measurement of fluid flow in closed conduits – Method by collection of the liquid in a volumetric tank

(iv) BS EN ISO 6817 – Measurement of conductive liquid flow in closed conduits – Method using electromagnetic flow meters

(v) BS EN 29104 (ISO 9104) – Measurement of fluid flow in closed conduit – Method of evaluating the performance of electromagnetic flow measuring system for liquid

(vi) ISO 9826: Measurement of liquid flow in open channel – Parshall Flume and Saniiri Flumes.

Flow measurement shall not be affected by physical properties of sewage viz., temperature, pressure, viscosity, density etc., within given limits. Contractor shall provide compensating electronic circuits if required. The overall accuracy of flow measuring systems shall be at least ±1.0 % of the measured value unless otherwise stated.

7.7.1.1 ***Electromagnetic Full Bore Type Flow Meter***

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

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

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

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

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.

Mandatory Accessories:

1) The sensor should be as per IP-68 protection & with flanges of up to PN 10 rating from CS-1 No. 2) The sensor coil housing shall be IP-68.This protected against external magnetic field. 3) The transmitter shall have one current 4 m A-20 mA output. 4) The current output shall be galvanically / optically isolated. It shall be fitted with switched mode power supply capability 85- 260 V & 45-65 Hz to cope with power transients without damage. 5) Signal & power cables shall be of 50 meters length/each. 6) Conduit pipe (PVC Plumbing schedule 4) 25 mm diameter with suitable rating of cable with digging, laying & concealed the duct - 25 meters/each. 7) UPS working on 230 V AC, 50 Hz power supply suitable for 12 hrs continuous operation-1 No. 8) Data storage capacity with built in or separate for date time, actual flow rate, totalizer & error messages if any with storage capacity of 120 days at 1 hour interval data logging-1 No. 9) Proper earthing shall be provided for protection against high voltage surge.11) Suitable over voltage protection unit for protection of instrument from higher voltage (up to 275 V-300 V AC).

General			
1.	Accuracy of flow measurement during FAT		± 0.5% of measured value
2.	Overall accuracy of flow measurement loop.		± 1.0 % of measured value
Flow tube			
(i)	Application	:	a) Clear Water Pumping
(ii)	Type	:	In line full bore electromagnetic
(iii)	Size of flow tube	:	Same as pipe size
(iv)	Process connection	:	Flanged
(v)	Weather Protection Class	:	IP 68 as per IS 13947
(vi)	Surge protection devices (SPD)	:	Required for protection from lightning

	between flow tube and flow transmitter		surges
(vii)	Material of Construction :		
	Electrodes	:	SS 316
	Coil Housing (fully welded construction)	:	SS 316,
	Flanges	:	SS.316
	Grounding ring (Grounding Electrodes are not acceptable)	:	SS 316
(viii)	Flow tube Lining	:	Hard Rubber
Flow Transmitter Unit			
(i)	Type	:	Microprocessor based with facility to configure the ranges.
(ii)	Type of display	:	2-line backlit LED actual flow rate, forward, reverse and sum totalizers (8-digit)
(iii)	Units of display	:	Flow rate –m^3 / hr. Totalized flow – ML
(iii)	Input	:	From flow tube
(iv)	Output	:	4-20 mA DC (isolated) proportional to flow rate
(v)	Power Supply	:	240 V
(vi)	Zero and Span Adjustment	:	Required
(vii)	Weather Protection Class	:	IP 65 as per IS 13947
(viii)	Battery backup for totalized flow Type Capacity Backup Time	:	 Online 2.5 mVA 24 hours.
(xi)	Facility for on line diagnosis	:	Required
Flow indicator and integrator			
Specifications shall be as given under 'Flow Indicator and Integrator'.			

7.7.1.2***Calibration***

The Electromagnetic flow meter shall be calibrated for three points for the full flow range specified as per BS EN 29104 (Methods of evaluation of electromagnetic flow meters).

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 Engineer. The Contractor shall also demonstrate complete calibration on the test bed in the flow meter laboratory. The flow meter shall be acceptable if the accuracy and repeatability is equal to or better than those specified.

7.7.1.3 ***Flow Indicator and Integrator***

Flow indicator and integrators shall be modular in design. It shall consist of two separate dedicated displays for flow rate indication and total flow indication. It shall accept 4-20 mA DC isolated input. The flow integration shall be carried out in the Programmable Logic Controller (PLC). The flow indicator cum flow integrator shall provide 4-20 mA retransmission output proportional to flow rate.

S. No.	**Details**	**Description**
1	Type	Microprocessor based
2	Mounting	Front fascia of Control Panel
3	Display	Digital, seven segment back lit LED display
4	Digit Height	14 mm or Higher
5	No. of Digits for Flow indicator Flow integrator	 4 Digits 6 Digits
6	Input	4-20 mA DC (Isolated) from flow transmitter through analogue signal multiplier (Refer Note 2)
7	Zero and span adjustment	Required
8	Manual Reset Facility for flow integrator	Required (shall be password protected)
9	Engineering units:	
	- Flow rate indicator - Flow integrator	Cum/hr. ML
10	Battery backup for integrator	Required
11	Retransmitted output	4-20 mA proportional to flow rate
12	Alarm and control outputs	2 NO+ 2NC for high-high, high and low alarms and trip (adjustable)
13	Communication port	RS-485 (With Modbus protocol) for interfacing with PLC
14	Weather Protection Class	IP-52 of IS 13947 Part I
14	Enclosure material	Die cast aluminium
15	Accuracy	± 0.25% of span or better.

Notes:

1. Digital flow indicator and flow integrator shall be a combined unit.

2. Facility shall be available in the analog signal multipliers and in the flow indicator and integrator for providing excitation voltage for the flow transmitter in case of 2-wire flow transmitters.

7.7.2 LEVEL MEASURING SYSTEM

7.7.2.1 *General*

Level measurement system shall consist of level transducer, level transmitter, digital level indicator and any other items required to complete the level measuring system.

To reduce the effect of water turbulence in reservoirs / tanks, averaging facility should be provided in the transmitter unit for providing steady readings. Stilling pipe shall be provided for level electrodes.

The design and application of the level measuring system shall take into account the reservoir construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

For ultrasonic type and radar level transducers, the design and installation shall avoid any degradation of instrument performance due to spurious reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. Facilities shall be provided for rejection of spurious reflection.

The level transmitters shall be mounted in suitable weatherproof lockable pedestal enclosures near the level sensor.

7.7.2.2 ***Capacitance/ RF Admittance Type Level Measuring System***

(i) The capacitance / RF Admittance type level measuring system shall consist of a sensing probe and transmitter and a digital indicator.

(ii) The level-measuring probe shall be installed on a tank and shall be connected to level transmitter.

(iii) Guide pipe shall be provided for probe.

General		
1	Accuracy	±1.5 % of span
Level sensor cum transmitter		
1	Mounting	Top of the tank
2	Probe type	Rod
3	Probe material	SS 316
4	Weather Protection Class	IP-65 of IS 13947 Part I
5	Output	4-20 mA DC, Isolated
6	Material of wetted parts	SS 316
7	Local indication	Required
8	Probe insulation	Teflon
9	Stilling pipe	SS 316 with perforations

Digital Level Indicator	As per panel meter specifications

7.7.3PRESSURE MEASURING SYSTEM

7.7.3.1 *Pressure Transmitters with data logger*

(i) Pressure measuring system shall consist of pressure transducer and transmitter and digital pressure indicator and any other items required to complete the pressure measuring system. Pressure transmitters shall be provided with a test port so that in-site calibration can be carried out.

(ii) 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 the monitored system.

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

(iv) Pressure sensor shall be capable of operating in the range of pumps discharge pressure, and be of the diaphragm type. It shall be provided complete with impulse tubings, fittings, two valve manifolds with drain cock/calibration valve. Local and remote display units shall be provided.

General		
1	Measuring Range	-1 to 20 Bar
2	Accuracy of measuring loop	+/- 0.1% of span
Pressure sensor and transmitter		
1	Sensor	Diaphragm Sensor
2	Material of sensor and other wetted parts/ Non-wetted parts Material	SS 316 L
3	Transmitter type	2-wire, Indicating type
4	Range	Adjustable over full span
5	Zero and span adjustment	Required
6	Output signal	4-20mA DC, Isolated
7	Enclosure protection	IP 65 of IS 13947 Part I
8	Accessories	2-valve manifold with drain cock, impulse tubing, snubbers and all installation hardware
9	Process Connection	½” NPT M
	Digital Pressure Indicator	As per panel meter specifications
	Data Logger	Shall be battery operated with minimum of 10 years battery backup and capable to communicate the signals via hardware, GSM/ hand equipment’s, etc. It shall have the minimum of 365 days data (hourly pressure) storage capacity.

7.7.3.2 ***Pressure Gauges***

(i) Pressure gauges and vacuum gauges shall comply with IS 3624 / BS 1780. Glycerin filled dial shall be provided where the gauge is subjected to pressure pulsation and / or vibrations. The internal parts of pressure gauge shall be stainless steel.

(ii) Pressure gauges shall be provided on discharge and on suction of each pump. Pressure gauges shall be bourdon type and calibrated for the required range. The gauge shall be supplied complete with impulse tubing, two valve manifold with drain cock, fittings etc.

(iii) The minimum diameter for pressure gauges shall be 150 mm. However, where the pressure gauge forms part of equipment, the equipment manufacturer’s standard sizes will be acceptable.

1	Accuracy	± 1% of full scale
2	Dial size	150 mm
3	Glass	Shatterproof
4	Over range Protection	125% of maximum pressure
5	Housing Material	Die Cast Aluminium
6	Material of sensor and other wetted parts	SS 316
7	Accessories	2-valve manifold with drain cock, impulse tubing, snubbers and all installation hardware

7.8**CABLES FOR DC SIGNALS**

Cables for DC signals shall be 1.5 sq.mm, 660V/1100V grade single pair / multi pair / single triad / multi traid cables using high conductivity annealed tinned stranded copper conductor having extruded PVC insulation. The cables shall be shielded individual pair / traid and overall shielded with aluminum Mylar tape with ATC drain wire run continuously in contact with aluminum tape and inner sheathed with extruded PVC. Armouring shall be with galvanized steel wire and overall sheath shall be extruded PVC. Applicable standard shall be IS 1554 / BS 5308 / IEC 189.

7.9**CABLES FOR AC SIGNALS**

Cables for AC signals shall be 1.5 sq.mm, 660V/1100V multicore cables using high conductivity annealed tinned stranded copper conductor having extruded PVC insulation. The cables shall be inner sheathed with extruded PVC. Armouring shall be with galvanized steel wire and overall sheath shall be extruded PVC. Applicable standard shall be IS 1554 / BS 5308 / IEC 189.

7.10**LAYING OF CABLES**

a. A distance of minimum 300mm shall be maintained between the cables carrying low voltage AC and DC signals and a distance of minimum 600mm shall be maintained between cables carrying HT and LT signals. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.

b. Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for Purchaser’s approval.

c. All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables. A loop of 1 metre shall be left near each field instrument before terminating the cable.

d. Cables shall be complete uncut lengths from one termination to the other.

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

f. Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.

g. The Contractor shall take the actual measurement of the cables and the associated accessories such as cable trays, conduits etc. required at site, prior to the placement of order on the cables.

7.11 JUNCTION BOXES

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

The junction boxes shall be readily accessible for maintenance and clearly labelled. Junction boxes shall be constructed of die cast aluminum and provide degree of protection IP 65.

Separate cables shall be used for digital and analog signals.

Wires and terminals for the digital and analog signals shall be segregated within junction boxes.

7.12 CABINETS FOR FIELD INSTRUMENTS

a. A lockable cabinet shall be provided for enclosing instruments and associated accessories which are mounted outside the control panel such as transmitters, SPDs, terminal blocks etc. at measurement locations in consultation with Purchaser. The cabinets for electronic indicating instruments like transmitters, flow transmitter cum computing units etc. mounted outdoors shall be provided with proper sunshade.

b. The cabinets shall be fabricated from cold rolled sheet steel of 2 mm thickness with powder coating and shall be suitable for wall mounting or pedestal mounting as required.

c. The cabinet shall be properly painted from inside by white paint and from outside by paint shade RAL 7032.

d. The cabinet shall conform to IP 65 weather protection and shall have built in locking facility. The cabinet shall be earthed properly. A steel plate/pipe, as per the requirement, shall be provided in the cabinet for mounting the instrument and accessories.

7.13 INSTALLATION OF INSTRUMENTS

Each instrument and sensing device shall be installed in accordance with the recommendations or instructions of the manufacturer for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, accurate reproduction of the quantity to be measured, ease of operation, reading, maintenance and servicing, freedom from any condition which could have adverse effects and with particular regard to the safety of personnel and plant. Each item of plant shall be levelled and securely fixed to the surface, bracket or framework on which it is mounted.

8 SUB-SECTION 8: MATERIALS, WORKMANSHIP AND SURFACE COATINGS

INTRODUCTION

This part of the Specification sets out the general standards of plant design/materials to be supplied and the workmanship required to be ensured by the Contractor. All component parts of the Works shall, unless otherwise specified, comply with the provisions of this part or be subject to the approval of the Engineer. Particular attention shall be paid to a neat, orderly and well-arranged installation carried out in a methodical competent manner.

The name of the manufacture and equipment proposed for incorporation in the work together with procedure, performances, capabilities, certified test reports and other significant information pertaining to the same shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the specification and such parts shall be replaced by the Contractor at no extra cost to the Engineer.

8.1 COMPLIANCE WITH STANDARDS

Where reference is made in the Specification to a British Standard Specification (hereinafter abbreviated to 'BS.') issued by the British Standards Institution or to an Indian Standard Specification (I.S.) issued by the Bureau of Indian Standards, (earlier known as Indian Standard Institution), American Society for Testing & Materials (ASTM) issued by ASTM or American National Standards Institute (ANSI) issued by ANSI. Or to any other equivalent standard it shall be to the latest revision of that standard at the Bid date.

All details, materials and equipment supplied and workmanship performed shall comply with these standards. If manufacturers offer equipment to other standards, the equipment/ material should be equal or superior to those specified and full details of the difference shall be supplied.

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

In the event of conflict between this Specification and the Codes for equipment, provisions of this Specification shall govern. Certain specifications issued by national or other widely recognized bodies are referred to in this Specification. Such specifications shall be defined and referred to hereinafter as Standard Specification. In referring to the Standard Specifications the following abbreviations are used:

IS	:	Indian Standard
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society of Testing and Materials
AWS	:	American Welding Society
AWWA	:	American Water Works Association
ISO	:	International Organization for Standardizations
JIS	:	Japanese Industrial Standard
DIN	:	Deutsches Institute fur Normung
BS	:	British Standard
JWWA	:	Japanese Water Works Association
IEC	:	International Electro technical Commission
IEE	:	Institution of Electrical Engineers

IEEE	:	Institute of Electrical and Electronic Engineers
NEMA	:	National Electrical Manufacturers Association
AGMA	:	American Gear Manufacturer's Association

8.2MATERIALS - GENERAL

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of reputed make/approved quality, free from imperfections and selected for long life and minimum maintenance. Non-destructive tests, if called for in the Specification, shall be carried out.

All submerged moving parts of the pumping stations equipment, or shafts and spindles or faces etc. in contact with them shall be of corrosion resistant materials. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall maintain their properties without aging due to the passages of time, exposure to light or any other cause.

The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works.

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

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals, and prevention of seizure by fretting where two metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants.

Where bronze is specified or used it shall be zinc free and conform to BS EN 1982 /IS: 318 GR LTB2. Fabricated mild steel shall be at least equivalent to BS: EN 10028 /IS: 2062. All such plate materials for pressure points and initial load bearing/machine components shall be ultrasonically tested to ensure that they are free from defects like laminations, discontinuities etc., before commencing fabrication.

Where 'steel' is specified or used it shall have resistance to corrosion in the environment concerned not less than that provided by PD 970:2005for forgings and BS EN 10293:2005 for castings.

Where Aluminium Alloy is specified or used, Aluminium structural supporting members shall be fabricated from HE- 30 EP aluminium alloy, which shall comply with ISO – 209/2, 3, 4 as appropriate for the sections, plate, sheet and other forms employed.

As soon as practicable after receiving the order to commence the Works, the Contractor shall inform the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.

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

All materials (viz. bricks, aggregates, floor tiles, door fixtures, sanitary fixtures etc.) shall be of best quality and got approved from Engineer before procurement. Various materials to be used in the works shall be subject to mandatory test in accordance with latest CPWD specifications. These tests shall be got done from Sri Ram Institute of Industrial Research, MPL or any other laboratory as directed by Engineer or any other laboratory of repute acceptable to both the parties. All the testing charges including sampling, conveyance, packaging, etc. shall be borne by the Contractor.

For routine quality control tests (e.g. cube tests, sieve analysis, etc.), Contractor shall establish a well-equipped laboratory at site. All tests required as per specification / IS codes and as desired by Engineer shall have to be done by Contractor in the presence of the Engineer.

8.3 **WORKMANSHIP - GENERAL**

The design, construction and layout of the pumping stations equipment shall be such as to ensure safety, simplicity and easy operation to allow economical maintenance. The pumping stations equipment shall be new and of sound workmanship and robust design. Workmanship and general finish shall be of first class quality and in accordance with best workshop practice.

All similar items of the pumping stations equipment and their component parts shall be completely interchangeable. Spare parts shall be supplied from the same vendor of original equipment and manufactured from the same materials as the originals and shall fit all similar items. Machining of renewable parts shall be accurate and to specified tolerances so that replacements can be readily installed. All equipment shall operate without excessive vibration and with minimum noise. All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds at any load up to the maximum there shall be no vibration due to lack of balance.

Where practical, all installations shall be indoors. Where a choice of location exists between an indoor and outdoor location, an outdoor location will not be permitted. Outdoor installation shall be weather proof, protected against accidental and malicious damage and designed to prevent the collection of water at any point.

Unless otherwise required in the contract all items of the pumping stations equipment shall be rated for continuous service at the specified duties under the prevailing atmosphere and operation conditions on site. The conditions under which the pumping stations equipment is required to operate are known to vary throughout the year. The conditions can be arduous with excessive heat, dust, rainfall and humidity. Reference ambient temperature for design of all electrical equipment is 45°C.

All parts that can be worn or damaged by dust shall be totally enclosed in a dust proof enclosure.

All necessary accessories required for satisfactory and safe operation of the pumping stations equipment shall be supplied by the Contractor unless it is specifically excluded from his scope.

Suitable provision by means of eyebolts or other means are to be provided to facilitate handling of all items that are too heavy or bulky for lifting and carrying by two men.

If, after installation, the operation or use of the materials or equipment furnished by the Contractor proves to be unsatisfactory, the Engineer shall have the right to operate or use such materials or equipment until correction of defects, errors or omissions, repair or partial or complete replacement is made without interfering with the Plant or pumping station operation. Except for any warranty provided for elsewhere in this Contract or unless otherwise agreed upon in advance, the period of such operation or use, pending correction of defects, shall not exceed one year.

All component parts shall be manufactured of a strict system to tolerance and complete interchangeability of similar parts as required.

All wearing parts shall be readily available within India. If not, they shall be listed in the tender as additional mandatory spares and sufficient spares for a period of five years within the schedule.

All parts subject to wear shall be readily accessible.

The ball and roller bearings shall have minimum running life of 70,000 hours for duty loading. All bearings shall comply with ISO standard SI unit dimensions where practical.

All warning sign, notices other sign, labels and the like shall be provided by the Contractor in Punjabi, Hindi and English.

8.4WELDING

8.4.1DESIGN APPROVAL

Welding shall comply with BS EN 1011 code. In all welded fabrications, before fabrication commences, the Contractor shall submit to the Engineer detailed drawings of fabrication with sizes of weld and weld preparation together with the details of the application codes. No welding shall be carried out before approval of the details by the Engineer. No alternations shall be made to any previously approved details of weld preparation or size without prior approval of Engineer.

8.4.2QUALIFICATION OF WELDERS AND PROCEDURES

Welders shall be qualified in accordance with the requirement of the appropriate section of BS EN 287. The Engineer shall have the right to call for further qualification from time to time from any welder, who, in the opinion of the Engineer, does not produce weld in accordance with the qualification. Each welder shall be assigned a number and letter. Each weld shall clearly be identified as to its welder marking the welder's code adjacent to the welds. A record chart shall be maintained for each welder showing the procedures for which he has qualified, the date of such qualification, the type of defects produced and their frequency. Engineer shall disqualify the welder whose work requires a disproportionate amount of repairs. All procedures, where required, shall be qualified as per BS EN 1418.

8.4.3GENERAL WELDING REQUIREMENTS

Inspection and quality of surveillance shall not be limited to the examination of finished welds. All aspects of materials, fabrication procedures and examination procedures shall be subject to the approval of the Engineer. The equipment used shall be suitable for the quality of work specified. The techniques employed shall be based on methods which are known to produce good results and which have been verified at Site by actual demonstration.

Haphazard striking of the electrodes for establishing arc shall not be permitted. The arc shall be struck either on the joint or on a starting tag. The starting tag shall be of the same material or a material compatible with the base metal being welded. In case of any inadvertent strike on place other than the welding, the area affected shall be ground flushed and examined by liquid penetration methods.

Generally, a stringer bead technique shall be used with a slight oscillation if necessary to avoid slag and to minimize the number of beads needed to fill the joint. However, the width of the deposited pass shall not exceed 3 times the wire diameter. Vertical welds shall be made in upward direction. For all pipes above 300 mm. dia., welding shall be done whenever possible, by 2 welders working simultaneously both sides of the pipe.

All joint fit ups shall comply with the tolerances specified on the design drawings. All fit ups shall be examined by Engineer before root pass. The root pass shall have less than 1.5 mm internal reinforcement. Defects like icicles burn through and excessive "suck back", etc. shall be cause for rejection of welds.

Final welds shall be suitable for appropriate fabrication of the non-destructive examination of the weld. If grinding is necessary, the weld shall be blended into the parent metal without gouging or thinning of the parent metal in any way. Uneven and excessive grinding may be a cause for rejection. Fillet weld shall preferably be convex and free from undercutting and overlap at the toe of weld. Convexity and concavity shall not exceed 1.5 mm. The leg lengths shall not exceed the specified size by more than 1.5 mm.

All attachments such as lugs, brackets and other non-pressure parts shall also be done by qualified welders in accordance with the design details and material specifications. Temporary attachments shall be removed in a manner that will not damage the parent metal. Areas of temporary attachments shall be dressed smooth and examined by ultrasonic or liquid penetration methods. If weld repairs are necessary, they shall be made using qualified procedures and welders and examined by ultrasonic/ liquid penetration methods.

All tack welds shall be made using qualified procedure and welders, the number and size of tack welds shall be kept as small as to consist of adequate strength and joint alignments. All tack welds shall be examined visually for defects and if found defective shall be completely removed. As welding proceeds, tack welds shall be either removed completely or shall be properly prepared by grinding or filing their starting ends so that they may be satisfactorily incorporated in the welds. Unacceptable defects shall be removed by grinding machine or chipping or gouging. Flame gouging may be permitted provided gouged surfaces are ground at least by 1.0 mm below the deepest indentation.

All weld repairs shall be carried out using the approved welding procedures and welders. Preparation of weld repair shall have the prior approval of the Engineer. Re-welded areas shall be re-examined by the methods specified for the original weld and repair procedures shall be duly qualified by the Engineer.

All welded components shall be stress relieved prior to matching.

8.4.4**PRE-HEATING AND POST-HEATING TREATMENT**

Pre-heating and post-heating treatment shall conform to the relevant application codes. Pre-heating not exceeding 121 degree C for all carbon steel construction above 25 mm. thickness would be mandatory. Such pre-heating would be maintained during flame cutting, flame or arc gouging, welding and repairs and may be done by gas heating by gas torches/gas rings with neutral flame. The temperature shall be checked by temperature indicating crayons. However, such pre-heating will not be necessary for welds less than 6 mm size. In large diameter pipes, fabricated out of plate materials, production control test plates in accordance with the BS EN 1418 to represent 30% of the long seams and each welder's performance would be mandatory.

8.5**ELECTRODES**

The brands of electrodes to be used shall be submitted for approval of Engineer. All electrodes shall be stored in their original sealed containers under dry conditions. Electrodes shall remain identified until consumed. All electrodes shall be dried before use. Drying ovens shall be provided in work areas for drying purposes. Electrodes withdrawn from oven shall be promptly used and excess unused electrodes shall be promptly returned to oven.

8.5.1**EXAMINATION/NDT/RADIOGRAPHY**

The various stages of examination and types shall be as stipulated in the respective fabrication code. Radiographic examination shall be carried out as per provisions of BS EN 1435, ultrasonic tests, where called for, shall be carried out as per provisions of BS 3923-2 & BS EN 1714; magnetic particle tests shall be carried out as per BS EN ISO 9334-1:2001. Liquid penetration tests shall be carried out as per BS EN 571-1.

8.5.2**CASTING**

Cast iron shall be of standard grey close-grained quality. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects in depth not exceeding 12.5 percent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall notify the large defects and no repair welding of such defects shall be carried out without prior approval of the Engineer. If the removal of metal for repair should reduce the stress resisting cross section of the casting by more than 25 percent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then casting shall be rejected. Test coupons shall be cast simultaneously with the main castings shall be identified to check physical, chemical analysis of casting. Major defects on casting are not acceptable.

Castings repaired by welding for major defects shall be stress-relieved after such welding. Castings subject to hydraulic pressure shall be pressure tested to 1 1/2 times the rated pressure or, twice the working pressure, whichever is higher and certified copies of test reports shall be forwarded to the Engineer as soon as each test has been completed. Non-destructive tests as directed by the Engineer will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine whether repair welds have been properly made.

8.6 FORGING

All major stress-bearing forgings shall be made to a standard specification which shall be submitted to the Engineer for approval before work is commenced. Forgings shall be subjected to magnetic particle testing or dye penetration test at the areas of fillets and change in section. The testing shall be conducted after rough machining (10 microns). Any defect which will not machine out during the final machining, will be gouged out fully, inspected by dye penetration or magnetic particle inspection to ensure that the defect is fully removed and repaired using an approved repair procedure. Any indication, which proves to penetrate deeper than 2.5% of the finished thickness of the component, shall be reported to the Engineer giving the details like location, length, width and depth. For the magnetic particle inspection the choice of wet or dry particles shall be at the Contractor's discretion. All forgings shall be de-magnetized after test and shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer. The Engineer or the Inspector may inspect such forgings and identify test coupons to check physical and chemical analysis and witness such tests at the place of manufacture with a representative of the Contractor.

8.6.1 GUARDING OF SHAFTS

All rotating shafts, couplings, gears, flywheels, bolts, drives etc. shall be fully guarded to BS: 5304 or equivalent.

Guards shall be designed to provide ready access to bearings, greasing points and other check points to allow routine observations to be made by the operating staff without danger or the need to dismantle of the guard, Hinged doors let into the guard with adequate fastening shall be provided wherever necessary, to facilitate access to the check points.

Opening giving access to rotating parts shall be such that the standard tests fingers as illustrated in BS: 5490 Fig-1 or equivalent when inserted through any opening does not touch any moving parts.

8.7 DESIGN LIFE

The Works as a whole shall be new, of sound workmanship, robustly designed for a long reliable operating life and shall be capable of 24 hours per day continuous operation for prolonged period in the climatic and working conditions prevailing at the Site, and with the minimum of maintenance. Particular attention shall be given to temperature changes, the stability of paint finish for high temperatures, the rating of engines, electrical machinery, thermal overload services, cooling systems and the choice of lubricants for possible high and prolonged operating temperatures. The Contractor shall be called upon to demonstrate this for any component part either by service records, or evidence of similar equipment already installed elsewhere or relevant type tests. Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.

The pumping stations equipment shall be designed to provide easy access to and replacement of component parts which are subject to wear, without the need to replace whole units. No parts in contact with chlorinated water shall have a life from new to replacement or repair of less than five years. Where major dismantling is unavoidable to replace a part, the life of such part shall not be less than ten years.

Design features shall include the protection of pumping stations equipment against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Pumping stations equipment shall operate without undue vibration, and parts shall be designed to withstand the maximum stresses under the most severe condition of normal service. Materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have a detrimental effect upon the performance or life of the Works.

Pumping stations equipment located outside lockable areas/buildings shall have additional features to prevent unauthorized operation.

8.8 LUBRICATION

8.8.1 GENERAL

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer. Contractor shall indicate indigenously available equivalent lubricants, with complete specification, to enable the Engineer to arrange for regular supply as required.

Pumping stations equipment shall be lubricated, as necessary to ensure smooth operation, heat removal and freedom from undue wear. Lubricated items shall be designed so that they do not require more than weekly lubrication, unless otherwise approved by the Engineer. All grease nipples, oil cups and dip sticks shall be readily accessible, being piped where necessary to a convenient position. The Contractor shall supply the first fill of oil and grease for the pumping stations equipment and maintenance equipment.

The Contractor shall also provide enough consumables for all equipment necessary for operation and maintenance. For grease-lubricated ball and roller bearings, lithium-based grease is preferred.

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 and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position. All grease nipples shall be of the same size and type for every part of the pumping stations equipment. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Oil containers shall be supplied complete with oil level indicators of the sight glass type, or where this is not practical, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The levels shall be clearly visible in the sight glass type indicators from the normal access floor to the particular item of pumping stations equipment and they shall be easily dismantled for cleaning. All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged.

All lubrication systems shall be designed so as not to cause a fire or pollution hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or any other potential source of fire.

8.8.2 OIL LUBRICATION

Gear boxes and oil baths shall be provided with adequately filling and draining plugs and oil level indication. Roller chain drives shall have oil-bath lubrication. Drain points shall be positioned so that an adequately sized container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container is difficult, a drain valve and plug shall be provided at the point of discharge. Bearings equipped with forced-feed oil lubrication shall be automatically charged prior to machinery starting up, and pressure monitored during operation with automatic shutdown of machinery and alarm on low oil pressure. All points where oil leakage may occur shall be suitably trapped to prevent oil contamination of water. Oil filling and drain points shall be arranged to avoid the risk of contamination of water by accidental spillage. Access, without the use of portable ladders, to lubrication systems shall permit maintenance, draining and re-filling, without contamination of the charged lubricant. The design of breathers shall take into account the conditions at the vent point, and include measures to prevent contamination of the lubricant.

8.8.3 GREASE LUBRICATION

Grease application shall be by steel lubrication nipples manufactured in accordance with BS: 1486. Anti-friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples. Plain bearings requiring frequent charging shall be fitted with button-head pattern nipples. A separate nipple shall be provided to serve each lubrication point. Where a number of nipples supply remote lubricating points they shall be grouped together on a conveniently placed battery plate, with spacing in accordance with the recommendations of latest version of BS: 1486-1:1959. The Contractor shall provide a grease gun for each size and type of nipple installed. Where different types of grease are involved, separate grease guns shall be provided for each type. They shall be suitably labeled and, if possible, be of different styles to prevent incorrect greasing.

8.9 GASKETS AND JOINT RINGS

Joint rings shall be manufactured to conform to BS: EN 681-1 and BS EN 681-2. They shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80°C or greater, to suit the application. Joints shall be made in accordance with manufacturer's instructions or as specified herein. Each rubber ring or gasket shall be stored in the dark, free from the deleterious effects of heat or cold, and kept flat so as to prevent any part of the rubber being in tension. Only lubricants recommended by the manufacturer shall be used for rubber rings and these lubricants shall not contain any constituent soluble in the fluid conveyed. They shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners.

Graphite grease or similar shall be applied to the threads of bolts before joints are made.

8.10 NAME PLATES

Each item of the pumping stations equipment shall have permanently attached to it in a conspicuous position, a nameplate and rating plate. Upon these plates, the manufacturer's name, type and serial number of the equipment, details of the loading and duty at which the item of the equipment has been designed to operate, and such diagrams as may be required by the Engineer shall be engraved or stamped. All indicating and operating devices shall have securely attached to them or marked upon them designations as to their function and proper manner of use.

Nameplates, rating plates and labels shall be of a non-flame propagating materials, either non-hygroscopic or transparent plastic with engraved lettering of a contrasting color. Fixing shall be by means of non-corrosive screws; drive rivets or adhesives shall not be used.

Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on a yellow background.

Instruction labels shall be provided where safety procedures such as wearing of protective clothing are essential to protect personnel from hazardous or potentially hazardous conditions. These labels shall have inscriptions (in Hindi & English) or graphic symbols in white on a blue background.

Provision shall be made to incorporate descriptive numbering codes as indicated on the layout drawings. All valves shall have an identification plate bearing the valve number and a short description of valve function.

8.11 NUTS, BOLTS, STUDS AND WASHERS

Nuts, bolts, studs and washers for incorporation in the pumping stations equipment shall conform to the requirements of the appropriate standard. Nuts and bolts shall be of the best quality of specified grade, machined on the shank and under the head and nut. Bolts shall be of one piece construction and shall be of sufficient length so that only one thread shall show through the nut in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary. Jointing hardware for the equipment shall be provided with sufficient spares to cater for site losses.

Where bolts pass through structural members taper washers shall be fitted, where necessary, to ensure that no bending stress is caused in the bolt. 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, nuts and washers which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

The Contractor shall supply all holding down, alignment and leveling bolts complete with anchorages, nuts, washers and packings required to attach the pumping stations equipment to its foundations, and all bed plates, frames and other structural parts necessary to spread the loads transmitted by the pumping stations equipment to concrete foundations without exceeding the design stresses.

Bolts, nuts, screws and washers which may be submerged in a corrosive liquid shall be of stainless steel.

8.12 THREADS

All threads shall be of preferred metric sizes with the standard coarse form of medium fit to BS 3643-1&2 except for special applications, for which the metric fine thread or other thread forms may be utilized, subject to the approval of the Engineer.

8.13 GUARDS FOR MOVING PARTS

All moving parts shall be protected by safety guards. Guards shall be rigid, securely fixed and designed to allow normal operation, running maintenance and routine inspection on equipment without the need to remove the guard. Where this is impractical, guards shall be designed for easy fixing, dismantling and reassembly.

Guards to protect equipment from rain water: All outside installations like push buttons, motors panels etc. shall be protected from rain water. The guards should be corrosion free.

8.14 SAFEGUARDING OF PUMPING STATIONS

The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-suppression devices, written notices, safety colors and the like shall be provided where necessary during erection permanently.

Pumping stations equipment layouts shall provide easy and safe access to all operating devices, free from hazardous obstructions. Nothing in this Specification shall remove the Contractor’s obligation from drawing the attention of the Engineer to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of the pumping stations.

8.15 NOISE AND VIBRATION

Except as provided for below, the noise emitted by any single item of the pumping stations equipment shall not exceed a sound pressure level to the test requirements of ISO 3746 ‘Acoustic determination of sound power levels of noise services -survey methods’ or the equivalent ANSI: S12 36 - 1990 (R1997). The Contractor shall be responsible for all noise tests on site. Sound pressure levels shall be measured in dBA using a calibrated sound meter with its response speed set to ‘slow’. For major items of the pumping stations equipment, the Contractor shall provide certificates from the manufacturer covering noise-level tests on the items or type test certificates for similar items of equipment. If any item of the equipment does not comply with the above requirement, the Contractor shall reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials until the requirement is met.

Pumping stations equipment such as compressors, diesel/biogas engine generators, gas turbines, blowers, pumps and the like, where reduction in noise to below the required levels (i.e. 70 dBA in industrial areas and 45 dBA in residential areas during night time or as specified by the competent authority (whichever is lower) at a distance of 1m) is impractical, will be installed in separate rooms constructed in or containing sound-absorbing material. The noise level shall not exceed required levels when measured 1m from the outside of the room or structure. The Contractor shall provide hazard warning notices at the entrance to the room indicating that ear defenders must be worn. The Contractor shall provide a minimum of three pairs of ear defenders to BS EN 352-1:2002 which shall be stored in a dust-proof locker. Dust –proof locker shall be provided by the Contractor.

Diesel-engine exhausts shall incorporate acoustic splitter-type louvers to reduce noise level to required level at 1m distance.

The Contractor shall provide and fix all material for the prevention of transmission of noise and vibration through the structure. Where appropriate all fans, A/C package units compressors, and other motive equipment shall be mounted on resilient mountings in such a manner that the equipment foundations are isolated from the floor or structure. In addition, all rotating equipment shall be statically and dynamically balanced. Mechanical vibration shall be eliminated by the use of anti-vibration mountings and flexible connections to ensure an isolation efficiency of 95% from the building structure.

The noise level produced by any equipment like pump sets, centrifuges, compressor sets and blower sets shall not exceed 85 dBA measured at a distance of 1.86 m from the outline of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 2372-1974 with Amendment 1-1983.

Table 27 Range of mechanical vibration

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	2.8

8.16**PIPE WORK**

In general all pipes and fittings shall be steel or ductile iron with flanges to BS EN 1092.

Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed.

Flexible joints shall be provided to facilitate installation and removal and/or differential movement of plant. Where required, flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrust along the pipe work as a whole.

The pipe work shall be laid out and designed such as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipe work is used, the number of flanges is to be kept to a minimum with the size of each unit of pipe work determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for draining the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange which shall conform to the dimensions stated in BS EN 1092 but remain undrilled.

Unless otherwise specified, nuts, bolts and washers for pipework shall conform to the requirements of ISO 4039 / IS 1363.

Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

8.17 STEEL PIPE WORK

Pipe/fittings material and dimensional standard shall conform to following, if not specified in Part-6,

(i) Design pressure

- Pump suction : 10.2 Kg-f/cm^2
- Temp. : Ambient
- Discharge : 10.2 Kg-f/cm^2
- Corrosion allowance : 2 mm
- Design and Fabrication code : BS 2633, ANSI B.31.3

Item	**Size in mm (NB)**	**Material Specification**	**Dimensional Standard**
Pipes	Up to 150	IS:1239 PT-1, ERW Black	IS:1239 PT-1 C1 Heavy
	200 & above	IS:2062, Gr. B	IS: 3589
Elbows	up to 50	ASTM - A 105	ANSI B 16.11 3000 # S.W.
	65 to 300	ASTM - A 234 Gr WPB	ANSI B 16.9 LR. BE. Sch 40
	Above 300	IS : 2062, Gr. B	ANSI B 31-1
Coupling	up to 50	ASTM - A 105	ANSI B 16.11 3000 # S.W.
Tees	up to 50	ASTM - A 105	- do -
	65 to 200	ASTM - A 234 Gr WPB	ANSI B 16.9 BE, Sch 40
	Above 200	IS:2062, Gr. B	IS : 2825
Reducers	up to 50	ASTM - A 105	ANSI B 16.11 3000 # S.W.
	65 to 300	ASTM - A 234 Gr WPB	ANSI b 16.9 BE, Sch 40
	Above 300	IS : 2062, Gr. B	IS : 2825, Thickness matching with that for the higher dia.
Flanges & Blind	Sizes up to 2000	IS : 2062, Gr. B	BS EN 1092

Item	Size in mm (NB)	Material Specification	Dimensional Standard
Flanges	(flanges above this size shall be designed to IS:2825)		
Bolts & nuts	All	SS 304	ISO 4039 / IS: 1363
Gaskets	MS	IS:638 (Rubber reinforced CAF: (air service)	3 mm thickness up to 900 mm pipe 5 mm for 900-1200 mm 6 mm above 1200 mm

Hydraulic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure as appropriate.

Buried pipes in addition to above, shall be designed to withstand external loading exerted by soil, water, and live loads as relevant. The external ground water shall be taken at ground level for design purposes.

Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines. The Engineer shall duly approve all support design. All pipe joints up to 50 mm shall be socket welded and above 50 mm pipe joints shall be butt welded.

End preparations and fabrication requirements shall generally conform as per BS 2633. Flanges, if fabricated in segments shall be fully radio graphed and stress relieved. If fabricated out of billets/bars by cold rolling, welded flanges shall be radio graphed and normalized.

Protection for pipes laid underground: Where specific requirement is not mentioned such underground piping shall be encased in concrete after hydro tests. Such encasing if otherwise not specified shall ensure at least a covering of 150 mm all round. Alternately a coating and wrapping system giving a final coat thickness of 4.5 mm may be employed. Such protection shall comprise 1.5 mm of coal tar primer application on a thoroughly cleaned surface, to be followed with fiber glass wraps set in coal tar enamel coats conforming to American Water Works Association specification for a total thickness of 3 mm. Such lining shall meet a spark test to be approved with a detector of 10000 Volts.

The following stage wise inspection shall be required:

- Material identification
- Welder qualification
- Edge preparation and weld set up
- Back chip where applicable
- Mechanical tests/production control test coupon tests
- NDT as required
- Hydrostatic test at shop and site
- 10% of all butt welds shall be radio graphed

All flanges shall be to BS EN 1092 unless otherwise specified and in the case of steel pipe work, shall be slip-on type in the form of a collar fitting over the end of the pipe and welded in position both internally and externally. All flanges shall be machined over the whole face.

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrusts along the pipe work as a whole, so that external anchorages at blank ends, bends, tees and valves may be kept to a minimum. The Contractor shall indicate in his detailed drawings what thrust blocks are required to anchor pipe work supplied by him. Particular care shall be taken to ensure that pipe work thrusts are, as far as possible, not transmitted to machinery or other associated apparatus.

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

8.17.1**SMALL BORE PIPES AND HOSES**

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joints or joints formed by solvent welding are proposed for any line, a sufficient number of flanged or flexible joints shall be provided to enable the pipe work to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall be provided at convenient points for flushing pipe work through as required. All impulse piping up to 12 mm diameter shall be of 304 type SS with compression fittings.

All pipes and hoses shall be labelled such that individual lines may be identified throughout their run. Unless agreed by Engineer otherwise racks or trays shall be fixed to duct walls or walls of tanks and buildings, and the pipes shall grouped and fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. Single impulse tubing up to 12 mm may be run on appropriate steel/aluminium extruded sections properly secured to the walls of duct, building or equipment. In all cases, the routing, supporting the manner such piping are run shall be subject to the approval of Engineer.

8.18**VALVES**

All the valves shall conform to relevant BIS / BS specifications

Each valve shall bear on its body, as cast indications in raised letters, the following information:

- Size of the valve
- Pressure rating in bar
- Year of manufacture
- Manufacturer’s name
- Heat number on valve body / disc / gear box
- The name “BUIDCO” shall be engraved on SS plate & shall be fixed on Valve body separately.

All the above information engraved on SS plate shall also be fixed separately on the gear box body.

Unless specified otherwise valve bodies for all valves shall be tested to 2.0 times the maximum pressure or twice the working pressure whichever is higher. All gate/globe/check valves up to 50 mm size shall be forged steel construction to ASTM A 105 with ANSI 410 type trims with bolted bonnet, rising stem, with screwed or flanged ends. Ball valves with balls of ANSI SS 304 or 316 type and cast steel body and Teflon seats may be acceptable in place of gate valves in certain applications.

Where valves are to be remotely or automatically operated, it shall also be possible to open or close the valves by using manual means such as a hand wheel. All valves which are intended for only occasional use may be supplied for manual operation by means of a hand wheel or other suitable device which shall be fixed to the valve, but not by means of a tee key and bar. The operating gear of all valves shall be capable of opening or closing the valves against an unbalanced head 15 percent in excess of the maximum to be expected in service. Hand wheels of the valves above 300 mm nominal dia shall be rotated clockwise to open the valves, and shall be clearly marked with the words 'OPEN' and 'CLOSE' and arrows in the appropriate directions. The rims of hand wheels shall be machined to a smooth finish and chromium plated or shall be smooth plastic coated unless otherwise approved by the Engineer prior to installation.

Valves of 600 mm nominal bore and above shall be fitted with position indicators showing the extent by which the valve is open or closed in relation to its full travel.

All internal hardware viz. nuts, bolts & washers shall be of SS 316 and all external hardware shall be of SS 304.

Submergence test at a depth of 3 m for 48 hours shall be carried out on the Gear Boxes and shall be witnessed by the Engineer.

Gear Box Overload test at 1.5 times the rated torque shall be carried out and witnessed by the Engineer.

One number of manually operated gear box from each lot shall be tested by subjecting the gear box components to an over load of 1.5 times its rated torque by a suitable mechanism and applying a counter force on the output shaft so that this overload is undertaken. In such a situation all gear components get subjected to 1.5 times over load including the two stoppers. In addition to this, procedure shall be repeated for 3 / 4 open intermediate position. After the test the gear box shall be dismantled and shall be carefully examined in presence of the inspecting Engineer for any evidence of damage on gear teeth, housing, stoppers & other components etc. All the components of the gear box shall withstand this overload test.

8.19 SUPPORT OF PIPE WORK AND VALVES

Pipe work, valves and other connected equipment, or forming part of the operating system, **s**hall be provided with adequate supports, brackets, thrust blocks and fixtures, as necessary and in an approved manner, to restrict any induced vibration to a minimum, under any operating condition. Valves, meters, strainers and other devices mounted in the pipe work shall be supported independently of the pipes to which they connect. All brackets or other forms of support, which can conveniently be so designed, shall be rigidly built up of steel by welding in preference to the use of castings. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer. Vibration measurements shall be taken on site by the Contractor at various points on each complete machine as defined above. Measurements shall also be taken on connecting the pumping stations equipment. If any item is found to be vibrating beyond the level considered by the Engineer to be a reasonable minimum, the Contractor shall reduce the vibrations to the required level as specified in the relevant standards.

8.20 ALLOWANCES FOR WASTAGE

The Contractor shall supply to the satisfaction of the Engineer reasonable excess quantities to cover wastage of those materials, which will be normally subject to waste during erection, commissioning and setting to work and rates quoted in price schedules of price bid shall be deemed to include allowance for wastage.

8.21 ACCESS STEELWORK FOR PUMPING STATIONS

The Contractor shall provide adequate access to all of the pumping stations equipment to which access is necessary for routine maintenance and operation. Any small areas or other covering needed to cover gaps between equipment and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of the equipment to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

Chequered plating shall be of ‘Durbar’ or other non-lip pattern, not less than 6 mm thick (exclusive of pattern) and hot-dip galvanized after fabrication in accordance with BS EN ISO 1461.

Diamond type pattern chequered plate shall not be used. Open-type or solid-type chequered plate flooring shall be used as appropriate for the location, taking into account ease of cleaning, precautions against slipping and areas below walkways.

8.21.1 HANDRAILING

Hand - railing shall be double rail 1100mm high and 900mm high on stairs measured vertically from the nose of the tread. Standards shall be 38mm diameter solid forged steel to BS: 7668 and BS: EN 10029. Grade 43A with 60mm diameter solid forged steel balls at handrail locating points drilled to give 1.5mm clearance to handrails. Each ball shall incorporate a concealed grub-screw with Allen-type head to secure the rail. Standards shall have a minimum base width of 65mm, drilled for M16 fixing bolts and be set at maximum 1800mm centers. Handrails shall be 33.7mm OD × 3.2mm thick tubular steel to BS: EN 10297-1. Joints shall be arranged to coincide with the spacing of standards where possible, otherwise they shall have butt joints with a tubular steel ferrule, plug welded or fixed with a 5mm diameter countersunk head pin. Removable sections of handrail shall have half-lap joints secured with a countersunk head pin. Chains across openings shall be 10mm × 3 links per 100mm galvanized mild steel. The hooks and retaining eyes shall be securely fixed to the balls of the standards. All components for hand railing shall be hot-dip galvanized after manufacture in accordance with BS EN ISO 1461.

8.22 MACHINERY, LIFTING AND DISMANTLING

Machinery bedplate design, packing and fixing shall minimize distortion and vibration. Aligned machinery shall be mounted on bed or sole plates, permitting removal and reinstatement without a requirement to re-grout. Bedplates shall incorporate fine adjustment of the vertical and horizontal alignment between driver and driven equipment. All machinery shall be fitted with lifting facilities. Large structures shall be provided with jacking points. For pumping stations equipment subject to frequent dismantling, tapped holes or other provision shall be made in all main castings, for the insertion of jacking screws or the fixing of drawing gear. Bolts or studs shall be used in preference to set screws.

8.23 SEALS

8.23.1 GENERAL

The Contractor shall select a seal, compatible with his equipment and best suited for the worst conditions likely to be met when the pumping stations equipment is in operation. All seal materials shall be compatible with the fluid (including gases) being handled. For potable water, seal materials shall be subject to approval.

8.23.2 SOFT-PACKED GLANDS

Shafts shall be provided with renewable gland sleeves. Glands subject to abrasive liquids or negative pressures shall include lantern rings and a clean water continuous flushing system. Gland adjustment nuts shall be readily accessible. Gland drain pipe work shall be provided, discharging to the nearest sump or drainage channel.

8.23.3 MECHANICAL SEALS

Mechanical seals which are subject to abrasive or corrosive fluids (including gases) or negative pressures shall be provided with a clean water gland flushing system. A back-to-back sealing arrangement with a flushing/cooling system will be accepted as satisfying the requirements of this clause.

8.24 BEARINGS

The Contractor shall select the most appropriate type of bearing for the pumping stations equipment being supplied. Single journal plain bearings shall be phosphor bronze or synthetic lubrication impregnated bushes with carbon or stainless steel journals respectively. Synthetic bearings shall be used only where bearing condition can be inspected readily. Plain-type bearings shall be self-lubricating either by grease, forced oil or impregnation. Ball and roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft. The dismantling of bearings shall be simple and free from risk of damage. Bearings fitted to gearboxes shall have a minimum design life of 100 000 hours at maximum loading.

8.25GEAR BOXES

Gearboxes shall have a life of 100000 hours, be selected in accordance with American Gearbox Manufacturers' Association recommendation for horsepower and service factor application. They shall employ a standard reduction ratio. Gearboxes which have to be angle-mounted shall have a rating, choice of bearings, seals and lubrication system designed for such mounting. Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced-feed method to reach all bearings and gears.

8.26SAFETY SIGNS

All signs providing health and safety information or instructions shall comply with BS: 5499- 5:2002 and equivalent local standards. Signs shall be of durable quality and shall comprise a substrate of 22 gauge aluminum, predrilled for fixing and with radiuses corners free of burrs or sharp edges. Symbols and lettering shall be screen printed.

8.27CORROSION AND EROSION

Unless otherwise specified, the Contractor shall make proper provision for the prevention of corrosion and erosion in any part of the Plants and pumping stations. Provision shall include the use of suitable materials, choice of operating speeds, design of components and type of protective coatings and finishes.

Special precautions shall be taken to prevent corrosion due to humidity, rainfall and moisture. All wall-mounted equipment shall be fitted with spacers to provide a minimum gap of 5mm. All holes in equipment shall be effectively sealed against the ingress of water. All items exposed to the weather or water shall be free of water traps; where necessary, drain holes shall be provided to prevent the accumulation of water. All fixings, fastenings and spacers which may be submerged in a corrosive liquid shall be galvanized or sherardized, unless otherwise specified. All electrical equipment which is not sealed against free movement of air shall be protected from condensation with anti-condensation heaters. In general, heaters shall be thermostatically-controlled and switched off when enough heat is generated by operation of the Plants and pumping stations.

8.28SPECIAL TOOLS

Any Special Tools provided for maintenance of the Pumping Stations equipment shall be identified within the tender and supplied and handed over to the Engineer on completion of the work. Prior to handing over to the Engineer, the Contractor shall examine the tools which have been used during pumping stations equipment erection to ensure that they are not damaged and are in good condition.

The recommended optional tools including any special tools gauge, jigs or extractors which may be required for maintenance of the Pumping Stations equipment should be set out in an appropriate Schedule. A suitable lockable box shall be provided for all the small tools to be provided. Contractor shall supply four sets of:

(i) The tool kit: i.e., for the Pump room one set

(ii) Each tool kit shall comprise of following:

1. Hammers: ½ kg capacity – 1 no.

   1 kg capacity – 1 no.

   2 kg capacity – 1 no.

   5 kg capacity – 1 no.

2. Cold Chisels: 1 set

3. Suitable outside and inside calipers: 1 set

4. Double end spanners: 1 set (consisting of all sizes up to 25 nos)
5. Ring Spanners: 1 set (consisting of all sizes up to 25 nos)
6. Hacksaw frame: 1 set with a dozen of hacksaw blades
7. Measuring tape (Steel); 1 No. 6 mts. Long
8. Allen keys: 1 set
9. Pipe wrenches: 1 No. each of 12”, 18”, 24” & 36” (heavy duty)
10. Right angle: 1 No.
11. Aluminum spirit level: No 12” size
12. Bastard flat round half round files: 1 No.
13. Slider wrenches: 1 No. 11” size
14. Screw drivers (Insulated): 1 set of 6”, 8”, 12”
15. Insulated pliers: 1 No.
16. Pair of hand gloves for electrical purpose – 2 nos.
17. Lifting wire: 1 No., 8 foot long with top sealing fitting
18. Line tester: 1 No., 220V
19. Multi meter: 1 No.
20. Hydraulic grease gun of different sizes: 1 set
21. Bearing puller: 1 set
22. L.T. megger: 1 No
23. Tong tester: 1 No.
24. Tacho-meter (electric digital type): 2 nos.
25. Air blower (electric hot attachment): 1 No.
26. Steal almirah: 1 No. 180 x 90 x 50 cm. size GODREJ make. One each pump room
27. Wall clock: 1 – One no. each for pump room
28. Shock treatment charts: 2 nos. Each pump room

(iii) The complete tool kit set shall be provided along with other special tools required. Contractor and Engineer shall confirm those tools that are necessary and the cost shall be included in the cost of the pumping stations equipment and machinery.

(iv) The tools shall be Taparia, Gedore, Everest, Tata or equivalent make and testers/ meters etc. of reputed make and duly approved by the Engineer only.

8.29 FABRICS, WOOD, ETC.

Fabrics, cork, paper and similar materials, which are not subsequently to be protected by impregnation, shall be treated with an approved fungicide. Sleeving and fabrics treated with linseed oil and/or vanish shall not be used. The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and termites and free from shakes and warp, sap and wane, knots, faults and other blemishes. All woodwork shall be treated to protect it against damage by moisture, fungus, bacteria or chemical attack, unless it is naturally resistant to those causes of deterioration. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types, which are impervious to moisture and to attack by insects. Only synthetic resin cement shall be used for jointing wood.

8.30 PAINTING AND PROTECTION

8.30.1 GENERAL

The preparation, application and conditions for work shall comply with the recommendations of BS: 5493 and BS: 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions.

Paints, primers and undercoats shall be obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use.

No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4°C and the relative humidity less than 85% or as otherwise specified by the paint manufacturer, whichever is minimum. The Engineer shall approve the methods for removing all dirt, oil, grease, etc., before Site painting commence.

Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes.

To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white.

Priming to two mating surfaces shall be applied prior to assembly.

All items of the pumping stations shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the pumping stations.

All paint thicknesses shall be checked using an Elco meter or equivalent instrument, supplied by the Contractor, for each layer of paint, to the requirement of the Engineer.

All coatings applied to any part of the plant in contact with water to be used for drinking, washing or cooking shall be non-toxic, non-carcinogenic, shall not impart taste, odor, colour or turbidity to the water or foster microbial growth. No manufacturer’s name-plate identification, vented filler plugs in gearboxes or grease nipples shall be painted over. Lead based paints shall not be used.

The Contractor shall liaise closely with the plant manufacturer who shall provide full facilities for him to inspect and check the preparation and painting during all stages. The Contractor shall report on his inspections to the Engineer.

The Contractor shall ensure that all coatings are free from defects and adequate in all respects for the purpose intended.

8.30.2 SURFACES TO BE PAINTED

In general following surfaces are to be painted:

(i) All exposed piping and metal surfaces, interior or exterior,

(ii) All submerged metal surfaces.

(iii) All structural and miscellaneous steel, including Tanks,

(iv) The interior of process Tanks, Channels, launders and pits as specified in the painting schedule and as required after equipment installation.

(v) The interior of structures as specified in the painting schedule and required after equipment installation.

(vi) Equipment furnished with and without factory finished surfaces, except as specified below.

(vii) All interior and exterior exposed surfaces of buildings.

8.30.3 SURFACES NOT TO BE PAINTED

The following surfaces in general shall not be painted:

(i) Concrete surfaces subject to pedestrian traffic.

(ii) Plastic surfaces.

(iii) Non-ferrous metal unless otherwise noted or indicated (Galvanized metal shall not be considered a non-ferrous metal).

(iv) Piping which is specified as galvanized.

In no case shall any concrete, wood, metal or any other surface requiring protection be left unpainted even though not specifically defined herein.

8.30.3.1 *Submittals*

Material specifications, surfaces preparation and application instructions, and colour sample cards shall be submitted to the Engineer for approval.

8.30.3.2 *Paint to be provided to Engineer*

The contractor shall leave on the job site at the conclusion of the contract a minimum of four (4) liters of each type and colour of finish paint used on the work. Each container shall be properly labeled for identification.

8.30.3.3 *Painting System Failure*

The painting system shall be deemed to have failed if:

(i) After painting, damage has been caused by handling, impact, abrasion or welding;

(ii) Any portion of the paint film separates from any other or the parent metal;

(iii) After painting the total dry-film thickness is less than that specified.

Failure shall not include:

(i) Loss of gloss;

(ii) Variation of shade, not affecting the anti-corrosive properties of the system.

8.30.4 COLOUR CODING AND LABELING OF PIPES AND EQUIPMENT

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures.

Valves and fittings shall be painted in the same colour as of the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment.

All pipelines shall be identified by stick-on 90 micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one piece removable liners. Titles shall be at intervals not less than 8 m, but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by the use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick, with lettering etched and filled with black enamel.

Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

8.31**CLEANING AND PREPARING AT PLACE OF MANUFACTURE**

The Contractor shall be responsible for the cleaning and preparation for painting, priming or otherwise protecting as specified of all parts of the Plant at the place of manufacture prior to packing.

Cleaning

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary by washing with an approved dewatering fluid prior to surface treatment.

8.31.1**PREPARATION**

(a) Bright parts:

Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

(b) Embedded parts:

Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly descaled and cleaned to the requirement of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

(c) Cast Iron and Steel Pipe Work:

All non-galvanized steel pipe work including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified in BS:7079

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with BS: 7079 to a standard between `First Quality' and `Second Quality’ given in Table 1 of BS: 7079 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

The first coat of primer shall be applied before the development of any detectable moisture or corrosion and, in any case, within four hours of completion of the grit blasting.

(d) Exposed Ferrous Parts Other Than Pipes Inside Buildings:

All exposed ferrous surfaces which will not be submerged below water or any other liquid or exposed to damp conditions shall be rubbed down, and well cleaned and given one coat of red lead primer to BS 2523 Type C before packing.

(e) Non- Ferrous Parts:

All surfaces of non-ferrous parts are to be protected from corrosion by the application of approved grease. Individual parts shall be prevented from touching during shipping by wrapping them separately with waterproof paper or tape. Care shall be taken to ensure that galvanic corrosion does not take place due to contact of dissimilar metals.

(f) Submerged Steelwork:

All submerged steel parts or parts exposed to damp conditions shall either be hot dip galvanized (120 microns thick) or be grit blasted and primed with a zinc dust epoxy resin based coating giving a dry film thickness of at least 50 microns.

8.31.2PAINTING AND FINISHING AT PLACE OF MANUFACTURE

This Clause governs the methods for the protective coatings to be applied to structural steel, metal work and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard – BS: 5493 "Code of Practice for the Protective Coating of Iron and Steel against Corrosion"

8.31.3PROTECTIVE COATING

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval.

Protective coating shall be designed in accordance with BS: 5493/BS EN ISO 12944 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in BS: 5493 Table 3 Part 2 `Exterior exposed polluted inland'. Bulkhead gates and stop logs shall be assumed to be exposed to a Table 3 Part 8 `Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems:

(i) Protective Coatings;

(ii) Galvanizing;

(iii) Galvanizing plus painting;

(iv) Multi-coat painting;

(v) Bitumen enamel;

(vi) Others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories, as follows:

(i) Trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;

(ii) Structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stop logs, grappling beams, steel tanks and other large items readily accessible for maintenance;

(iii) Valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications:

(iv) Other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty;

(v) Electrical switchgear, transformers, control panels etc.

All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

Plant supplied to site with final coating applied: cubicles, cabinets etc. other than those specified in elsewhere in tender document.

Before any steel work is painted, the steel must be thoroughly cleaned and an approved anti-rusting priming coat shall be applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two stoved undercoats and two top coats of air drying paint. The undercoats shall be easily distinguishable in shade or colour from the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

8.31.4 CHROMIUM PLATED PARTS

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of BS EN 12540 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be bright. Where the base metal is steel, plating shall be applied in accordance with relevant Table of BS EN 12540. Other base metals shall be plated in accordance with relevant Tables of BS EN 12540 as appropriate. For all base metals the service condition table number 2 shall be used.

Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before Taking Over.

8.31.5 GALVANISED PARTS

All materials to be galvanized shall be shown on the approved drawings or specified. All punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanizing process begins. Parts to be galvanized shall be shot blasted as specified above in clause 3.29.4.2. Such parts shall be galvanized not more than four hours after commencement of shot blasting.

All galvanizing shall be done by the hot dip-process in accordance with BS EN ISO 1461. Minimum thickness of 120 microns shall be ensured with coating thickness gauge. No alternative process may be used without the approval of the Engineer. No components shall be galvanized which are likely to come into subsequent contact with oil.

The zinc coating shall be uniform, clean smooth and free from spangle as far as possible. In the case of component parts the zinc coating shall weigh not less than 610 g/sq.m of area covered and shall not be less than 120 microns in thickness.

Where hot-dip galvanizing is not practicable bolts and nuts shall be sherardized, which shall conform to BS: 4921. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanized parts shall be protected from injury to the zinc coating due to differential seration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with approved zinc-dust paint or other approved flake metallic compound as approved by the Engineer as follows.

8.32 DUCTILE IRON AND STEEL PIPE WORK: (INTERNAL SURFACES)

(i) The internal surfaces shall have an approved coating.

(ii) Where a bitumen based coating is used, it shall be in accordance with Type 2 of BS: 4147.

(iii) Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with BS: 534. After installation, the internal lining shall be made good and satisfactorily tested with required detector.

(iv) The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the `Taste and smell test' (Appendix E of BS: 4147) and `Effects on water test' (Appendix C of BS: 3416) and forward 3 copies of the test results to the Engineer for approval.

(v) Where pipes are to be welded after the protective coatings have been applied, the pipe surfaces shall be primed and all other coating stopped of the weld preparation. Collars and fittings shall be primed but no other coating will be applied.

(vi) The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials. In case manufacturer does not supply suitable materials to repair damage, it is the contractor’s responsibilities to supply the same at his own cost and do the necessary repair.

(vii) The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of BS: 3416. The Contractor is to ensure the same.

8.32.1 MACHINERY- (INTERNAL SURFACES):

8.32.1.1 *(e.g. Pumps, valves, strainers, rising and suspension mains of wet well pumps):*

As specified for cast iron and steel pipe work (Internal surfaces).

8.32.2 PLANT FORWARDED TO SITE FOR FINAL FINISHING:

Cast iron and steel parts (External surfaces) outside buildings: All non-galvanized metal parts, which will be exposed to the outside atmosphere, shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings: All exposed metal surfaces which will not be immersed in waste water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

8.32.3 PAINTING AT SITE

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer’s works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal-tar epoxy polyamine coating to a total dry film thickness of 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint. Before application of each coat of epoxy based coal-tar paint giving a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes.

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.

8.32.4 PAINTING SYSTEM REQUIREMENTS

The painting work shall conform to the following requirements:

(i) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005

(ii) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.

(iii) For finish painting, after application of primer as in (b) of clause 5.4.1 above, two coats of synthetic enamel paint conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.

(iv) Colours shall be selected as per IS: 5

(v) No painting shall be carried out unless the item has been inspected and accepted by Engineers at the Manufacturer's works

(vi) The dry paint film thickness shall be measured by Elco meter or other instruments approved by the Engineer. In order to obtain the dry film thickness (DFT) specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm2. Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

8.32.4.1 *Painting Procedure*

The painting procedure shall be submitted by the contractor in the following format:

(i) Surface Preparation

(ii) Reference Standard

(iii) Conditions of Work

(iv) Type of Materials

(v) Tests and inspection methods and sequence, thickness (DFT)

(vi) Colour in final coat

(vii) Total thickness of coats (DFT)

(viii) Other necessary data and information

The following items in the plant are required to be painted:

(i) Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated waste water

(ii) Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.

(iii) Internal Plant and pipe work, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather

(iv) Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.

(v) Steelwork exposed to humid weather and requiring hard maintenance and repairs

(vi) Buried steelwork

(vii) Buried pipes and fittings prior to application of wrapping

(viii) Other equipment, as per requirement of Engineer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil lime wash or any other coating.

No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the qualified, experienced & competent painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure.

The Plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's Works and at the Site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Engineer.

8.32.5 **FUSION-BONDED EPOXY POWDER COATINGS**

All fabricated steel pipe work and other Plant where specified, shall have a lining and coating, not less than 250 microns thick, of 100% solids, thermosetting fusion-bonded, dry powder epoxy coating. All grit and dust shall be removed and coating shall be started before formation of visible oxidation of the surface. The metal shall be pre-heated to a temperature recommended by the manufacturer and the epoxy powder applied by immersion in a fluidized bed, after which excess powder shall be removed. The powder shall be allowed to flow out completely before curing. The thickness of the coating, including any repaired areas, shall be checked with a calibrated tester. Spark testing, for pinholes, voids, contamination, cracks and damaged areas, shall use a high-voltage spark generator. Repairs due to coating imperfections or damage shall be done using a brush-applied compatible two-pack liquid epoxy compound. The area to be repaired shall be cleaned to remove dirt, grease, scale and damaged coating, which shall be feathered. Pinhole surface preparation is not required other than removal of detrimental contaminants which could impair the adhesion of the repair material. The surface coating shall be applied by an approved applicator. GRP covers and guards shall be pigmented to give the finished colour without painting.

8.32.6 PUMPING STATIONS FINISH

A high standard of finish, defined as “the pumping stations “is required for all surfaces to be painted as detailed below.

8.33 WELDING AND FLAME CUTTING

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions.

8.34 CASTINGS

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be specially selected with this in mind.

All castings shall be shot blasted before machining.

8.35 COVERS

All covers shall be firmly fixed. Weld mesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

8.36 FLANGES AND BEADINGS

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

8.37 ITEMS TO BE CHROMIUM PLATED

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good, by the contractor at his cost.

All pipes and fittings etc., shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

8.38 EXTERNAL SCREWS, BOLT HEADS, NUTS AND WASHERS

These shall be chromium plated, sherardised or made in stainless steel.

8.39 GAUGES

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

8.40 PAINT MATERIALS

All paint materials shall be first quality products manufactured for the exposures involved, as approved by the Engineer. Paints which are to be in contact with water or chemical solutions shall be completely inert and free of lead and other toxic substances.

8.41 WORKMANSHIP

Protection of the Work: The Contractor shall take the necessary steps to protect the work of others during the time his work is in progress. The Contractor shall be responsible for any and all damage to the work. Paint shall be applied only during periods of favorable weather.

Preparation of Paint: All materials specified or selected for use under these specifications shall be delivered unopened at the job site in their original containers and shall not be opened until inspected by the Engineer. Paint containers shall be opened only when required for use. Paint shall be thoroughly stirred or agitated to uniformly smooth consistency suitable for proper application. In all cases, paint shall be prepared and handled in a manner to prevent deterioration and inclusion of foreign matter. No paint shall be reduced or applied in anyway except as herein specifically called for or, if not specifically called for, then it shall be applied in accordance with the manufacturer's recommendations.

Preparation of Surfaces: The Contractor shall examine carefully all faces to be finished and before beginning any of his work shall see that the work of the other trades has been left or installed in a workmanlike condition to receive paint. Metals shall be clean, dry, and free from mill scale, rust, grease, and oil.

Quality: Each coat of paint shall be applied at the proper consistency and brushed evenly, free of brush marks, sags, runs, with no evidence of poor workmanship. Care shall be exercised to avoid lapping paint on glass or hardware. Paint shall be sharply cut to lines. Finished paint surfaces shall be free from defectsor blemishes.

Protective Coverings: Protective coverings or drop cloths shall be used to protect floor, fixtures, and equipment. Care shall be exercised to prevent paint from being spattered onto surfaces which are not to be painted. Surfaces from which such paint cannot be removed satisfactorily shall be painted or repainted, asrequired to produce a satisfactory finish.

Tints: Whenever two (2) coats of paints are specified, the first coat shall contain sufficient powered aluminium or carbon black to act as an indicator or proper coverage, or the two (2) coatings must be of contrasting colour.

Instructions: All coatings shall be performed by personnel experienced in the application of said coating systems and in accordance with the manufacturer's printed instructions. The final appearance shall exhibit a uniformly textured and coloured coating free of excessive gloss or dull spots, blemishes, sags, runs, pinholes, and other defects.

8.42 VENTILATION

The Contractor shall not permit painting to begin in enclosed places, until a forced draft ventilation system of sufficient air volume has been placed in operation.

8.43 RIGHT OF REJECTION

No exterior painting or interior finishing shall be done under conditions which may jeopardize the appearance or quality of the painting or finishing in any way. The Engineer shall have the right to reject all material or work that is unsatisfactory, and require the replacement of either or both at the expense of the Contractor.

9 SUB-SECTION 9: INSPECTION, TESTING, ERECTION AND COMMISSIONING

9.1GENERAL

Inspection and tests schedule shall be as follows;

(i) Manufacturer tests

(ii) Acceptance Inspection / Quantity checking

(iii) Install /Site Inspection

(iv) Site Acceptance Test

All equipment of the plant shall be liable for inspection and testing before dispatch at the Manufacturer's premises or workshop, as required by the Engineer, who reserve the right to be present in all testing to see that the equipment conform to the specifications. No materials shall be delivered to the site without inspection having been carried out or waived in writing by the Engineer.

All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification, relevant Indian Standard or internationally approved equivalent standard.

All types (as applicable), routine and acceptance tests shall be conducted in the presence of Engineer / Third Party Inspection Agency on all the equipment as per latest applicable IS/IEC at no extra cost. Any modification / revision in the equipment as required by the Engineer shall be carried out by the Contractor without any extra cost. All such costs / fees for revisions / modifications shall be deemed to be included in the prices of supply of equipment as quoted by the Contractor. Typical type test reports for other equipment shall be submitted by the Contractor for approval by Engineer.

After award of contract, Contractor shall furnish a QA plan for approval by Engineer. QA plan shall include testing for incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Contractor alone and those by both Contractor and Engineer.

The Engineer and/or duly authorized and designated representative/Third Party Inspection Agency, to be appointed by Engineer, shall be entitled to attend the aforesaid inspection and/or tests.

The Engineer and/or duly authorized and designated representative/Third Party Inspection Agency shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Engineer to inspect as if the plant and equipment was manufactured on the Contractors own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Engineer who will have the right to witness or inspect the above mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

For bought out items, the Manufacturers shall have to show to the Engineer the test and guarantee certificates of the original materials supplier and furnish photocopies of the same for Engineer's records.

Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance and provide all of test result with necessary document including its data and photo to show Engineer that test is carried out in proper condition and the its test results.

The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract in whatever place they are specified shall be as described below.

(i) The Contractor shall give the Engineer at least 21 clear days' notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. The Engineer or his duly authorized representative shall thereupon at his discretion notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The Engineer shall then give notice in writing to the Contractor, and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Engineer shall issue to the Contractor a notification to that effect.

(ii) The Contractor shall forward to the Engineer duly certified 6 copies of the test certificates and characteristics performance curves for all equipment.

(iii) If the Engineer fails to attend the inspection and/or test, or if it is agreed between the parties that the Engineer shall not do so, then the Contractor may proceed with the inspection and/or test in the absence of the Engineer and provide the Engineer with a certified report of the results thereof as per (ii) above.

(iv) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

(v) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works.

(vi) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Engineer, or the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.

(vii) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Engineers at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognized/Laboratory for the Engineer's consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

(viii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Engineer and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.

(ix) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

(x) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Engineer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following :

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling, if any sampling test to be conducted.
- Contractor's or Engineer's witness points.

(xi) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Engineer written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Engineer's satisfaction.

(xii) The Inspection and Testing procedures shall be carried out for the equipment as applicable. The detailed procedure shall indicate or specify, without limitation, the following:

- Material Certificates for all the specified materials
- Welding Qualification
- Stage Inspections (in process inspection)
- Visual Inspection.
- Dimension Checking
- Dynamic balancing for all rotating parts
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Operation check
- Liquid penetrate tests or magnetic particle tests for all machined surfaces of pressure parts.
- Ultrasonic test for forging materials viz.,
    - Plates of thickness 20mm and above for pressed / formed parts.
    - Plates, flanges and bars of thickness / dia. 40mm and above used for fabrication of pressure and load bearing members and rotating parts.
- Radiographic testing for all but welded parts, as per applicable codes.
- Hardness tests for all Hardened surfaces.
- Type, routine and acceptance test, as applicable

The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and based on the datasheets / drawings / specifications.

The expenses incurred during inspection shall include, but not be limited to, all travelling, boarding, lodging and out-of- pocket expenses.

(i) For inspections within India, the Contractor shall incur all the expenses of Engineer/Engineer and/or duly authorized(s)/Third Party Inspectors. All the Contractor's expenses with respect to the aforementioned inspection shall be reimbursed by the Engineer against the provisional sum inclusive of contingencies on production of documentary evidence and invoice.

(ii) For inspection outside India, the Contractor shall incur the expenses of Engineer, Engineer and delegates of Engineer)/Third Party Inspectors. All the Contractor's expenses with respect to the aforementioned inspection(s) shall be reimbursed by the Engineer against the provisional sum inclusive of contingencies on production of documentary evidence and invoice.

(iii) However, cost of inspection when equipment/material or any part of the facilities is not ready at the time specified by the Contractor for inspection or when re-inspection is necessitated by prior rejection shall be borne by the Contractor and will not be reimbursed.

Witnessed testing will normally be waived off on standard types of equipment such as small motors made by approved manufacturers, individual standardized instruments, small mass produced components used in the manufacture of Plant items, small bore pipework and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

All destructively tested samples shall be replaced with new.

9.2MATERIALS, PLANT AND EQUIPMENT

The Contractor shall place orders for the material and the equipment only after approval of the Engineer.

The contractor shall submit detailed credentials about experience, turnover, quality assurance system of the manufacturers of following items for approval of Engineer before submission of data sheets and drawings for approval:-

S. No.	Equipment
[A] MECHANICAL EQUIPMENT	
1.	Submersible Pump sets and Vertical Turbine pump set
2.	Electric Motors
3.	Gate Valves / Sluice Valves, Non Return Valves, Dual Plate Check Valve
4.	Butterfly Valves
5.	Actuator
6.	Sluice Gates
7.	Cast Iron Pipes & Fittings and Dismantling Joints
8.	Chain Pulley Block
9.	Flow Meters
10.	Dosing Pump/Metering pump
11.	Electro Chlorination System
12.	Gear Box
13.	Fire Extinguisher
[B] ELECTRICAL & MECHANICAL EQUIPMENT	
1. 1.	Outdoor Substation Equipment
	SF6 Circuit Breakers
	Isolators
	Lightning Arrestors
	Voltage and Current Transformers
	Insulators and Hard wares
	Relay & Control Panel
2.	Power transformers
3.	Auxiliary transformers
4.	HV Metal enclosed switchgears /MCC

S. No.	Equipment
5.	HV Vacuum Circuit Breaker
6.	Protective Relays
7.	H.T & L.T Current Transformers
8.	Neutral earthing resistors
9.	LV Switchgears /MCC
10.	Lighting Fixtures and Accessories
11.	L.T Power Capacitors
12.	Cables
13.	Battery
14.	Battery Chargers
15.	Cable Termination Kits
16.	Lighting Arrester
17.	Soft Starter/SD starters
18.	Ceiling Fan
19.	Exhaust Fan
20.	Submersible Pump sets
21.	Electric Motors
22.	Gate Valves / Sluice Valves, Non Return Valves
23.	Butterfly Valves
24.	Actuator
25.	Ductile Iron Pipes & Fittings and Dismantling Joints
26.	Chain Pulley Block
27.	EM Flow Meters
28.	Dosing Pump/Metering pump
29.	Electro Chlorinator
30.	Gear Box
31.	Fire Extinguisher
[C] INSTRUMENTATION EQUIPMENT	
1.	Level Indicator Transmitter
2.	Flow meters/Flow Indicator/ Transmitter/ domestic and bulk flow water meters

S. No.	Equipment
3.	Pressure Gauges
4.	Pressure Indicator Transmitter

The Contractor shall submit the detailed drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein:

The Contractor shall supply the manufacturer's test results and quality control certificates. The Engineer will decide whether he or his representative will inspect and test the material / equipment or whether he will approve it on the basis of the manufacture’s certificate.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawing and data sheets have to be approved by the Engineer before manufacture and testing. The equipment/material has to be inspected by the Engineer or a third party inspecting agency approved by the Engineer at the manufacturer’s premise before packing and dispatching. The contractor shall provide the necessary equipment and facilities for tests and the cost thereof shall be borne by the Contractor.

Category B: - The drawings and data sheets of the equipment have to be submitted and approved by the Engineer prior to manufacture. The equipment/material has to be tested by the manufacturer/contractor and the manufacturer’s test certificates are to be submitted and approved by the Engineer before dispatching of the equipment. Notwithstanding the above, the Engineer, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of the Engineer’s and Contractor’s representatives.

Category C: - Samples of the materials and/or equipment shall be submitted to the Engineer for pre-construction review and approval. Following approval by the Engineer, the material may be manufactured as per the approved standards and delivered to the Site.

For material/equipment under Category “A” and “B”, the Engineer will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

9.3 CATEGORY OF INSPECTION

The categorization of the various material, equipment and plant for purpose of inspections is as below. However, this list can be altered and additions or subtractions done or categories changed in due course during the implementation of the Contract by the Engineer.

9.3.1 MECHANICAL WORKS

Table 28 Category of Inspection for Mechanical Works

S. No.	Items	Category of Inspection
A)	**Mechanical Works**	
1.	Submersible Pump sets and VT pumpsets	Category A
2.	Sluice Valves with / without Actuators (above 300 mm size)	Category A
3.	Butterfly valve with the actuator (above 300 mm size)	Category A
4.	Non-Return Valves/Dual Plat Check Valves	Category A
5.	Pipe work above 100mm	Category A

S. No.	Items	Category of Inspection
6.	Electro Chlorinator	Category A
7.	Dismantling joints	Category C
8.	Fire Extinguisher	Category C

9.3.2**ELECTRICAL WORKS**

Table 29 Category of Inspection for Electrical Works

S. No.	Items	Category of Inspection
1.	HV Outdoor Current Transformer	Category A
2.	HV Outdoor Switch Disconnector/ Isolator	Category A
3.	HV Outdoor Lightning Arrester	Category A
4.	Gantry/ Structure for Switchyard/ Transmission Line	Category A
5.	Transformer	Category A
6.	HV Vacuum Circuit Breaker and Bus Coupler	Category A
7.	HV and LV switchboards	Category A
8.	Starter for LV motors	Category A
9.	Battery and Battery Charger and DCDB	Category A
10.	Outdoor 11 kV accessories for substation (i.e. Fuse, ACSR Conductor, Clamps and connectors, hardware,	Category B
11.	Neutral Grounding Resistor	Category B
12.	Sub-Distribution Boards, Lighting Panels	Category B
13.	Lighting System	Category B
14.	UPS System	Category B
15.	HV, MV and LV Power and Control Cables	Category A
16.	Earthing System	Category B
17.	Cable tray and accessories	Category B

9.3.3**INSTRUMENTATION WORKS**

Table 30 Category of Inspection for Instrumentation Works

S. No.	Items	Category of Inspection
1.	Level switches	Category B

S. No.	Items	Category of Inspection
2.	Bulk Flow Meter	Category A
3.	Full Bore Electromagnetic Flow meters	Category A
4.	Ultrasonic type level measuring systems	Category A
5.	Instrumentation and Control câbles	Category B
6.	Battery and Battery Charger Panel	Category B
7.	Pressure transmitter	Category A
8.	Motorized Actuators for valves	Category A
9.	Chlorine dosing control panel	Category B
10.	Pressure Gauges	Category B

9.4**FACTORY ACCEPTANCE TEST (FAT) DOCUMENT**

Thirty (30) days prior to commencement of inspection of each Plant and equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Un-priced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests, the Contractor shall provide four copies of all test certificates, curves etc. for the inspected Plant item. Test certificates shall be provided for the Plant item as a whole plus certificates for the relevant component parts.

The Contractor shall submit to the Engineer, not later than 35 days prior to the commencement of the first inspection and test during manufacture, a programme detailing the inspection dates for all Plant. Those items of Plant that the Engineer has specifically identified for witness testing test shall be highlighted in the programme.

The Contractor shall keep the Engineer informed of any changes to the programme.

The Engineer shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Engineer’s Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material etc. a subsequent date shall be finalised for carrying out the inspection in which event all expenses incurred by the PWSSB for such visits shall be recovered from the Contractor. In case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the PWSSB for such visits shall also be recovered from the

Contractor. Contractor's Representatives shall essentially be present during all inspections. The following information shall be given in the inspection call letter mentioned above:

(i) Name of manufacturer/supplier;

(ii) Address of place where inspection is to be carried out;

(iii) Proposed date/s and equipment to be inspected;

(iv) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.

(v) Name of Contractor's Representative who will be present during the inspection.

(vi) Confirmation that internal testing has been completed.

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, engineers/ workers, and others to carry out the tests after assembly at his cost. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates with expire date and name of authorization agency for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests.

If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer.

9.5**TESTS AT MANUFACTURER'S PREMISES – MECHANICAL EQUIPMENT**

9.5.1**MECHANICAL EQUIPMENT**

9.5.1.1***Submersible Pump sets***

1. General

The performance guarantee tests shall be conducted in two stages i.e., first at the manufacturer’s works and finally at work site after complete installation and commissioning, including all preliminary test before final successful test in complying with the Engineer’s approved test and inspection method and relevant standards.

The contractor shall state the guaranteed performance figures in Schedule VIII, Part 1- Section IV, Bidding Forms. i.e. the efficiencies and duties of the pumping plants, when working at specified condition of the pumping and the guaranteed performance in K.W. hour input under various conditions of working at $\pm$ 25% of designed heads.

The guaranteed performances are also to be specified under following conditions i.e., variation in head, discharge and energy power consumption in the following cases:

When there is variation of +/- 10% in supply voltage.

(i) When supply voltage varies from rated voltage by $\pm$ 10%.

(ii) When there is fluctuation of + 5% in the frequency of the A.C. power supply i.e., 50 c/s.

(iii) When there is combined variation in voltage and frequency of A.C. power supply simultaneously by + 10%.

All pump sets shall undergo witness performance tests at the pump manufacturer’s Works. The pumps shall be stripped after performance test and checked for any wear and tear and for final tolerances and clearances. In case any wear-tear is noticed and specified clearances are exceeded, the pump set shall be rejected.

All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted. 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.

Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.

The tests shall cover the entire range of total head from shut-off to the minimum total head at which the pump can operate without cavitations, noise, or vibration with suction well water level indicated on the drawings as low water elevation. The minimum head shall be equal to or less than the run out head specified for each pump. Data shall be recorded for not less than seven points between shut-off and minimum total head for suction well low water elevation.

For final tests, pumps shall be run so as to obtain the range heads specified in the performance tables by means of throttling of opening valves on the pumping mains and test results will be compared with those guaranteed by averaging the KW consumption hour and overall efficiency/quantity curves shall be plotted to demonstrate that the plant will be capable of meeting the full range of operating conditions at Site.

After factory performance tests, the Contractor shall submit six (6) copies of test reports.

2. Performance Guarantee Tests (Factory Tests)

For performance tests, pumps shall be run so as to obtain the designed head and range heads specified in the performance tables by means of throttling of opening valves on the pumping mains and test results will be compared with those guaranteed by averaging the KW consumption.
The pumps shall undergo witnessed performance (acceptance) tests as per BS EN ISO 9906:2000/ ISO 9906 applicable for Grade 1 at the rated speed at the pump manufacturer's factory. Performance test shall be conducted at the rated speed at manufacturer's works to measure the capacity, total head, efficiency and power. For acceptance, criteria specified by the said standard (BS EN ISO 9906:2000/ ISO 9906 applicable for Grade 1) for minus tolerance of pump discharge flow, pump head, pump efficiency etc. shall not be allowed. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over the entire range comprising shut off head to maximum flow at run out head specified at which the pump can operate without cavitation, noise, or vibration with suction pool water level indicated. Minimum seven readings approximately equidistant shall be taken for plotting the performance curve. The following formula shall be taken for computing the power input to the pump set:

$$\text{Power input to the Pump set in kW} = \frac{Q \times H}{367.2 \times \eta_p}$$

Where, Q = Discharge in cub-m/hr

H = Total head in mwc in case of Horizontal Pumps and Effective Head in case of V T Pumps

η_p = Efficiency of pump set.

If the vibration, noise level readings taken during performance test at manufacturer's works show higher values than that permitted, Contractor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor. If the proposed modifications recommended by the contractor are not acceptable to the Engineer, the pump unit shall not be accepted.
The material certificates, physical properties, heat treatments and shop test certificates of pump casing, impeller, shaft, shaft sleeve, impeller and casing rings shall be duly approved and certified by the manufacturer and these shall be subject to review and approval by Engineer.

Notwithstanding the above requirement for inspection and quality control, the following inspection and quality control measures shall be carried out by the Manufacturer, but not limited to:

(i) Identification of all materials used in construction, check of their conformity to standards specified, sample coupon identification for cast, forged components, particularly of impeller, shafts, couplings, fasteners etc. and approval of materials for further processing.

(ii) Check of heat treatment of various components.

(iii) Check of machining accuracies, tolerances including horizontality, parallelism, concentricity, surface finish, run outs, rating tolerances, etc.

(iv) Mating clearances, tolerances, machining accuracies, run outs etc. of bearing housing, impeller and casing wear rings, etc.

(v) TIR of shafts.

(vi) Dyes penetrate Test on impeller and wear rings.

(vii) Ultrasonic test of all shafts.

(viii) Hardness test of mating components where differential hardness is specified like wear rings.

(ix) Surface preparation and painting of external surfaces.

(x) Any other tests, including NDT (as applicable), as specified in the data sheets / drawings / specifications.

3. Failure to Attain Guaranteed Discharge and Power Consumption

If during Performance Guarantee Tests, the discharge and energy power consumption of any of the pumps are found to be lesser than the guaranteed figures specified in Technical Schedule Section VII B; Volume 4, the Contractor shall make such changes, modifications and/or additions as may be necessary and shall arrange for the tests to be repeated at his own cost and expense to achieve the guaranteed performance. If, after such corrective measures, the pump is still unable to achieve the guaranteed figures within the allowable tolerance, the Engineer shall reject the pump.

In case the Contractor elects to pay liquidated damages to the Engineer in lieu of making changes, modifications and/or additions to the Facilities, then the Contractor shall pay liquidated damages at the rate mentioned here below, but not limited to:

(i) The guaranteed figures stated by the contractor in the required Technical Schedule shall be subject to no tolerance and average results shall be obtained during tests on each pump.

(ii) If the less satisfactory results than the guaranteed are obtained, then the contractor shall pay liquidated damages as mentioned in Schedule VIII. Functional Guarantees, Section IV (Table 1 (D)) (Part 1) relating to each pump set installed:

9.5.1.2***Valves***

All tests shall be carried out on all valves as per the latest edition of BIS or internationally approved standard.

During testing there shall be no visible evidence of structural damage to any of the valve component.

Motorized valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.

Hydrostatically testing shall be as per relevant IS/BS standard for each type of valve.

The following tests shall be carried out for sluice valves, Knife Gate valves:

(i) Pressure test

(ii) Leakage test

(iii) Seat leakage test

(iv) Body hydrostatic test

(v) Valve operation

The following test shall be carried out for non-return valves:

(i) Pressure test

(ii) Leakage test

(iii) Seat leakage test

(iv) Body hydrostatic test

(v) Valve operation

9.5.1.3 *Cast Iron / Ductile Iron Pipes*

(i) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Engineer. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

(ii) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

(iii) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

(iv) Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

9.6 ACCEPTANCE TESTS ON ELECTRICAL EQUIPMENT AT MANUFACTURER'S WORKS

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of the bid specifications.

9.6.1 SWITCHGEAR AND MOTOR CONTROL GEAR ASSEMBLIES

Switchgear and control gear shall be witness tested as complete assemblies.

Factory built assemblies of HT/LV switchgear and control gear shall be tested in accordance with relevant Indian Standards. Additionally, switchgears and control gear assemblies shall be tested for the following:

1. Interchange Ability

All components of the same rating and construction, designated as draw out or plug-in shall be demonstrated as being interchangeable.

2. Protection and Control Circuits

For all forms of current transformer protection the following information, as applicable shall be made available to the Engineer before the time of inspection:

(i) Current transformer magnetising curve.

(ii) Recommended relay setting.

(iii) Calculated primary operating current at this setting

(iv) Calculated through-fault stability values where applicable.

(v) Values of any stabilising and setting resistors employed in the system.

As far as possible, based on the completeness of the circuits, in the final manufactured form within manufacturer's premises, the satisfactory operation of associated control and protection circuits shall be proved by the following tests as applicable:

(i) To ensure the correct operation of all relays and coils at the recommended setting by current injection.

(ii) To ensure the correct polarity between current and voltage elements of power relays, meters and instruments.

(iii) To ensure the correct operation of control circuits at normal operating voltage by operation of local control switches and simulation of operation from remote control positions.

Note: Checking the operation of protection relays and control circuits shall be carried out with all relevant circuits energized at their normal rated voltage.

The following tests shall be carried out:

(i) Dielectric tests at approved voltages.

(ii) Primary injection tests to ensure correct ratings and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.

(iii) Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.

(iv) 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.

(v) Correct functionality of the equipment in all modes of control.

9.6.2 TRANSFORMERS

Transformers shall be subject to routine and acceptance tests including efficiency tests, as defined in the relevant standard.

Type test certificates not later 3 years shall be provided for the following:

(i) Impulse voltage withstand

(ii) Temperature rise.

9.6.3 BATTERY AND BATTERY CHARGER WITH D.C DISTRIBUTION BOARD

The Battery and Battery Charger with D.C Distribution Board will be subject to works routine and acceptance tests as defined in the relevant standards

9.6.4 CABLES

All cables and armoured cables shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards.

Test certificates shall be provided against each drum and/or cable length.

The tests carried out on every cable length and/or drum at manufacturer's premises shall include:

(i) High voltage DC insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable

(ii) Insulation resistance test

(iii) Core continuity and identification

(iv) Conductor resistance test.

9.6.5 HV DISCONNECTORS

Disconnectors shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards.

9.6.6 HV LIGHTNING ARRESTOR SET

Lightning Arrestor shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards.

9.6.7 HV DROP-OUT FUSE

Drop-Out Fuse shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards.

9.6.8 HV OUTDOOR ISOLATOR KIOSK

HV Outdoor Isolator Kiosk shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards.

9.7 TESTS AT SITE - MECHANICAL EQUIPMENT

In addition to the progressive supervision and inspection by Engineer, the Contractor shall offer for inspection to Engineer, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Engineer. Such tests shall include but not be limited to the tests specified in following clauses.

The Contractor shall possess during the entire working period the Electrical Contractor's license of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

9.8 PUMPS

9.8.1 PERFORMANCE GUARANTEE TESTS (FIELD - PROJECT SITE) AND OTHER INSPECTION

As soon as convenient after the pumps are installed, each pumping unit shall be field tested to determine that the units have been properly installed, to verify factory tests, and to demonstrate that the complete units will operate continuously without overheating and that the drives are not overloaded.

The performance tests will be witnessed by the Engineer and these tests shall be conducted as per details mentioned under "Factory Tests".

The tests to demonstrate satisfactory continuous operation shall be for five (5) continuous hours. During the field test operation the total head shall be as near the condition point total head as conditions at the site will permit.

Reading off all essential data shall be taken and recorded at 30 minute intervals. All instruments required for the readings shall be acceptable calibrated devices furnished by the Contractor at no additional cost to the Engineer. Readings required include, but are not limited to, voltage, amperage, power factor, RPM, suction water level, discharge pressure and flow, temperatures and vibration. Full details of test procedures will be determined or approved by the Engineer based on conditions existing in the field at the time of the tests. The Contractor shall submit six (6) copies of all results arranged and neatly presented for the approval of the Engineer.

The following testing and inspections will also be performed:

(i) Visual inspection of the pump and motor alignment, integrity of the couplings and levelness of the base-plate.

(ii) Verify the integrity of the coating systems. Any gouges, scratches, unbonding or other holidays (i.e. low voltage porosity detectors or pin whole detectors) in the coating system shall be repaired.

(iii) Verify the integrity of the connecting piping, valves, gauges and instrumentation devices.

(iv) Check the start-up and shutdown sequencing for each pump and verify it is correct.

(v) During pump operation, check for the sounds of air binding, cavitation and bearing misalignment. Contractor has to take corrective actions should any of these be found.

(vi) Measure the shut off head and head at full pump speed with all valves fully open. Check these values against the specification for any significant discrepancies.

(vii) Take vibration, noise and power draw measurements, using portable equipment, for compliance with the specifications.

(viii) Operate each pump continuously for 24 hours without the need to restart the pump resulting from an automatic or forced shutdown procedure.

No pump shall be accepted by the Engineer until each of these items has been complied with.

9.9 PIPING AND VALVES

Leakage tests shall be carried out on all erected pipework, pumps and valves immediately after erection and where possible before being built in.

Operating tests shall be conducted on valves.

The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

9.10 MOTORS

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

9.11 CRANES

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load.

9.12 SLUICE GATE

Leakage test shall be performed by the Contractor after installation of the Sluice Gates.

Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS: 13349, for shop testing.

9.13 ACCEPTANCE TESTS ON UNINTERRUPTIBLE POWER SUPPLIES AT MANUFACTURER'S WORKS

The contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilizing the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

(i) Change-over from full load with mains present to full load on battery supply

(ii) Carry out a discharge test on the system at full load and for the specified duty bridging time period.

(iii) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

9.13.1 INSPECTION AT SITE

During erection of the plants and equipment the Engineer will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Engineer.

9.13.2 PLANT PROTECTION ON SITE

Factory finished plants and equipment shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

9.14 ERECTION

9.14.1 GENERAL

The Contractor's staff shall include adequate and competent erection engineers with proven, suitable, previous experience on similar Contracts to supervise the erection of the Works and sufficient skilled, semi-skilled and unskilled labour to ensure completion of Works in time. The Contractor shall not remove any representative, erector or skilled labour from the Site without prior approval of the Engineer.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering.

In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate. Also the Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all Plant.

The Contractor shall ensure that no installation or erection work shall commence until full and unconditionally approved working drawings, signed and stamped by the Engineer are available at Site.

The Contractor's erection staff shall arrive on the Site on dates to be agreed by the Engineer. Before they proceed to the Site, however, the Contractor shall first satisfy himself, as necessary, that sufficient plant of his (or his sub-contractors) supply has arrived on Site so that there will be no delay on this account.

The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

The Contractor's representative responsible for erection shall be an erection engineer who is conversant with the erection and commissioning of the complete Works. If there are more than one erector, one of them will be in charge and the Contractor shall inform the Engineer in writing which erector is designated as his representative and is in charge. Erection engineer is to report to Project Manager.

During erection of the Plant the Engineer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Engineer.

It shall be the responsibility of the contractor to obtain necessary License / Authorization / Permit for work from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

9.15 WORKMANSHIP

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors or operating staff who may be present at the time. Before commencing any erection work, the Contractor shall check the dimension of structures where the various items of Plants are to be installed and shall bring any deviations from the required position, lines or dimensions to the notice of the Engineer.

Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the approved drawings. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid approved drawings. If any damage is caused by the Contractor during the course of erection to new or existing Plant or buildings or any part thereof, the Contractor shall, at no additional cost to the Engineer, make good, repair or replace the damage, promptly and effectively as directed by the Engineer and to the Engineer satisfaction.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the items concerned. The Contractor shall ensure that all equipment is securely held and remains in correct alignment before, during and after grouting-in.

The Contractor shall be responsible for setting up and erecting the plant to the line and levels of reference and of the positions, levels dimensions and alignment, appliances and labour in connection therewith. The checking of setting out of any line or level by Engineer shall not in any way relieve the Contractor of his responsibility for the correctness thereof.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the Engineer. In case the cleaning is not up to the Engineer’s satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the Engineer in this regard will be to the Contractor’s account.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipework and all other apparatus.

9.16 PRECAUTIONS

The approval by the Engineer of the Contractor’s proposals for rigging and hoisting any items of the Plant into their final positions shall not relieve the Contractor from his responsibility for damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items, whether structural, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No Plant, equipment or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be uniformly transferred to floor beams and girders. If it is required to reduce bending stresses and deflection, the beams and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Engineer.

9.17 CONTRACTOR’S EQUIPMENT, MATERIALS AND APPURTENANCES

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Engineer shall be made good by the Contractor to the satisfaction of Engineer.

9.18 LEVELLING AND GROUTING OF MACHINERY

Contractor shall undertake, sufficiently in advance, chipping of any unevenness of concrete on foundations, anchor bolt pockets, cut-outs etc., to achieve uniform level of reference for erection. All concrete surfaces receiving grout shall be chipped as required to ensure better bonding with the grouting.

Contractor shall undertake the inspection of all components to be erected sufficiently in advance to check their soundness and conformity to drawings and the inspection records shall be signed by the Engineer as approval for undertaking the installation of the components. Any damage, shortfalls etc. shall be made good to the satisfaction of the Engineer.

All grout for equipment shall be carried out using non-shrinkable continuous grout materials with suitable framework of at least 12mm thickness. Surfaces to receive the grout shall be chipped and roughened and laitance shall be removed by wire brush or blast of air. Concrete surface shall be blown off by compressed air before commencing grouting. Grouting shall be done in one continuous operation from one side such that grout flows in a single wave until grout reaches all confined spaces with no air pockets and air from all confined spaces is expelled. A hydrostatic head of 150 mm shall be maintained during grouting operations. All grouting shall be carried out in the presence of the Engineer. All lines and levels shall be checked after grout is set. Blockouts shall be closed using cement concrete of the same grade as that of the parent structure.

9.19 RECORDS, PROCEDURES AND REPORTS

The Contractor shall maintain records pertaining to the quality of installation / erection work and inspection, testing, compliance with all technical requirements in respect of all his works as described in the previous paragraphs. The reporting formats shall be in the approved formats. The Contractor shall submit such records to the Engineer after the completion of any particular work before submitting the bill of supply / progress of work. Such report shall comprise shop inspection reports, shop testing reports, material test reports, based on which dispatch clearances are provided, and all the quality control reports of welding, erection and alignment records.

All the above mentioned records shall be submitted in the final form duly countersigned by the Engineer attesting conformity to specifications and his approval of installation, and duly incorporating all the additions, alternations, and information as required by the Engineer, on the basis of preliminary reports giving the progress of the work. Such records notwithstanding, any records submitted earlier with bill of supply / progress, etc., shall be duly bound and submitted to the Engineer in six copies by the Contractor on his notification of the mechanical completion of erection.

9.20 GENERAL PREPARATIONS BEFORE COMPLETION OF THE ERECTION WORKS

All documents are to be completed in accordance with the Contract schedule before completion of erection.

The Engineer and the Contractor shall preserve and control these documents in a safe and appropriate place on Site in order that both parties' personnel can make use of them at any time.

9.20.1 TECHNICAL DOCUMENTS

(i) Operation and Maintenance manual

(ii) Design documents including the Contractor's design data, drawings and Specifications.

(iii) Tools and test equipment list

(iv) Spare parts list

(v) Lubricant list

9.20.2 PROCEDURES

(i) Mechanical testing procedure

(ii) Electrical testing procedure

(iii) Instrumentation testing procedure

(iv) Detailed pre-commissioning and commissioning procedures

(v) Detailed Performance Test procedure

9.20.3 MANPOWER

Required manpower shall be provided as agreed between the Contractor and the Engineer in a Manpower Mobilization Plan, which shall include the number and qualifications of the operator and maintenance personnel to be furnished by the Engineer for the Plant.

9.21 FIELD CONTROL INSPECTION

Contractor shall conduct periodic field control inspection to prevent any field accident. The Engineer shall field inspect jointly or conduct unannounced inspections.

9.22 COMPLETION OF ERECTION

The completion of plants and equipment under erection by the Contractor shall be deemed to occur if all the units of the Plant are structurally and mechanically complete and will include, among other such responsibilities, the following:

(i) Plants and equipment in the Scope of the Contract has been erected, installed and grouted as per specifications.

(ii) Installation checks are completed and approved by the Engineer.

(iii) Erected plants and equipment are totally ready for commissioning checks.

At the stage of completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the plants and equipment is fit and sound to undergo tests on completion and subsequent pre-commissioning checks.

Upon achieving the completion as described above, the Contractor shall, after having given 21 days advance notice of the expected date for carrying out the inspection, notify the Engineer by a written notice intimating completion of erection and notify the Engineer for inspection. The Engineer shall proceed with the inspection of such units within 24 hours of such a notice.

The Engineer shall certify completion when there are no defects / defaults in the Works or provide the Contractor with a list of deficiencies for rectification, hereinafter referred as the “Punch List”. The Contractor shall complete the rectification work within a jointly agreed period before pre-commissioning activities and obtain the Engineer’s acceptance or approval before proceeding with the same.

The Engineer may inform the Contractor that the works are accepted with the Punch List (items which do not hamper operability, safety or maintainability) and allow the Contractors to proceed with the pre-commissioning checks when the Contractor under-takes to complete such outstanding works within an agreed time prior to or during the defects liability period. Taking over shall be based on rectification of all deficiencies which are to be completed before acceptance, as advised by the Punch List.

The erection period indicated by the Contractor would be deemed to cover all the activities up to Completion as stipulated in previous paragraphs, notice of completion by the Contractor, inspection by the Engineer for Completion, and Contractor’s rectification of all deficiencies as noticed by the deficiency/Punch List, and acceptance by the Engineer of such rectification’s, prior to Tests on Completion.

Minor defects, which in the opinion of Engineer do not hamper operability or maintainability, will not be taken into account for deciding Mechanical Completion Such defects shall be rectified concurrent to commissioning checks before Tests on Completion. However, the Engineer’s decision in this regard is final.

The commissioning period as notified by the Contractor shall include all periods of pre-commissioning, trial runs and tests on completion.

It is in the Contractor's interest to offer the section/units/systems, progressively under Identified milestones within overall erection period, duly completed for rectification of any deficiencies pointed out by the Engineer and to achieve mechanical completion before undertaking the tests on Completion within the specified erection period. The Engineer also reserves the right to withhold the cost as estimated to be equivalent to the rectification of deficiencies pointed out to the Contractor until such a time as the deficiencies are rectified by the Contractor to the satisfaction of the Engineer.

9.23 INSPECTION AFTER ERECTION

After the erection of any item of plants and equipment and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per relevant specifications.

All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Engineer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Engineer

(i) All shop inspection records compiled and bound in 4 (four) copies.

(ii) All erection and commissioning procedures duly approved.

(iii) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Engineer of such completion of section/units/systems and readiness for inspection for acceptance of mechanical completion of erection. The Engineer/ Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Engineer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

9.24 PRE-COMMISSIONING

After the completion of erection, pre-commissioning activities listed below shall be carried out to make the Plant ready for commissioning. All instruments, materials and provisions necessary for conducting site tests shall be provided by the Contractor at his own cost.

Upon completion of erection of each piece of equipment, facility, mechanical checks and tests shall be carried out according to the Contractor's checklist. The mechanical checks and tests shall be to establish that:

(i) The plants and equipment is erected in accordance with the Contractor's construction drawings, pipe work drawings, instrument diagrams, etc., issued for the Plant;

(ii) Materials are installed and mechanically function in accordance with the Contract; and

(iii) Applicable codes as listed in the Contract are followed for materials and workmanship.

Items such as painting, thermal insulation and final clean-up which do not materially affect the operation or safety of the Plant will be excluded. All these items shall be listed and completed after pre-commissioning or commissioning at the discretion of the Contractor, but before acceptance.

The Contractor shall prepare and maintain at Site test forms and records, which shall include:

(i) Description of type of test or check;

(ii) Date and times of test or check;

(iii) Identification of equipment and facilities;

(iv) Test pressure, test data and results, including remarks, if any; and

(v) Signature of the Contractor's personnel attesting to data recorded; if any. The Contractor's construction forces thereof shall carry out checks, tests and records.

Wherever the Engineer's witnessing or attesting of the check or test is required, the Engineer or his Representative shall attend such check and test. For this purpose, the Contractor shall keep the Engineer informed of a day-to-day test plan schedule. The test plan schedule may be revised from time to time to reflect the actual progress of the work and test.

Any items found incomplete or requiring repair or adjustment shall be marked as such on the test records and reported by the Contractor to the Engineer and the Contractor's personnel in charge of the relevant construction area.

Checking procedures shall be repeated until all the items on the checklist are cleared.

A complete set of test records shall be handed over to the Engineer on completion.

9.25 **PRE-COMMISSIONING INSPECTION AND TESTS**

The tests on the different mechanical, electrical and instrumentation equipment shall include but not be limited to the following:

9.25.1 **MECHANICAL**

1. Pumps, Piping and Valves

(i) 1.5 times the shut off Pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract.

(ii) Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.

(iii) Operating tests shall be conducted on valves.

(iv) The pumps shall be tested for mechanical performance to check and verify efficiency, KWI of each pump and vibrations. The vibration and noise levels shall be checked to be within the specified limits.

(v) Pump performance tests shall be conducted for all raw sewage and sludge pump sets with initial duty impellers. Each pump shall be tested at a time.

(vi) The clear water pumps shall be tested at specified flow as per BS EN ISO 9906:2000 or any latest revision.

2. Pump Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

3. Instrumentations

(i) Tests on Cables

- Check details are in accordance with the specification
- Check for physical damage
- Megger test between each core and armour / sheath
- Continuity check
- Connections

(ii) Continuity of Signal/Control/Power Supply Cables

After laying of the field signal/control/power supply cables and prior to connection up to the control panels/instruments, the following procedures shall be adopted:

- The signal/control/power supply cables shall be disconnected from each termination point in turn when the wires shall be 'rung-through' for identification and tagged.
- The signal/control/power supply cables shall be reconnected to the termination points and again 'rung-through'.

(iii) Loop Test

After testing and calibration of individual instruments forming the various loops, simulated functional test of the whole loop shall be performed before pre-commissioning. The procedure for conducting these tests shall be decided by the Engineer and results shall be recorded. During loop test, it is the Contractor's responsibility to ensure that the calibration of instruments is intact and in order and if any instrument is found defective in calibration, he shall recalibrate the same without any extra cost. After the loop test is over, he shall connect back all the terminations and connections removed for loop test.

(iv) Tests on Electrical Installation

- Check all closing, tripping, supervision and interlocking of control devices.
- Check operation of all alarm circuits.

(v) Final Operational Testing and Acceptance

- Upon completion of instrument calibration, all systems shall be tested under process conditions.
- The testing shall include, but not limited to all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failures, interlocks and operational interlocks between systems and/or mechanical equipment.
- Any defects or malfunctions shall be immediately corrected using approved methods and materials and the tests shall then be repeated.

Upon completion of final operational testing, a report shall be submitted, indicating that the total control system provided meets all the functional requirements specified herein. This report shall be made in the format required by the Engineer. The Engineer shall certify this report when he approves it and it shall constitute final acceptance of the control system.

9.25.2**ELECTRICAL**

The commissioning engineer may verify any commissioning tests / completion checks to satisfy him that the plant is fit and sound.

The commissioning tests / completion checks to be carried out shall include, but not be limited to, those described in subsequent paragraphs, as applicable to the individual equipment / system.

1. Preliminary Checks

In general, the following checks shall be carried out on all the equipment/systems, as applicable.

- Name plate details according to approved drawings / specifications
- Any physical damage or defect and cleanliness
- Tightness of all bolts, clamps and connections
- Oil leakages and oil level
- Condition of accessories and their completeness
- Clearances
- Earthing connections
- Correctness of installation with respect to approved drawings / specifications
- Lubrication of moving parts
- Alignment
- Correctness and condition of connections

2. General tests

(i) Commissioning Tests of Motor

- Insulation resistance test of motor windings and cables. (PI for MV motors only)
- Continuity check for power and control cables.
- Winding resistance measurement in case of motors rated 55 kW and above.
- Control, interlock and protection schemes.
- Operation and setting of timer, in case of Star Delta starters.
- Phase sequence and rotation.
- No load trial run for observation of vibrations, noise and temperature of bearings etc.
- On load operation, starting and running load current (also observe vibrations, noise and temperature of bearing and winding).
- Relay setting as per relay co-ordination chart
- Simulation check of motor control circuit by local/ remote closing and tripping.

(ii) Commissioning Tests of Transformer

- Test oil for dielectric strength, tan delta, acidity, and resistivity and dissolved gases, Insulation resistance test of windings.
- Capacitance and tan delta test of condenser type bushings, before assembly.
- Test the transformer for the following:
  - Voltage / turns ratio at all the taps.
  - Winding resistance at all the taps.
  - Short circuit impedance (at low voltage)
  - Magnetic balance.
  - Core loss at normal tap at low voltage.
  - IR and PI.
- Vector group test.
- Phase sequence test.
- Test the current transformers for following:

  - Continuity test.
  - Polarity test.
  - Insulation resistance test.
  - Magnetization characteristics.
  - Measurement of secondary winding resistance.

- Line connection as per phasing diagram.
- Winding resistance.
- Insulation resistance of control wiring.
- Buchholz relay operation (for alarm and trip).
- OLTC control indicating and alarm circuit.
- Operation test of all protective devices (electrical and mechanical) and interlocks.
- Calibration of temperature indicators (oil and winding) and temperature relays.

(iii) Commissioning Tests of Switchboard

- Checks on relays.
- Insulation resistance test
- High voltage test
- Millivolt drop test for busbar joints
- Checks on motors/ simulation check.
- Setting of relays, other alarms, tripping devices and interlocks as per scheme.
- Phase angle checks, measurement of magnitude and phase angle of current transformer secondary currents and potential transformer secondary voltage.
- Functional checking of all power and control circuits e.g. closing, tripping, control, interlock, supervision and alarm circuits including proper functioning of the component equipment.

(iv) Commissioning Checks of Relay

- Check operating characteristics over the entire range by secondary injection.
- Check minimum pick up voltage.
- Check operation of electrical / mechanical targets.
- Relay settings.

(v) Commissioning Checks of Meter

- Check calibration.
- Megger all insulated portions.
- Check CT and VT connection with particular reference to their polarities for relevant meters.

(vi) Commissioning Test of Circuit Breaker

- Check control wiring for correctness of connections, continuity and IR values.
- Manual operation of breaker.
- Power closing / operating manually and electrically.
- Breaker tripping and closing time.
- Trip free and anti-pumping operation.
- IR Values, resistance and minimum pick up voltage.
- Contact resistance.

- Simultaneous closing and mechanical interlocks provided.
- Check electrical and mechanical interlocks provided.
- Checks on spring charging motor, correct operation of limit switch and time of charging,
- Checks on CTs.
- High voltage test,
- All functional tests.

(vii) Commissioning Tests of Voltage Transformer

- Insulation resistance test.
- Polarity test.
- Ratio test on all cores.
- Line connections as per connection diagram.
- Open delta test with low voltage, wherever required.

(viii) Commissioning Tests on Current Transformer

- Megger between windings, winding terminals and body.
- Polarity test.
- Ratio identification checking of all ratios on all cores by primary injection of current.
- Magnetization characteristics, secondary winding resistance.
- Capacitance and tan delta test.
- Dielectric test of oil (wherever applicable).

(ix) Commissioning Checks of Cable

- Megger test between each core and armour / sheet.
- Continuity check.
- Connections.
- High voltage test for cables above 3.3kV.

(x) Commissioning Checks for Battery

- Specific gravity test.
- Cell voltage test.
- Capacity test.
- Initial charging/ discharging cycle.

(xi) Commissioning Checks of Battery Charger

- Functional check of auxiliary devices, such as alarms, indicating lamps etc. and operational checks.
- Insulation test of all circuits.
- Measurement of voltage regulation and efficiency.
- No load current and voltage (AC) and voltage and current (both AC and DC) at different points.
- Voltage at tap cell (While boost Charging)

(xii) Commissioning Checks of Capacitor

- Measurement of capacitance
- Capacitor loss tangent measurement (for above 1000V)

(xiii) Commissioning Checks of Neutral Grounding Resistor

- High voltage test
- Ohmic value test

(xiv) Lighting System

Commissioning tests stipulated in applicable standards and code of practice covering all lighting system equipment

(xv) Earthing System

Continuity of all conductors and joints shall be checked. The Engineer may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth grid resistance value should be not greater than one ohm.

9.25.3**INSTRUMENTATION AND CONTROL**

1. General

The testing of all the equipment and accessories shall be carried out as per latest applicable Indian/International standards recommendations.

After installation and commissioning, the Contractor shall demonstrate, by tests in the field, compliance of the values, functionalities, quality and reliability of the complete system and its components, both hardware and software, as specified and as per guarantees.

2. Site Calibration

Standard calibration procedures shall be used for calibrating all field instruments. All reference equipment, used for calibration, shall be certified from an authorized certifying agency, to be arranged by the Contractor at his own cost. At the time of calibration, standard calibration norms shall be adopted and the same will be documented for record purposes.

Calibration shall be performed in the presence of the Engineer. The instrumentation shall be calibrated while being commissioned in order to verify that the high quality calibration carried out during FAT is not being disturbed (No undue adjustments shall be made for minor deviations). The Contractor will monitor and check the instrument calibration throughout the Operation and Maintenance period.

3. Instrumentation Installation and Pre-Commissioning Checks

(i) Check the exact location of the instrument with reference to the pipe and instrumentation diagram and/or the General Arrangement drawing.

(ii) Check that tag plate with tag no. and description is provided for each instrument.

(iii) Check the model No. and instrument type with reference to the technical specification requirements.

(iv) Check all mounting and fixing arrangements and required accessories such as isolation valve, nuts and bolts, siphon etc.

(v) Check that the instrument installation is as per the installation drawing.

(vi) Check the cable type, connections for power supply as well as signal cables.

(vii) Check that cable shields for the instruments are properly terminated.

(viii) For the flow meters, check that the flow rate and totalized flow reading on the various displays match.

(ix) Check that the earthing is as per manufacturer’s recommendation.

(x) Check that there are no leakages.

(xi) For the level switches check that the level electrodes are connected to the correct level control units.

(xii) Check the loop continuity for every circuit. While this is being done, the power supply to the instrument shall be cut-off.

(xiii) Calibration checks of the instruments shall be carried out to ensure integrity with the manufacturer's factory test reports. (No undue adjustments shall be made for minor deviations

(xiv) After switching on the instrument/system, it shall be monitored hourly and the data obtained shall be recorded and compared with the reference norms to ascertain whether any recalibration is required. If recalibration is required it shall be carried out using standard reference equipment/instruments at no extra cost.

4. Instrumentation Commissioning

(i) Annunciation system shall be checked as performance testing by simulating the condition and by passing in actual mode and then individual loop will be checked for annunciation system.

(ii) All motorized valves shall be checked in manual mode first, from controls on the control panel, and feed-back from the field for valve on/off shall be checked on the panel.

5. Control Panel

(i) Check name plate details of every piece of associated equipment for conformity with the specifications.

(ii) Check the tightness of all bolts, clamps, connecting terminals.

(iii) Check for physical damage.

(iv) Check cleanliness

(v) Check switch development

(vi) Each wire shall be traced by continuity tests and it should be confirmed that wiring is as per the relevant drawings. All interconnections between panels/equipment shall be checked

(vii) Megger test on all wires.

(viii) Check on meters

(ix) Check that the primary devices are set as per the system requirements.

(x) Checks on the control circuit for the functional requirements

(xi) Check that the control panel front fascia layout is as per approved drawings.

(xii) Check that the panel and all the panel equipment (viz. panel indicators, alarm annunciators, etc.) are connected to the proper earth.

(xiii) Check that spare cutouts on the control panel are blanked.

(xiv) Check that the panel indicator tag plates reflect the tag no. and the correct service description.

(xv) Check whether the panel meters are fixed properly in their cutouts.

(xvi) Check that the instruments are identified inside the panel.

(xvii) Check that the panel meter instrument ranges are as per approved data sheets.

(xviii) Check that panel meters are provided with password protection facility.

(xix) Check that the alarm inscription details are as per approved drawings.

(xx) Check that the MCBs are identified by their function.

(xxi) Check that safety guards are provided for power supply terminals.

(xxii) Check the cables terminating in the control panel are properly dressed.

(xxiii) Check that proper node addresses are given to the panel meters/ scanners connected on the communication bus.

(xxiv) Check that the communication bus is terminated properly.

(xxv) Check working of alarm annunciator by simulating alarm conditions.

(xxvi) Check that the panel meter readings match with other displays.

(xxvii) Check that the no. of decimal places and unit of measurement are same for all the displays.

(xxviii) Check that the data sheets and drawings are updated to reflect the as-built status.

9.26 COMMISSIONING TESTS

Following commissioning tests are to be carried out on all the equipment/systems, as applicable.

(i) Insulation resistance measurement of equipment, accessories, cabling/wiring etc.

(ii) Dielectric tests on equipment, accessories, cabling/ wires etc.

(iii) Phase sequence and polarity

(iv) Voltage and current ratios

(v) Vector group

(vi) Resistance measurement of winding, contacts etc.

(vii) Continuity tests

(viii) Calibration of indicators, meters, relays, etc.

(ix) Control and interlock checks

(x) Settings of equipment and accessories

(xi) Checking of accuracy/error

(xii) Checking of operating characteristics, pick-up voltages and currents, etc.

(xiii) Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.

(xiv) Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.

(xv) Complete commissioning checks of the system

9.27 SAFETY PROCEDURE AND PRACTICE

Following safety procedure and practice should be provided by the Contractor in the switchboard room/ substation as per latest edition of I.S. 5216.

(i) Rubber matting in front of HV and LV switchboard and other panels in switchboard room

(ii) Shock treatment chart in switchboard / electrical equipment room

(iii) Caution/Danger Board on -

- HV and LV switchboard and other LV panels
- Lighting distribution board
- Transformer yard.

(iv) Sand bucket in switchboard / electrical equipment room/ transformer yard

(v) Fire extinguisher in switchboard/ electrical equipment room

(vi) One set of hand gloves in switchboard room

(vii) First aid box in switchboard / electrical equipment room

9.27.1 FIRE SAFETY

The requirement of hand appliance in switchboard room, electrical equipment room shall be as per the latest edition of Fire Protection Manual of Govt. of India / Punjab Government.

9.28 SITE ACCEPTANCE TEST DOCUMENT

7 days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

9.29 PERFORMANCE/ACCEPTANCE TESTS ON COMPLETION

9.29.1 GENERAL

Prior to the commencement of Tests on Completion the Contractor shall submit for approval the following:

(i) Site Acceptance Test Documents

(ii) As-Built Drawings

(iii) Operation and Maintenance Manuals

(iv) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, chemical, etc. necessary for Tests on Completion shall be provided by the Contractor. Water and electricity required for Tests on Completion will be provided by the Engineer free of charge.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

9.29.2 PERFORMANCE TESTS

Performance Tests shall be carried out to demonstrate the compliance with the technical particulars furnished in Technical Schedules.

Prior to conducting Performance Test, the Contractor and the Engineer shall agree upon detailed Performance Test Procedure.

Performance Test shall be carried out by the Contractor’s personnel according to the instructions set forth in the Contractor’s Operation and Maintenance Manual and under the supervision of Engineer’s operating personnel.

9.29.3 EVALUATION OF PERFORMANCE TEST DATA

Evaluation of Performance Test data accumulated during, or as a part of Performance Test shall be done by the Contractor within seven days (7) after the completion of Performance Test and to be submitted to the Engineer for his approval.

Any abnormal test data which is not compatible with other significant data shall be ignored or the test data in question may be taken again if practical from the Plant operating conditions.

9.29.4 TOLERANCES

(i) The performances of the clear water pumping units shall be evaluated on the basis of the average performance results as described in the testing procedure.

(ii) The performances of the all other equipment, except clear water pumps, shall be evaluated on the basis of the average performance over the entire period of Performance.

(iii) The guarantees given in respect of output and power Input of pumping units shall be verified according to the standard BS EN ISO-9906:2000 criteria at the manufacturer's work subject to tolerances mentioned in the Guaranteed Performance data sheet,

(iv) The guarantees given in respect of output and power Input shall be verified according to the standard BS EN ISO-9906:2000 criteria at the manufacturer's work,

9.29.5 REPORT OF TEST RESULTS

- The Contractor shall submit to the Engineer a report on Performance Test in writing, indicating whether the Performance Guarantee has been met.
- The report shall include:
  - Test results,
  - Analysis,
  - The Contractor's evaluation, and
  - Reference information supporting the evaluation.

9.29.6 REASONS FOR FAILURE

If Performance Test results show that Test was unsuccessful, the Contractor shall state probable reasons for such failure.

9.29.7 THE ENGINEER'S RESPONSE TO THE REPORT

Within fourteen (14) days after receipt of the performance Test Report, the Engineer shall signify in writing agreement or comments.

9.29.8 CONTRACTOR'S ACTION IN THE CASE OF PERFORMANCE TEST FAILURE

If the evaluation of Performance Test results shows that the failure of Performance Test is Contractor's fault then the Contractor shall advise the Engineer of his intention as to whether he wishes to pay the Liquidated Damages or takes corrective measures and repeat Performance Test.

9.29.9 ADDITIONAL PERFORMANCE TEST

If, due to the Contractors default, any parts of the Performance Guarantee are not met and the Contractor takes corrective actions to enable the Plant to satisfy the Guarantees, an additional Performance Test shall be conducted.

9.29.10 MODIFICATIONS OF THE PLANT

Before repetition of any Performance Tests, the Contractor shall take the following actions:

- Investigate the cause for non-fulfilment of the Performance guarantees,
- Make such changes, modifications or additions to the Engineering or equipment of the Plant as considered necessary to meet the Guarantees.

9.29.11 ENGINEER'S PERMISSION

The Engineer shall allow the Contractor necessary time to carry out any actions deemed necessary by the Contractor and the Engineer shall make the Plant available for that purpose and operate the Plant in such conditions as required by the Contractor.

9.30 ACCEPTANCE

9.30.1 ACCEPTANCE CONDITIONS

Acceptance will occur in any of the three following possible ways:

(i) Fulfilment of Guarantees

When Performance Tests have been successfully completed and the Performance Guarantees are met.

(ii) Deemed Acceptance

When Performance Tests have not been completed or has not been carried out for reasons not attributable to the Contractor within the specified date or other mutually agreed period.

9.30.2 PROCEDURES FOR ACCEPTANCE

Procedures for acceptance are stated as below:-

For each of the above three cases, the Contractor shall submit a written request to the Engineer for a Taking over Certificate to be issued with the following statements:

(i) Fulfilment of Guarantees

- Identification of the Plant (or any individual unit),
- Date of Completion of Performance Test,
- Date and Reference No. of Performance Test Report. and
- Statement that all the performance Guarantees have been met.

(ii) Deemed Acceptance

- Identification of the Plant (or any individual unit),
- Specified or mutually agreed date of Completion Date, and
- Statement that Performance Test has not been carried out or completed due to the reasons not attributable to the Contractor and specifying the reasons thereof.

(iii) Payment of Liquidated Damages

- Identification of the Plant (or any individual unit)
- Date of Completion of Performance Test,
- Date and Reference No. of Performance Test Report, and
- Document showing that the Contractor has paid to the Engineer a due amount of Liquidated Damages corresponding to the performance deficiencies.

The works under this contract shall include, but not limited to, the following activities:

i) Preliminary works like setting and maintenance of permanent bench marks, reference points, etc. It shall also include making adjustment in the layout if required as per site conditions and as directed by the Engineer. The lay out shall be got approved from the Engineer before starting actual work. Existing levels of the areas under the scope of work shall also be recorded. The Contractor is advised to inspect the sites before tendering to ascertain the quantum and cost of work and include this cost in their offer.

ii) Clearing of site for construction of the work and all activities connected therewith before commencement of work to the satisfaction of the Engineer. Protection and maintenance of existing services shall be done by Contractor complying with requirements of Line / Statutory

Authorities. It shall be deemed to be part of contract and no extra payment shall be made for the same.

iii) Providing adequate arrangement for barricading as per requirements of Local / Statutory Authorities at all required locations viz. to cover the entire construction site including all T &P and materials. This shall include reflective signs, markings, flags, steel posts with GI cover sheets and flagman.

iv) Provision for all safety measures for traffic, pedestrian, workmen, machinery etc. including construction and maintenance of temporary diversion as considered necessary by the Engineer. The cost of all such works shall be deemed to be included in the rates quoted by the Contractor for all the items in the Bill of Quantities and no extra amount shall be paid for these works.

v) Assist in identification of services like sewer lines, water supply lines, electric and telephone poles & cables, underground utilities etc. and liaison with the employer and respective line departments for shifting and / or protecting the same as & where necessary.

vi) Repair / re-construction of service lines, water supply lines, electric lines, telephone poles, cables etc. and other structures / properties affected by any action / inaction and activities of the Contractor. For such works no extra cost shall be paid to the Contractor.

vii) The work may have to be carried out in narrow lanes and populated areas at some places and before taking up the work, trial pits are to be made to found out the actual alignment of the existing pipes / utilities which are required to be changed / shifted. The cost for such works shall be deemed to be included in the overall cost of the work.

viii) Dismantling, if required, of existing old work, brick work, RCC slabs, etc. making them good including disposal of debris complete as per directions of the Engineer.

ix) Cutting of road, dismantling of tiles and other structures as required for the proposed works after proper approval from the Engineer and making them good including disposal of debris complete as per the direction of Engineer.

x) Excavation of trenches and foundations in all sorts of strata for laying of pipes and construction of allied structures, back filling of trenches, disposal of surplus soil and site clearance works.

xi) Supply, storage, handling, laying and jointing of pipes, valves, appurtenances, specials and all other materials required as per specifications and drawings.

xii) Cleaning, testing, commissioning and disinfection of all pipes and appurtenances laid.

xiii) All allied civil works like construction of pipe supports, thrust / anchor blocks, valve chambers and pressure gauge chambers as per the drawings and specifications

xiv) Removal of defects in laying and jointing works of all pipelines, valves and specials till the final commissioning and up to the completion of maintenance period.

xv) All roads, lanes, pavements, footpaths curbs, gutters or other properties damaged for the purpose of the contract shall be restored to the condition as decided by the Engineer.

xvi) Provisional sum is provided to cover the cost for shifting of utilities, third party inspection and other miscellaneous items not envisaged at the time of bidding.

xvii) Dismantling if required of old pipe lines, valves etc. of different diameters, stacking and transporting to GMC store.

xviii) Dismantling of existing valve chambers, thrust block etc. wherever required and clearing of debris.

xix) Implementation of Environmental Management Plan included in the Bid Document. The cost of implementation of EMP shall be deemed to be included in the quoted rates of the each item.

xx) Quality Assurance and Quality control manual of MORT&H, BIS and IRC shall be strictly followed.

xxi) Clearing of site to the satisfaction of the Engineer after execution and as well as after undertaking any repairs during maintenance period.

9.31 SURVEYS AND EXECUTIVE DESIGN

The Detailed Design for the Works of laying DI pipes and their allied works has been undertaken by Design Consultants. However, the Contractor is to verify information provided and assist the **Engineer** to undertake the Executive drawings.

9.32 DOCUMENTS AND DRAWINGS

A list of Drawings for the proposed work is provided in Section 6.3 of the bid document. Construction Drawings will be issued to the Contractor by the Engineer during progress of work.

The Contractor shall verify all dimensions, quantities and details shown on the Drawings, Schedules, or other data and the Employer shall not be held responsible for any omissions and discrepancies found therein. Failure to discover or correct error or discrepancies shall not relieve the Contractor of full responsibility for unsatisfactory works. The Contractor shall assume all responsibilities for the making of estimates of the sizes, kinds and quantities of materials and equipment included in the work to be done under the Contract. He shall not be allowed to take advantage of any errors or omissions, as full instructions will be furnished by the **Engineer** if such errors or omissions be discovered.

9.33 OTHER CONTRACTS AND CONTRACTORS

The Contractor must ascertain to his own satisfaction the scope of the sub – project and the nature of other contracts that have been or may be awarded by the Employer in the execution of the project to the end that the Contractor may perform the Contract in the light of such other contracts.

Nothing herein contained shall be interpreted as granting to the Contractor exclusive occupancy of the sites in the project area. The Contractor shall not cause any unnecessary hindrance or delay to any other contractor working in the project area. If the performance of any contract for the project is likely to be interfered with by the simultaneous execution of some other contract or contracts, the Employer shall decide which contractor may proceed.

The Employer shall not be responsible for any damages suffered or extra costs incurred by the Contractor resulting directly, or indirectly, from the award or performance or attempted performance of any other contracts or line departments related to the project, or caused by any decision or omission of the Employer respecting the order of precedence in the performance of the contracts awarded for completion of the project.

10 MISCELLANEOUS

10.1 GENERAL

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

10.1.1SIGN BOARD

The Contractor shall provide a sign board at the site of the Works of approved size and design which provides (i) the name of the Project and the financing agency; (ii) the names and addresses of the Employer, the Consultant; and the Contractor (iii) short description of the Project, (iv) the amount of the Contract Price; and (v) the starting and completion dates. It shall be deemed to be part of contract and no extra payment shall be made for the same.

10.1.2COSTS FOR MOBILIZATION AND TEMPORARY WORKS

No payment above the unit prices quoted shall be made to the Contractor for mobilization costs, i.e. for providing transportation, light, power, tools, and equipment, or for furnishing building and maintaining construction plant, access roads, sanitary conveniences, disposal, work, water supply, fire protection, guards, telephone system and other temporary structures, plant and materials, or for medical attention or health protection, or for watchmen or guards, or for any other services, facilities, or materials necessary or required to execute the work in accordance with the provisions of the Contract as these shall be considered as having been included in the prices stipulated for the various items of the Bill of Quantities

10.1.3CONTRACTOR’S OFFICES, STORES AND EQUIPMENT

The Contractor shall make his own arrangements for renting or acquiring sufficient land for the erection of his offices and stores plus parking / maintenance area for vehicles and equipment to be used on the Works at his own expense. The contractor shall establish and maintain these utilities at his own cost and no additional payment shall be made.

The contractor shall establish a laboratory with equipment’s and all other facilities for carrying out tests at site.

The Contractor will also provide a minimum 50 m^2 area of air conditioned office space furnished with desks, chairs, filing cabinet, shelves, computer with accessories, including washing and toilet facilities, within the vicinity of the sub-project stretch, for the sole use of the Engineer and supervisory staff. The cost of the same for whole project period shall be treated as included in quoted item rates. The daily cleaning and maintenance of office shall be arranged by the Contractor.

10.1.4VEHICLE FOR THE ENGINEER:

The Contractor shall provide hard top, petrol / diesel driven light motor vehicle having cylinder capacity of minimum 1400 cc for the sole purpose of the Engineer. The cost of providing the vehicle during the Contract Period, its operation & maintenance, driver, fuel charges and all other statutory expenses etc. shall be borne by the Contractor and shall not be paid extra.

10.1.5CONTRACTOR'S WATER AND POWER SUPPLY:

The Contractor shall make his own arrangements for a hygienically clean and potable water supply for labor and construction work.

The Contractor shall make his own arrangements at his own expense for the supply of electricity services either using a metered connection from local mains or by providing his own generating plant (NOC from pollution control Board is must for installing any generator) to meet the requirements.

10.1.6TRANSPORTATION AND STORAGE OF MATERIALS

Transportation of any material by the Contractor shall be by suitable vehicle which when loaded does not cause spillage and all loads shall be suitably secured. Any vehicle which does not comply with this requirement or local traffic regulation and law shall be removed from the Site. All heavy materials which are not permitted to transport by traffic and police department during day time shall be transported at night time with required permissions from local authorities. All materials when brought to site by the Contractor shall be stacked and stored in a manner suitable to protect against, spillage, damage, breakage, pilferage etc., and readily available for checking by the Engineer or his authorized representative at any time. The Contractor shall arrange for watch and ward of the materials at all times in a suitable manner satisfactory to the Engineer, all at his own expense.

10.1.7SETTING OUT OF THE WORKS

The setting out of the works should avoid un-necessary disturbance or removal of garden plants and trees. Only the removal of plants and trees that is absolutely necessary for the construction of the works will be permitted following the approval of the competent authority.

The Contractor shall at his own expense establish working or construction lines and grades as required and shall furnish and maintain stakes and other such materials and give such assistance including qualified staff as may be required by the Employer for checking setting out lines and grade marks. The Contractor shall be solely responsible for the accuracy thereof.

The Contractor shall safeguard all points, stakes, grade marks and bench marks made or established for the work, bear the cost of re-establishing them if disturbed, and bear the entire expense of rectifying work improperly done due to not maintaining or protecting, or removing without authorization, such established points, stakes and marks.

Any work done beyond the lines, levels and limits shown on the drawings or not agreed by the Engineer shall not be paid for and the Contractor shall make good any extra excavation as directed by the Engineer, at his own expense.

10.1.8SAMPLES AND TESTS DURING CONSTRUCTION

For ensuring the requisite quality of construction, the Materials and Works shall be subject to the quality control tests as per relevant IS codes as applicable. The testing frequencies set forth are desirable minimum and the Engineer shall have full authority to get the additional tests carried out by the Contractor as frequently as he may deem necessary, to satisfy himself that the Materials and Works comply with the appropriate Specifications.

The materials to be incorporated in the permanent works such as pipes, valves, pipe specials and other mechanical equipment shall be subjected to Third Party Inspection as decided / directed by the Engineer, the cost of which will be paid out of the Provisional Sum of the Contract.

Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted Engineering practice to the satisfaction of the Engineer.

The Contractor shall be responsible to develop a quality control program and to provide all necessary materials, apparatus, instruments, equipment, facilities and qualified staff for sampling, testing and quality control of the materials and the works under the Contract. Without limiting the generality of the foregoing, the Contractor shall establish either (i) establish a testing laboratory at the site of Works which is adequately equipped and staffed to carry out all sampling and testing in accordance with the requirement set out in the General Specifications and / or these Specifications and provide all field equipment and apparatus as necessary to conduct all specified in-situ tests and / or any Tests on Completion, or (ii) arrange for routine sampling, testing and reporting, as required, through a certified independent testing laboratory acceptable to the Engineer. The Engineer may also direct the Contractor to arrange additional independent sampling and laboratory testing under the supervision of the Engineer, the cost of which shall be borne by the contractor. The Contractor shall furnish certified copies of all test reports to the Engineer within 3 days of completion of the specified tests.

The Contractor shall, within 14 days after the date of the notice to proceed, submit to the Engineer for his consent, a detailed description of the arrangements for conducting the quality control program during execution of the Works, including details of his testing laboratory, equipment, staff and general procedures. If following submission, or at any time during the progress of Works, it appears to the Engineer that the Contractor's quality control program is not adequate to ensure the quality of the Works, the Contractor shall produce a revised program which will be adequate to ensure satisfactory quality control.

10.1.9**PROTECTION OF UTILITIES**

The Contractor is required to carefully examine the location of the Works and their alignments and to make special enquiries with all authorities or service suppliers concerning all utility lines such as water supply, sewers, gas pipe, telephone (underground and/or overhead) lines, electric cable (underground and/or overhead), cable TV lines, etc.; and to determine and verify to his own satisfaction the character, sizes, position and lengths of such utilities from authentic records. The Contractor shall be wholly responsible for the protection and/or facilitating relocation of such utilities as may be required, and shall not make any claim for extra work that may be required to protect or facilitate relocating such utilities or services. If any major shifting or realignment of water supply, sewers, drains, electric and telephone lines are necessary due to their interference with the proposed Works, the same will be arranged through the line agencies. The cost of such relocations will be paid by the Contractor which will be reimbursed under the provisional sum item, following approval by the Engineer.

In case the alignment of the pipeline crosses the high tension electrical transmission lines belonging to the Power Development Department, Bihar or other authorities, the Contractor shall take all precautions necessary to see that the work is carried out with care and safety, without disturbing such transmission lines. The Contractor will be responsible to carry out all construction activities in such reaches in consultation with the owners of such facilities. However, satisfactory completion of the entire work will be the responsibility of the Contractor.

10.1.10**WORKMANSHIP.**

All workmanship shall be in conformance with the best trade practice. Particular attention shall be given to the appearance of exposed work without compromising on the Quality Standards.

10.1.11 SITE PHOTOGRAPHS/VIDEOS

The contractor shall arrange to take color photographs at locations of the works to demonstrate conditions of the site before work commences / progresses during the construction period and after completion of the works. The photographs/video may be required as evidence in defense of claims against the contractor for damage to buildings and property due to the execution of the works. Contractor will take all necessary work photographs as per directions of Engineer. All site photographs shall be handed over to the Engineer and will become property of the Employer.

10.1.12 COOPERATION AT SITE AND NIGHT WORK

Construction may be carried out in areas of restricted circulation. The Contractor's attention is particularly drawn to;

a. The need to maintain existing services and reasonable access for local residents and traders during the construction period; and

b. The probable presence of other contractors on site is to be coordinated by the main Contractor.

c. Heavy Materials shall preferably be transported to site during night time with necessary permissions from all concerned authorities.

All work shall be carried out in such a way as to allow access and afford all reasonable facilities for any other contractor and his workmen and for workmen of the Employer and any other person who may be employed in the execution and / or operation at or near the site of any work in connection with the Contract or otherwise.

Night work in residential areas would not normally be agreed unless is essential for safety of the public and/or property. For this, specific case-by-case authorization of the Engineer would be required. However, sometimes work may be required to be only undertaken during night hours to avoid disturbance to traffic movements. The contractor is to keep provisions for such requirements in his bid pricing.

In the preparation of his program of work, the Contractor shall at all times take full account of and cooperate with the programming of the work of other contractors so as to cause the minimum interference to them and to the public.

10.1.13 PROTECTION OF WORKERS AND PUBLIC

The contractor shall exercise precautions at all times for the protection of labour employed and public life and property at and around the sites of work. The safety provisions of applicable laws, building and construction codes shall be observed. Machinery, equipment and all hazards shall be guarded or eliminated in accordance with safety provisions.

During the execution of the work, the contractor shall put up and maintain during the night time such barriers and lights as will effectively prevent accidents. The contractor shall provide suitable barricades, red light “Danger” or “Caution” signs and watchmen at all places where the work causes obstructions to the normal traffic or constitutes in any way a hazard to the public.

10.1.14 ENVIRONMENTAL PROTECTION

The contractor will ensure that all actions are taken to ensure that the local environment of the site is protected and that surface and groundwater, soil and air are kept free from pollution (including noise) due to the works being undertaken.

The Environmental Management Plan (EMP) provided in the document gives a list of identified impacts and mitigation measures. Contractor is required to implement Environmental Management Plan to the satisfaction of the Engineer. The cost for implementation of Environmental Management Plan (EMP) shall be deemed to be included in the quoted rates of BOQ.

10.1.15 RECORD DRAWINGS

The contractor shall prepare reproducible drawings of the whole works "as built". The drawings shall be produced to a standard similar to that of the Contract Drawings.

Record drawings shall be prepared to the Engineer's approval as the work proceeds and shall be handed over to the Engineer on completion of work in each Rising main. The Record Drawings shall then become the property of the Employer.

10.1.16 FINAL CLEARANCE OF THE SITE

On completion of work, wherever applicable, the contractor shall clear away and remove from the site all constructional plant, surplus materials, rubbish, scaffolding and temporary works of every kind and leave the whole of the site and works in a clean condition. Final contract payment shall be withheld until this has been done, to the satisfaction of the Engineer. During operation and maintenance period whatsoever repair works are taken up by the contractor, he will leave the whole of the site and works in a clean condition.

10.2 TECHNICAL REQUIREMENTS

10.2.1 GENERAL SPECIFICATION

In the absence of any definite provisions on any particular issue in the aforesaid Specifications, reference may be made to the relevant latest codes and specifications of BIS. Where even these are silent, the construction and completion of the works shall conform to sound Engineering practice as approved by the Engineer and in case of any dispute arising out of the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor

10.2.2 PROTECTION OF ENVIRONMENT & NATURAL HABITAT

10.2.2.1 *Site Environmental Plan (SEP)*

The contractor shall carry out the work for fulfilling the requirement of environmental impact assessment and management plan as related to construction of work as per the EMP provided in the document.

The Contractor shall prepare a detailed Site Environmental Plan (SEP) for the work site, base camp, etc., showing arrangements for disposal of sanitary and other waste, location of fuel, oil and lubricant depots, sheds for equipment, labor and housing facilities, etc., prior to the construction for approval of the Engineer.

10.2.2.2 *Safety, Security and Protection of the Environment*

The Contractor shall take all necessary precautions against pollution or interference with the supply or obstruction of the flow of, surface or underground water. These precautions shall include but not be limited to physical measures such as earth bunds of adequate capacity around fuel, oil and solvent storage tanks and stores, oil and grease traps in drainage systems from workshops, vehicle and plant washing facilities and service and fueling areas and kitchens, the establishment of sanitary solid and liquid waste disposal systems, the maintenance in effective condition of these measures, the establishment of emergency response procedures for pollution events, and dust suppression, all in accordance with normal good practice and to the satisfaction of the Engineer. Should any pollution arise from the Contractor's activities he shall clean up the affected area immediately at his own cost and to the satisfaction of the Engineer and shall pay full compensation to any affected party.

10.2.2.3***Protection of Trees and Vegetation***

The Contractor shall ensure that no trees or shrubs are felled or harmed except for those required to be cleared for execution of the Works. No tree shall be removed without the prior approval of the Engineer and any competent authorities.

10.2.2.4***Use of Wood as Fuel***

The Contractor shall not use wood as a fuel for the execution of any part of the Works, including but not limited to the heating of bitumen and bitumen mixtures and the manufacture of bricks for use in the Works, and to the extent practicable shall ensure that fuels other than wood are used for cooking, and water heating in all his camps and living accommodations.

10.2.2.5***Water Supply***

The Contractor shall make his own arrangements at his own expense for water supply for construction and other purposes. Only clean water free from deleterious materials and of appropriate quality for its intended use shall be used. In providing water the Contractor shall ensure that the rights of and supply to existing users are not affected either in quality, quantity or timing. In the event of a dispute over the effect of the Contractor's arrangements on the water supply of others, the Engineer shall be informed immediately and shall instruct the Contractor as to appropriate remedial actions to be undertaken at the Contractor's expense.

10.2.2.6***Power Supply***

The Contractor shall make his own arrangements at his own expense for power supply for construction and other purposes. Only power from authorized connections or from well operational generator sets shall be used. In case of work in night shifts the Engineer shall be informed well in advance and all arrangements should be get approved by the Engineer in charge.

10.2.2.7***Relations with Local Communities and Authorities***

In sitting and operating his plant and facilities and in executing the Works the Contractor shall at all-time bear in mind and to the extent practicable minimize the impact of his activities on existing communities. Where communities are likely to be affected by major activities such as road widening or the establishment of a camp, large borrow pit or haul road, he shall liaise closely with the concerned communities and their representatives and if so directed, shall attend meetings arranged by the Engineer or Employer to resolve issues and minimize impacts on local communities.

10.2.2.8***Fire Prevention***

The Contractor shall take all precautions necessary ensure that no vegetation along the line of the road outside the area of the permanent works is affected by fires arising from the execution of the Works. The Contractor shall obtain and follow any instructions of the competent authorities with respect to fire hazard when working in the vicinity of gas installations. Should a fire occur in the natural vegetation or plantations adjacent to the road for any reason the Contractor shall immediately suppress it. In the event of any other fire emergency in the vicinity of the Works the Contractor shall render assistance to the civil authorities to the best of his ability. Areas of forest, scrub or plantation damaged by fire considered by the Engineer to have been initiated by the Contractor's staff or labor shall be replanted and otherwise restored to the satisfaction of the Engineer at the Contractor's expense.

10.2.3 MATERIALS

10.2.3.1*Scope*

Materials to be used in the work shall conform to the specifications mentioned in the relevant IS codes/similar other national specifications and to the requirements laid down in this section and specifications for relevant items of work covered under these specifications.

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

10.2.3.2*Sources of Material*

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

10.2.3.3*Bricks*

Burnt clay bricks shall conform to the requirement of IS: 1077, except that the minimum compressive strength when tested flat shall not be less than 7.5 MPa for individual brick. They shall be free from cracks and flaws and nodules of free lime. The brick shall have smooth rectangular faces with sharp corners and emit a clear ringing sound when struck. The size may be according to local practice with a tolerance of ± 5 per cent.

10.2.3.4*Cement*

Cement to be used in the works shall be any of the following types with the prior approval of the Engineer. These have to be procured from reputed ISO: 9000 organizations:

1. Rapid Hardening Portland Cement, conforming to IS: 8041.
2. Ordinary Portland cement, 43 Grade, conforming to IS: 12269.
3. Portland slag cement, 53 Grade conforming to IS: 455.
4. Pozzolana Portland Cement (PCC) conforming to IS: 1489.

Cement conforming to IS: 8041 shall be used only for precast concrete products after specific approval of the Engineer. For RCC works, Ordinary Portland Cement 43 grade confirming to IS 12269 will be used.

10.2.3.5*Coarse Aggregates*

For plain and reinforced cement concrete (PCC and RCC) or works, coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or granite or other approved inert material. They shall not consist pieces of disintegrated stones, soft, flaky, elongated particles, salt, alkali, vegetable matter or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack the steel reinforcement. Coarse aggregate having positive alkali silica reaction shall not be used. All coarse aggregates shall conform to IS: 383 and tests for conformity shall be carried out as per IS: 2386 Parts I to VIII.

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

Nominal size of coarse aggregate for various components in PCC & RCC is mentioned in BOQ. In case of discrepancy the decision of the Engineer is final.

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

Table 31 Conditions requirement for grading of Coarse Aggregate

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

10.2.3.6***Sand/Fine Aggregates***

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

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

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

Table 32 Conditions requirement for grading of Fine Aggregate

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

10.2.3.7***Steel***

Reinforcement

For reinforced cement concrete (RCC) works, the reinforcement / non-tensile steel as the case may be shall consist of the following grades of reinforcing bars:

Table 33 Conditions requirement for grading of Reinforcing Bars

Grade Designation	**Bar type conforming to governing IS specification**	**Characteristic strength Mpa**	**Elastic Modulus GPa**
Fe 500	IS:1786 High Yield	500	200
	Strength Deformed Bars		

All steel shall be procured from original producers, or their authorized re-rollers.

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

Whenever specified, either in drawings or BOQ, reinforcement steel i.e. high yield strength deformed bars. Utmost care should be taken so that bars are not damaged during handling and transportation.

<u>Structural Steel</u>

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

IS: 226	Structural Steel (Standard Quality)
IS: 2062	Weldable Structural Steel
IS: 1730	Dimension for Steel Plate, sheet and strip for structural and general engineering purposes
IS: 1731	Dimension for Steel flats for structural and general engineering purposes

The use of structural steel not covered by the above standards may be permitted with the specific approval of the Engineer.

10.2.3.8***Bitumen***

The bitumen shall be paving bitumen of Penetration Grade S65 or A 65 (60/70) as per Indian Standard Specifications for “Paving Bitumen” IS: 73. In case of non-availability of bitumen of this grade, S90 (80/100) grade bitumen may be used with the approval of the Engineer. Guidance to selection of the grade of bitumen may be taken from Appendix 4 of MORT&H Specifications for Roads and Bridge Works (IV Revision).

10.2.3.9***Water***

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete.

10.2.3.10***Timber***

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

10.2.3.11***Concrete Admixtures***

General

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

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

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

i. Normal dosage and detrimental effects, it any, of under dosage and over dosage.

ii. The chemical names of the main ingredients in the admixtures.

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

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

v. Whether or not the admixture leads to the entertainment of air when used as per the manufacturer's recommended dosage and it so to what extent.

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

vii. There would be no increase in risk of corrosion of the reinforcement or other embedment's as a result of using the admixture.

10.2.3.12***Physical and Chemical Requirements***

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

i. Synthetic fiber (Polyester 12mm Recron 3S) triangular; admixtures shall be added in all concrete works.

ii. "Plasticizers", "Super - Plasticizers" shall meet the requirements indicated for "Water reducing Admixture".

iii. Except where resistance to freezing and thawing and to disruptive 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.

iv. 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 (not to exceed 1.5% of the weight of cement in each batch of concrete) shall also be observed.

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

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

- Dry Material Content: to be within 3 per cent and 5 per cent of liquid and solid admixtures respectively of the value stated by the manufacturer.
- Ash content: to be within 1 per cent of the value stated by the manufacturer.

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

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

10.2.4PIPES AND FITTINGS

10.2.4.1*Ductile Iron (DI) Pipes*

The pipes will be centrifugally cast (spun) Ductile Iron pipes for Water confirming to the IS 8329: 2000. The pipes used will be either with push-on flexible joints with Rubber Gasket (SBR / EPDM) or Flanged joints (Rubber Gasket). The class of pipe to be used shall be of the class K-7 of different diameters. The Pipes are in standard lengths of 5.5 / 6.0 meters.

10.2.4.2*Ductile Iron (DI) specials (Fittings)*

The Ductile Iron (DI) push-on Joint Socket Fittings suitable for Tyton joints shall be used with Ductile Iron pipes with tyton jointing system or Flanged Fittings(Flat Rubber Gasket) in accordance with IS: 9523. The Ductile Iron (D.I) Fittings without branches conform to class K-12 are used. The D.I. Fittings with branches shall be of the class K-12 for different diameters.

10.2.4.3*Valves*

The sluice valves of different sizes for Water Works purposes having double flanged ends for connections shall be conforming to IS: 14846 and shall bear ISI mark. The Sluice Valves shall be designed for a Nominal Pressure rating of PN-1.6

All necessary fittings including bolts, nuts, gaskets, counter flanges, jointing material, etc. having best quality as required shall be supplied with each valve.

10.2.5STORAGE OF MATERIALS

10.2.5.1*General*

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

10.2.5.2*Brick*

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

10.2.5.3*Aggregates*

Aggregate stockpiles may be made on ground that is denuded of vegetation, is hard and well drained If necessary, the ground shall be covered with 50 mm plank or brick flat soling. Coarse aggregates shall be delivered to the site in separate sizes agreed by the Engineer in writing.

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

10.2.5.4***Cement***

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

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

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

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

10.2.5.5***Reinforcement Steel***

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

10.2.5.6***Pipes***

The pipes shall be transported and handled as per IS: 12288. All precaution set out shall be taken out to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes

The pipes shall be stacked in layers on dry surface preferably on the projected bench/ surface

All the pipe specials, rubber rings / joints, nut, bolts including valves etc. shall be stored in closed room or shed.

10.2.5.7***Mechanical Items***

All the items of mechanical required shall be stored in closed room or shed with original packing.

10.2.5.8***Water***

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

10.2.5.9***Tests and Standards of Acceptance***

All materials, even though stored in an approved manner shall be subjected to an acceptance test prior to their immediate use. Independent testing of cement for every consignment shall be done by the Contractor at site or in a laboratory approved by the Engineer before use. Any cement with lower quality than those shown in manufacturer's certificate shall be debarred from use. In case of imported cement, the same series of tests shall be carried out before acceptance.

10.2.5.10***Testing and Approval of Material***

The Contractor shall furnish test certificates from the manufacturer/supplier of materials along with each batch of material(s) delivered to site. Tests shall be as specified in QA/QC Manual.

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

Tests which cannot be carried out in this field laboratory have to be got done at the contractor’s cost at any recognized reputed laboratory/testing establishments approved by the Engineer.

10.2.5.11***Sampling of Materials***

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

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

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

10.2.5.12***Rejection of Materials not conforming to the Specifications***

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

10.2.5.13***Testing and Approval of Plant and Equipment***

All Plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturers

Specifications and shall be got approved by the Engineer before use.

The procurement of above material and its consumption / fitting shall be inclusive in the quoted prices.

10.2.5.14***Field Laboratory equipment shall be (minimum)***

Compressive strength testing machine with jack – 1 No

Standard stainless steel sieves – 2 Sets

Slump cone and rod – 3 sets

Equipment and apparatus for measuring proctor density

Measuring cylinders 1000 ml capacity – 6 nos. or as required

Assorted beakers

Weighing scale (analog dial) 0 – 500 kg

Weighing scale electronic 0 – 5 kg

Electric heater

Any other equipment that may be required according to the Engineer as per relevant tests given in QCS.

This laboratory should be housed properly with a competent laboratory technician.

10.2.5.15***Testing and Approval of Plant and Equipment***

All Plants and equipment used for preparing, testing and production of materials for incorporation into the permanent works shall be in accordance with manufacturers

Specifications and shall be got approved by the Engineer before use.

10.3 TESTING AND COMMISSIONING

10.3.1 COMMISSIONING GENERAL

After successful sectional tests after pipe laying and other pre-commissioning tests after physical completion, the pipeline shall be commissioned by the Contractor. Dynamic commissioning shall be made in conjunction with or after the commissioning of the respective system.

During testing/commissioning, the Contractor shall supply all material and labor to supervise, adjust, test, repair and do all things necessary to maintain the testing/ commissioning. This shall include labor on a 24 hour-a-day basis during the test period and for such other period of continuous operation as the Engineer in Charge may consider necessary to establish the efficient operation.

If any test result shows noticeable variation from the specification requirements for the system the Contractor shall immediately take steps to rectify the deficiency without any extra cost to Employer.

The Contractor shall test and commission the system for 7 days at a stretch, from the date of commissioning. On expiry of this period the system shall be taken over by the Engineer- In-Charge and a taking-over certificate shall be issued by the Engineer in Charge, provided all defects and/or deficiencies noticed are rectified to the satisfaction of the Engineer- In-Charge.

Any repairs or replacement required during this period shall be done by the Contractor at his own cost.

The Contractor shall allow for commissioning to be conducted at any time during the commissioning period without extra charges under the Contract.

The main indicators for the successful commissioning are:

- no leaks in pipes, joints, specials and valves
- all valves are properly installed and operational
- execution of the entire work including finishing according to the drawings and the specifications
- submission of as built drawings

10.3.2 DYNAMIC COMMISSIONING

The dynamic commissioning shall commence after the work has been physically completed to the satisfaction of the Engineer in Charge. It shall simulate the design and operation conditions which are as follows:

- All branches into existing lines (if already in position) to be shut off.

- Water being put into the system through overhead tank or direct pumping as the case maybe.
- Closing of the valves against full static or dynamic pressure.
- Operation of all valves including scour valves (open-close-open).
- Operation of all air valves.
- Operation of all locking arrangements of valve chambers.

10.4 PROPORTIONING, CONSISTENCY, BATCHING AND MIXING OF CONCRETE

10.4.1PROPORTIONING

10.4.1.1*Aggregate*

The proportions which shall be decided by conducting preliminary tests shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to IS: 2722 capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of Engineer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions. The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregate shall be checked as frequently as possible, as determined by Engineer, to ensure maintaining of grading in accordance with the sample used in preliminary mix design. The material shall be stock piled well in advance of use.

10.4.1.2*Cement*

The cement shall be measured by weight.

10.4.1.3*Water*

Only such quantity of water shall be added to the cement and aggregates in the concrete mix as to ensure dense concrete, specified surface finish, satisfactory workability, consistent with the strength stipulated for each class of concrete. The water added to the mix shall be such as not to cause segregation of material or the collection of excessive free water on the surface of the concrete.

10.4.1.4*Definition of Water Cement Ratio.*

The water cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix.

10.4.1.5*Water / Cement Ratio*

The actual water cement ratio to be adopted shall be as per the design mix and approved by Engineer.

10.4.1.6*Proportioning by Water / Cement Ratio*

The W/C ratio specified for use by Engineer shall be maintained. Contractor shall determine the water content of the aggregates as frequently as directed by Engineer In- Charge as the work progresses and as specified in IS: 2386 (part III) and the amount of mixing water added at the mixer shall be adjusted as directed by Engineer so as to maintain the specified W/C ratio. To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made.

10.4.1.7***Consistency and slump***

Concrete shall be of a consistency and workability suitable for the condition of the job. After the amount of water required is determined, the consistency of the mix shall be maintained throughout the progress of the corresponding parts. Compacting factor tests, in accordance with IS: 1199 shall be conducted from time to time to ensure the maintenance of such consistency.

The following table gives a range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Engineer.

Table 34 Range of Slump

Types of Construction	**Slump in mm**	
	Maximum	**Minimum**
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructure walls	75	25
Slabs, Beams and reinforced walls	100	25
Building columns	100	25
Pavements / Canal Lining on slope	50	25
Heavy mass construction	50	25

10.4.1.8***Batching and mixing of concrete***

The materials and proportions of concrete materials as established by the preliminary tests for the mix design shall be rigidly followed for all concrete on the project and shall not be changed except when specifically permitted by Engineer.

Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked and calibration certificate in this regard be obtained from NABL Lab as when it is due. They shall be set up level on a firm base and the hopper shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, Engineer In- Charge may permit volume batching by subsequent conversion of the weights of important pours involving concrete of not more than 0.25 cubic meters, on days when other pours involving weigh batching are not likely to be taken up. Concrete shall be of strength stipulated in the respective items. All concrete shall be mixed in mechanically operated batch mixers complying with IS: 1791 and of approved make with suitable provision for correctly controlling the water delivered to the drum.

The quantity of water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The test should be made while the mixer is running. The volume of the mixed material shall not exceed the manufacturer's rated mixer capacity. The batch shall be charged into the mixer so that some water will enter the drum in advance of cement and aggregates. All water shall be in the drum by the end of the first 15 seconds of the specified mixing time. Each batch shall be mixed until the concrete is uniform in colour, for a minimum period of two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged in one operation before the raw materials for the succeeding batches are fed into the drum.

Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

10.4.1.9***Sampling for strength of concrete:***

At least 6 test cubes of each class of concrete shall be taken for every 150 cum. concrete or part thereof. Such samples shall be drawn on each day for each type of concrete of each set of 6 cubes, three shall be tested at 7 days age and three at 28 days age. The laboratory test results shall be tabulated and furnished to Engineer. Engineer will pass the concrete if average strength of the specimens tested is not less than the strength specified, subject to the condition that only one out of three consecutive tests may give a value less than the specified strength but this shall not be less than 90% of the specified strength.

10.4.1.10***Consistency:***

Slump tests shall be carried out as often as demanded by Engineer and invariably from the same of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

10.4.1.11***Bonding mortar:***

Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar.

10.4.1.12***Transportation:***

All buckets, containers or conveyers used for transporting concrete shall be mortar-tight. Irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of Engineer and concrete shall not be re-handled before placing.

10.4.1.13***Re-tempered or contaminated concrete:***

Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by Engineer.

10.4.1.14***Cleaning of equipment***

All equipment used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets, hoppers, chutes, pipelines and other equipment shall be thoroughly cleaned after each period of placement.

10.5 PROCEDURE FOR PLACING OF CONCRETE:

10.5.1 ENGINEER'S APPROVAL OF EQUIPMENT & METHODS

Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and methods shall be submitted to Engineer for approval if so demanded by Engineer and no concrete shall be placed until Engineer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing, without segregation of materials, considering the size of the job and placement location.

10.5.1.1***Time interval between mixing and placing***

Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer, and once compacted, it shall not be disturbed.

10.5.1.2***Avoiding segregation***

Concrete shall, in all cases, be deposited as nearly as practicable directly in its final position, and shall not be re-handled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts or impair its strength. For locations where direct placement is not possible, and in narrow forms, Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete.

Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

10.5.1.3***Placing by manual labor***

Except when otherwise approved by Engineer, concrete shall be placed in the shuttering by shovels or other approved implements and shall not be dropped from a height more than 1.0 M or handled in a manner which will cause segregation.

10.5.1.4***Placing by mechanical equipment***

The following Specification shall apply when placing of concrete by use of mechanical equipment is specifically called for while inviting bids or is warranted considering the nature of work involved.

The control of placing shall begin at the mixer discharge by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

10.5.1.5***Concrete in layers***

Concrete, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 to 90 cm or as directed by Engineer. These shall be placed as rapidly as practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum of shoveling. Any tendency to segregation shall be corrected by shoveling stones. Such a condition shall be corrected by redesign of mix or other means, as directed by Engineer.

10.5.1.6***Bedding of layers***

The top surface of each pour and Bedding planes shall be approximately horizontal unless otherwise instructed.

10.5.1.7***Compaction***

Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, is free of pockets of coarse aggregate fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

10.5.1.8***Type of Vibrators***

Vibrators shall conform to IS Specifications. Type of vibrator to be used shall depend on the structure where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to transmit the vibration and string enough not to be damaged by it. Immersion vibrators shall have "no load" frequency, on the size of the vibrator.

Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

10.5.1.9***Use of Vibrators***

The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of lift e.g. in a column or wall.

10.5.1.10***Melding Successive Batches***

When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

10.5.1.11***Penetration of Vibrator***

The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

10.5.1.12***Vibrating Against Reinforcement***

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

10.5.1.13***Use of Surface Vibrators***

The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, such as highways, runways and similar constructions, surface vibration by specially designed vibrators may be permitted, upon approval of Engineer.

10.5.2**CURING, PROTECTING, REPAIRING AND FINISHING**

10.5.2.1***Curing.***

All concrete shall be cured by keeping it continuously damp for the period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated covering of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even- textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as the one used for mixing concrete.

Certain types of finish or preparation for overlaying concrete must be done at certain stages of the curing process and special treatment may be required for specific concrete surface finish.

10.5.2.2***Curing with water***

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin immediately after the concrete has hardened. Water shall be applied to unformed concrete surfaces within 1 hour after concrete has set. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

10.5.2.3***Continuous Spraying:***

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by Engineer.

10.5.2.4***Protecting fresh concrete:***

Fresh concrete shall be protected from the elements, from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in this Specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by Engineer shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials etc. that may impair the strength and / or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that workmen enter the area of freshly placed concrete, Engineer may require that bridges be placed over the area.

10.5.2.5***Curing of Patched Work***

The patched area shall be covered immediately with an approved non staining, water saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days.

10.5.2.6***Approval by Engineer:***

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Engineer. All fillings shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

10.5.2.7***Foundation Bedding, Bonding and Jointing***

All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering, as may be indicated in the plans or as Engineer, may direct, to meet the various situations encountered in the work.

Soft or spongy areas shall be cleaned out and back filled with either a soil cement mixture, lean concrete or clean sand fill compacted to a minimum density of 90% Modified Proctor, unless otherwise mentioned in Schedule of Quantities.

Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from Engineer as to the suitability of the soil.

10.5.2.8***Preparation of earth strata of foundations***

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft, yielding solid shall be removed and replaced with suitable earth well compacted as directed by Engineer. Where specified, lean concrete shall be provided on the earth stratum for receiving concrete. The surface of absorptive soils against which concrete is to be placed shall be moistened thoroughly so that no moisture will be drawn from the freshly placed concrete and later shall help to cure the concrete.

10.5.2.9***Preparation of concrete surfaces***

The preparation of concrete surfaces upon which additional concrete is to be placed later, shall preferably be done by scarifying and cleaning while the concrete is between its initial and final set. This shall consist of cutting the surface with picks and stiff brooms and by use of an approved combination of air and water jet as directed by Engineer. Great care shall be taken in performing this work to avoid removal of too much mortar and the weakening of the surface by loosening of aggregate.

It shall be a pitted surface from which all dirt, unsound concrete, laitance and glazed mortar have been removed.

10.5.2.10***Hot weather requirement.***

All concrete work performed in hot weather shall be in accordance with IS: 456 except as herein modified.

10.5.2.11***Admixtures may be used only when approved by Engineer.***

Adequate provisions shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of reflective paints on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38^{o}C.

In order to reduce loss of mixing water, the aggregates, wooded forms, sub grade, adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting. Placement and finishing shall be done as quickly as possible.

Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous water curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

10.6 INSPECTION

All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of Engineer.

All materials supplied by Contractor and all work or construction performed by Contractor rejected as not in conformance with the Specifications and Drawings, shall be immediately replaced at no additional expense to the Owner.

Approvals of any preliminary materials or phase or work shall in no way relieve the Contractor from the responsibility of supplying concrete and or producing finished concrete in accordance with the Specifications and Drawings.

All concrete shall be protected against damage until final acceptance by Engineer or his representative.

10.7 CLEAN-UP

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.

All debris i.e. empty containers, scrap wood, etc. shall be removed to "dump" daily or as directed by Engineer.

The finished concrete surfaces shall be left in a clean condition satisfactory to Engineer.

Preparation of Mortars and its Grade

10.7.1GRADE OF MASONRY MORTAR

The grade of masonry mortar will be defined by its compressive strength in N/mm2 at the age of 28 days as determined by the standard procedure detailed in IS: 2250-1981.

10.7.1.1*Proportioning*

The ingredient in specified proportions shall be measured using boxes of suitable sizes. Sand and puzzolonic material shall be measured on basis of their dry volume.

10.7.1.2*Cement Mortar*

This shall be prepared by mixing cement and sand with or without the addition of Puzzolona as specified.

10.7.1.3*Proportioning*

Cement bag weighting 50 kg shall be taken as 0.035 cubic meters. Other ingredients in specified proportion shall be measured using boxes of size 40 X 35 X 25 cm. Sand shall be measured on the basis of its dry volume.

10.7.1.4*Mixing*

The mixing of mortar shall be done manually. The Contractor shall take permission of the Engineer in writing before the commencement of the work.

Hand Mixing: The measured quantity of sand shall be leveled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform color. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry trough with just sufficient quantity of water to bring the mortar to a stiff plaster of necessary working consistency.

10.7.1.5*Precautions*

Mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

10.7.2MEASUREMENT AND RATE

The cement concrete shall be measured in cubic meters. In reinforced concrete the volume occupied by the reinforcement shall not be deducted.

Any concrete used in excess of the theoretical dimensions as shown on the drawings will not be paid for.

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account of such items as leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the schedule of quantities. No extra claim shall also be entertained due to change in the number, position and / or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift or scaffolding etc. All these factors should be taken into consideration while quoting the unit rates. Unless provided for in the Bill of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments of concrete will be made on the basis of unit rates quoted for the respective items in the schedule of quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned up to the underside of slabs.

The unit rate for precast concrete members shall include formwork, moldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement etc. complete.

The contract price shall include all operation for completion of work including material and machinery.

10.8 FINISHING WORKS

10.8.1 SCOPE

These Specifications cover the general requirements of different kinds of finishes and is applicable for both new construction and renovation works.

10.8.2 CEMENT PLASTERING

The cement plaster shall be as specified in the BOQ and drawings.

10.8.2.1 *Scaffolding.*

For all exposed brick work, double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other civil works single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one meter in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

10.8.2.2 *Preparation of Surface*

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

10.8.2.3 *Mortar*

The mortar of the specified mix shall be with sand and cement as described in the item of BOQ.

10.8.2.4 *Application*

Ceiling plaster shall be completed before commencement of wall plaster.

Plastering shall be started from the top and worked down towards the floor. All put-log holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 meters intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one meter long to ensure through filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or sandy granular texture is required.

When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly joint together.

10.8.2.5***Thickness***

Where the thickness required as per description of the item is 20 mm the average thickness of the plaster shall not be less than 20 mm whether the wall treated is of brick or concrete. In the case of brick work, the minimum thickness over any portion of the surface shall be not less than 15 mm while in case of concrete work the minimum thickness over the bushings shall be not less than 12 mm.

10.8.2.6***Curing***

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Contractor’s expense by such means as the Engineer may approve.

10.8.2.7***Precaution***

Any cracks which appear in the surface and all portions which sound hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer.

When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6 mm drawn with any suitable method with the wall while the plaster is green.

To prevent surface cracks appearing between junctions of column/beam and walls, the plastering of walls and beam/column in one vertical plane junction should be carried out in one go.

10.8.2.8***Preparation of the Surface***

The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filing up the undulations and then sand papering the same after it is dry.

10.8.2.9***Application***

The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion paint is applied.

The Specifications in respect of scaffolding, protective measures, measurements and rate shall be inclusive under Clause 11.6.

10.8.2.10 *Utility shifting*

In case of impossibility of deviation of pipeline, poles of electricity lines, telephone lines or anchor cables of poles have to be relocated. These works have to be executed by the respective department or according to its instructions by the contractor. Cost of such works will be paid under provisional sums.

10.9 ROADS AND PAVEMENTS

10.9.1 GRANULAR SUB-BASE

10.9.1.1 *Scope*

The work shall consist of laying and compacting well-graded material on prepared sub grade in accordance with the requirements of these Specifications. The work also includes restoring of pipe trenches, pavements, kerbs etc. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections as directed by the Engineer.

10.9.1.2 *Materials*

The material to be used for the work shall be natural sand, moorum, gravel, crushed stone, or combination thereof depending upon the grading required. Materials like crushed slag, crushed concrete, brick metal and kankar may be allowed only with the specific approval of the Engineer. The material shall be free from organic or other deleterious constituents and conform to grading given in Table 35

Table 35 Grading for Close-Graded Granular Sub-Base Materials

IS sieve	Per cent by weight passing the IS sieve		
Designation	Grade I	Grading II	Grading III
75.0 mm	100	-	-
53.0 mm	80-100	100	-
26.5mm	55-90	70-100	100
CBR Valve (minimum)	30	25	20

10.9.1.3 *Physical requirements*

The material shall have a 10 percent fineness value of 50 KN or more (for sample in soaked condition) when tested in compliance with BS: 812 (Part III). The water absorption value of the coarse aggregate shall be determined as per IS: 2386 (Part 3); if this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS: 383.

10.9.1.4 *Strength of Sub-base*

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished.

The CBR test shall be carried out in field to determine dry density and moisture content for quality of material.

10.9.1.5 *Construction Operations*

- Preparation of sub grade

Immediately prior to the laying/restoring of sub-base, all loose and disintegrated material shall be removed from the excavated area and surface lightly sprinkled with water if necessary and rolled/compacted with two passes of 80-100 KN smooth wheeled roller.

The surface shall be firm and clean in all respects.

10.9.1.6***Spreading and compacting***

The sub-base material of grading specified in Table 16.2 shall be spread on the prepared surface maintaining the required slope and grade.

When the sub-base materials consist of combination of materials, mechanically/manual mixing shall be done before placing /spreading.

Moisture content of loose material shall be checked and suitably adjusted by sprinkling additional water uniformly and at controlled quantities to variable width of surface or means approved by the Engineer. While adding water, due allowance shall be made for evaporation losses thereafter rolling and compaction shall start by road rollers/vibrators until the layer is uniformly wet. Attention be paid for the compaction on the edges.

The single layer be compacted up-till 225mm thick with 80 to 100 KN road roller or equivalent capacity roller capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional cross fall and super elevation and shall commence at the edges and progress towards the centre for portions having cross fall on both sides.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and cross fall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material determined as per IS: 2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

The edges of the surface shall be protected with laying of F.P.S bricks of class designation 75. The bricks shall be laid in full brick width and half brick depth including excavation, refilling and disposal of surplus material.

Table 36 Grading Requirements of Coarse Aggregates

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
1.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10
		11.2 mm	0-5

10.9.1.7***Surface Finish and Quality Control of Work***

The surface finish of construction shall conform to the requirements of the work as specified in Section 902 of MORT&H specifications for Road and Bridge Works (IV revision).

Quality control of material and works shall be exercised in accordance with Section 900 of MORT&H specifications for Road and Bridge Works (IV revision).

10.9.1.8***Measurements and Rate***

The contract unit price of the entire item required for carrying out the above operations including full compensation for:

1. Making arrangements for traffic and construction of diversions;
2. Furnishing all materials to be incorporated in the work including all royalties, fees, rents where necessary and all leads and life;
3. All labor; tools, equipment and incidentals to complete the work to the Specifications; and
4. Carrying out the work in part widths of trench/road where directed including edge protection.

10.9.2**WATER BOUND MACADAM SUB-BASE**

10.9.2.1***Scope***

This work shall consist of clean, crushed aggregates by rolling/compacting and bonding together with screening, binding material where necessary and water laid on a properly prepared sub grade/sub-base/base or existing pavement, as the case may be and finished in accordance with the requirements of these Specifications and in close conformity with the lines, grades, cross-sections and thickness as directed by the Engineer.

Water bound macadam shall be laid on the sub grade surface.

10.9.2.2***Materials***

- Coarse aggregates

Coarse aggregates shall be either crushed or broken stone, crushed slag, or any other naturally occurring aggregates such as kankar and laterite of suitable quality. Material other than crushed or broken stone and crushed slag shall be used in sub-base courses only. If crushed gravel/shingle is used, not less than 90 per cent by weight of the gravel, shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements as per IS: 2386 (Part 1 to 5)

- Crushed or broken stone

The crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other deleterious material.

- Grading requirement of coarse aggregates

The coarse aggregates shall conform to one of the Grading given in Table 37 as specified, provided; however, the use of Grading No. 1 shall be restricted to sub-base courses only.

Table 37 Grading Requirements of Coarse Aggregates-1

Grading No.	Size Range	IS Sieve Designation	Per cent by weight passing
1.	53 mm to 22.4 mm	63 mm	100
		53 mm	95-100
		45 mm	65-90
		22.4 mm	0-10

		11.2 mm	0-5

- Screenings

Screenings to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate.

Screenings shall conform to the grading set forth in Table 38. The consolidated details of quantity of screenings required for various grades of stone aggregates are given in Table 36. The table also gives the quantities of materials (loose) required for 10 m^2 for sub-base/base compacted thickness of 100/75 mm.

Table 38 Grading for Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by weight passing the IS Sieve
B	11.2 mm	11.2 mm 5.6 mm 180 mm	100 90-100 15-35

Approximate Quantities of Coarse Aggregates and Screenings required for 100/75 mm. Compacted Thickness of Water Bound Macadam (WBM) Sub-Base /Base Course for 10m^2 Area is given below:

Table 39 Approximate Quantities of Coarse Aggregates and Screenings

Classification	Size Range	Compacted thickness	Loose Qty.	Screenings			
				Stone Screening		Crushable Type such as Moorum or Gravel	
				Grading Classification & size	For. WBM Sub-base/ base course (Loose quantity)	Grading Classification & size	Loose Qty.
Grading 3	53 mm to22.4 mm	75 mm	0.91 to 1.43 m2	Type B 11.2 mm	0.18 to 0.21 m3	-do-	0.22 to 0.24 m3

10.9.2.3***Binding material***

Binding material to be used for water bound macadam as a filler material meant for preventing raveling, shall comprise of a suitable material approved by the Engineer having a Plasticity Index (PI) value of less than 6 as determined in accordance with IS: 2720 (Part-5).

The quantity required for 75 mm compacted thickness of water bound macadam will be 0.06-0.09 m3/10m^2 and 0.08-0.10m3/10m2 for 100 mm compacted thickness.

10.9.2.4 *Construction Operations*

Preparation of base and spreading

The surface of the sub grade/sub-base/base to receive the water bound macadam course shall be prepared to the specified lines and cross fall (camber) and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled/compact until firm surface is obtained if necessary by sprinkling water. Any sub-base/base/surface irregularities, where predominant, shall be made good by providing appropriate type of profile corrective course (leveling course) as per the site conditions or as directed by Engineer.

As far as possible, laying water bound macadam course over an existing thick bituminous layer may be avoided since it will cause problems of internal drainage of the pavement at the interface of two courses. It is desirable to completely pick out the existing thin bituminous weaning course where water bound macadam to be laid over it. The directions and depth of furrows shall be such that they provide adequate bondage.

The spreading shall be done from stockpiles along the side of the road or directly from vehicles. No segregation of large or fine aggregates shall be allowed and the coarse aggregate as spread shall be uniform gradation with no pockets of fine material.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregates as may be required. The surface shall be checked frequently with a straight edge while spreading and rolling so as to ensure a finished surface.

10.9.2.5 *Rolling*

Immediately following the spreading of the coarse aggregate, rolling shall be started with three wheeled power rollers of 80 to 100 kN capacity or plate compactor hand roller (where width does not permit use of road roller). The type of roller to be used shall be approved by the Engineer based on trial run.

Rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inward parallel to the centre line of the road, in successive passes uniformly lapping preceding tracks by at least one half width.

During rolling, slight sprinkling of water may be done, if necessary. Rolling shall not be done when the sub grade is soft or yielding or when it causes a wave-like motion in the sub grade or sub base course.

The rolled surface shall be checked transversely and longitudinally, with templates and any irregularities corrected by loosening the surface, adding or removing necessary amount of aggregates and re-rolling until the entire surface conforms to desired cross fall (camber) and grade. In no case shall the use of screenings be permitted to make up depressions.

Material which gets crushed excessively during compaction or becomes segregated shall be removed and replaced with suitable aggregates.

It shall be ensured that shoulders are built up simultaneously along with water bound macadam courses as per requirement.

10.9.2.6 *Application of screenings*

After the coarse aggregate has been rolled to Clause 16.2.4.1, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motions of hand shovels or directly from tipper with suitable grit spreading arrangement. Tipper operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming. In no case shall the screenings be applied as fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling, and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

10.9.2.7***Sprinkling of water and grouting***

After the screenings have been applied, the surface shall be sufficiently sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operation shall be continued, with additional screenings applied as necessary until the coarse aggregate has been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or sub grade does not get damaged due to the addition of excessive quantities of water during construction.

10.9.2.8***Application of binding material***

After the application of screenings in accordance with Clauses 16.2.7.2 and 16.2.7.3 the binding material where it is required to be used (Clause 16.2.4.8) shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling of voids, forms a wave ahead of the wheels of the moving roller.

10.9.2.9***Setting and drying***

After the final compaction of water bound macadam course, the pavement shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer shall have the discretion to stop hauling traffic from using the completed water bound macadam course, if in his opinion it would cause excessive damage to the surface.

The compacted water bound macadam course should be allowed to completely dry and set before the next pavement course is laid over it.

10.9.2.10***Surface Finish and Quality Control of work***

The surface finish of construction shall conform to the requirements.

Control on the quality of materials and works shall be exercised in accordance with Section 900 of MORT&H Specifications for Road and Bridge Works (IV Revision).

10.9.2.11***Reconstruction of defective macadam***

The finished surface of water bound macadam shall conform to the tolerance of surface regularity of existing road. However, where the surface irregularity of the course exceeds the tolerances or where the course is otherwise defective due to sub grade soil mixing with the aggregates, the course to its full thickness shall be scarified over the affected area, reshaped with added material or removed and replaced with fresh material as applicable and re-compacted. In no case shall depressions be filled up with screenings or binding material.

10.9.2.12***Measurements and Rate***

The contract unit price of the entire item required for carrying out the above operations including full compensation for all components listed in Clause 16.1.11 (1) to (4) including arrangement of water used in the work as approved by the Engineer.

10.9.3**TACK COAT**

10.9.3.1***Scope***

The work shall consist of application of a single coat of low viscosity liquid bituminous material on base and course road surface preparatory to superimposition of a bituminous mix prior to water bituminous macadam as per the specification.

10.9.3.2***Materials Binder***

The binder used for tack coat shall be a bituminous emulsion complying with IS 8887 of a type and grade as specified in the contract or as directed by the Engineer. The use of cut back bitumen as per IS 217 shall be restricted only for sites at sub-zero temperature or for emergency applications as directed by the Engineer.

10.9.3.3***Weather and Seasonal Limitations***

Bituminous material shall not be applied to a wet surface or during a dust storm or when the weather is foggy, rainy, or windy or when the temperature in the shade is less than 10 degree C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cut back bitumen, the surface shall be dry.

10.9.3.4***Construction***

Equipment: The tack coat distributor shall be self-propelled/hand spraying equipped for spraying the material uniformly at a specified rate as directed by the Engineer

10.9.3.5***Preparation of base***

The surface finish of all granular layers on which bituminous work are to be placed, all loose and disintegrated materials shall be removed and free from dust in accordance with the requirement of Clause 902 of MORT&H specifications of Road and Bridge Works (IV revision).

After cleaning the surface, it shall be correct to line and level, with tolerances specified for base courses. The pot holes shall be filled with material such as coarse aggregate.

After the removal of any non-integral loose material and immediately before the application of the tack coat the surface shall be swept clean with broom/brush.

10.9.3.6***Application of tack coat***

The application of tack coat shall be at the rate as specified in the contract, and shall be applied uniformly.

Table 40 Rate of Application of Tack Coat

S. No.	Type Surface	Quantity of Liquid Bituminous Material in kg Per sqm area
1.	Non bituminous surfaces	
(i)	Granular base (not primed)	0.35 to 0.40

Table 41 Rate of Application of Tack Coat

S. No.	Type Surface	Quantity of Liquid Bituminous Material in kg per sqm area
2.	Normal bituminous surfaces	0.20 to 0.25
3.	Dry and hungry bituminous surfaces	0.25 to 0.30
4.	Granular surfaces treated with primer	0.25 to 0.30
5.	Non bituminous surfaces	
(i)	Granular base (not primed)	0.35 to 0.40
(ii)	Cement concrete pavement	0.30 to 0.35

The normal range of spraying temperature for a bituminous emulsion shall be about 20 to 70 degree C.

10.9.3.7***Curing of tack coat:***

The tack coat shall be left to cure until all the volatiles have been evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction. The finish work shall be required quality and quantity.

10.9.3.8***Measurements and Rate***

The contract unit price of the entire item required for carrying out the above operations including full compensation for all components listed in Clause 16.1.11 (1) to (4) including arrangement of water used in the work as approved by the Engineer.

10.9.4**BITUMINOUS MACADAM**

10.9.4.1***Scope***

The work shall consist of construction, in a single course having 25mm thick surface with 3 cum of stone chippings 10mm nominal size per 100 sqm premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications.

10.9.4.2***Materials***

- Bitumen

The bitumen shall be paving bitumen of Penetration Grade S65 or A65 (60/70) as per Indian Standard for “Paving Bitumen” IS: 73. In case non availability of bitumen of this grade, S90 (80/100) grade bitumen may be used with the approval of Engineer. Guidance to selection of grade of bitumen may be taken from Appendix 4 of MORT&H specification for Road & Bridge works (IV Revision)

- Coarse aggregates

The coarse aggregates shall consist of crushed stone, rock, gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, and durable, of cubical shape, free from dust and soft friable matter organic or other deleterious matter. Before approval of the source, the aggregates shall be tested for stripping.

The aggregates shall satisfy the physical requirements set forth in Table 16-8.

Where crushed gravel is proposed for use as aggregate, not less than 90% by weight of the crushed material & retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 42 Physical Requirements for Coarse Aggregates for Bituminous Macadam

Property	Test	Specifications
Cleanliness	Grain size Analysis[1]	Max. 5% passing 0.075mm sieve
Particle Shape	Flakiness and elongation Index (Combined)[2]	Max. 30 %
Strength*	Los Angeles Abrasion Value[3] Aggregate Impact Value[3]	Max. 40 % Max. 30 %
Durability	Soundness[4] Sodium Sulphate Magnesium Sulphate	 Max. 12 % Max. 18 %
Water Absorption	Water Absorption[5]	Max. 2%
Stripping	Coating and stripping of Bitumen Aggregate Mixtures[6]	 Minimum retained coating 95 %
Water Sensitivity[7]	Retained Tensile Strength	Minimum 80 %

Notes

1. 1. IS 2386 Part 1 4.IS 2386 Part 5
2. 2. IS 2386 Part 1 5. IS 2386 Part 3
3. (the elongation test to be done only on non-flaky aggregate in the sample)
4. 3. IS 2386 Part 4*
5. 6. IS 6241
6. The water sensitivity test is only required if the minimum retained coating in the stripping test is less than 95 %

* Aggregates may satisfy requirement of either of these two tests.

10.9.4.3***Proportioning of materials***

The aggregates shall be proportioned and blended to produce a uniform mixture complying with the requirement of specification. The binder content shall be within a tolerance of ± 0.3 per cent by weight of total mixture when individual specimens are taken for quality tests in accordance with the provisions of Section 900 of MORT&H Specifications for Road and Bridge Works (IV Revision).

10.9.4.4***Construction Operations***

- Weather and seasonal limitations

The provisions of Clause 501.5.1 of MORT&H Specifications for Road and Bridge Works (IV Revision) shall apply.

- Preparation of the base

The surface on which bituminous macadam are to be placed, all loose and disintegrated materials shall be removed and the surface be swept clean with broom/ brush and kept free from dust in accordance with the requirement of Clause 902 of MORT&H specifications of Road and Bridge Works (IV revision).

- Preparation and transportation of mixture

The provisions of Clause 501.3 and 501.4 of MORT&H Specifications for Road and Bridge Works (IV Revision) shall apply.

- Spreading

The mix bituminous macadam shall be spread uniformly and evenly upon the prepared surface in required quantities. In no case should these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The surface of the bituminous macadam shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of material is allowed. The bituminous macadam as spread should be of uniform gradation with no pockets holes etc.

The provisions of Clause 501.5.3 of MORT&H Specifications for Road and Bridge Works (IV Revision) shall apply.

Table 43 Manufacturing and Rolling Temperatures

Bitumen Penetration	Bitumen Mixing (^oC)	Aggregate Mixing (^oC)	Mixed Material (^oC)	Rolling (^oC)	Laying (^oC)
25	160-170	160-175	170 Maximum	100 Minimum	130 Minimum

10.9.4.5***Rolling***

Compaction shall be carried out in accordance with the provisions of Clause 501.6 and 501.7 of MORT&H Specifications for Road and Bridge Works (IV Revision).

Rolling shall be continued until the required compaction/density is achieved.

10.9.4.6***Compaction***

After the bituminous macadam has been laid for the required thickness, grade and cross fall/camber the same shall be uniformly compacted, to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100 KN weight may be used. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/super elevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the centre line of the road, uniformly over-lapping each preceding track by at least one third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the centre parallel to the centre line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good.

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling shall be continued till the density achieved is at least 98 per cent of the maximum dry density for the material as determined by the method outlined in IS: 2720 (Part-8).

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

10.9.4.7***Surface Finish and Quality Control of Work***

The surface finish of completed construction shall conform to the requirements of Clause 902 of MORT&H Specifications for Road and Bridge Works (IV Revision). For control of the quality of materials supplied and the works carried out, the relevant provisions of Section 900 of MORT&H Specifications for Road and Bridge Works (IV Revision).

10.9.4.8***Protection of the Layer***

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, the course shall be covered by a seal coat to the requirement of Section 513 of MORT&H Specifications for Road and Bridge Works (IV Revision) before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

10.9.4.9***Measurement and Rate***

The work of roads and pavement shall be measured in square meters for all the operation described for construction/restoration works

Payments shall be made on the basis of unit rates quoted for the respective items in the schedule of quantities.

The contract price shall include all operation for completion of work including material and machinery.

11 QUALITY ASSURANCE AND QUALITY CONTROL

11.1 QUALITY ASSURANCE

The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the contract. The system shall be in accordance with the details stated in the contract. The Engineer shall be entitled to audit any aspect of the system.

Details of all procedures and compliance documents shall be submitted to the Engineer for information before each design and execution stage is commenced. When any document of a technical nature is issued to the Engineer, evidence of the prior approval by the contractor himself shall be apparent on the document itself.

Compliance with the quality assurance system shall not relieve the contractor of any of his duties, obligations or responsibility under the contract.

Assurance and Quality control manual of MORT&H, BIS and IRC shall be strictly followed

11.1.1GENERAL RESPONSIBILITIES

Contractors are responsible for providing:

- All necessary plant, labor, equipment and construction materials to be used in the works;
- All plant, equipment, materials and labor for temporary and auxiliary works;
- All equipment and components to be installed or incorporated in the works;
- Transportation and storage facilities for all materials and equipment.
- Office and accommodation for staff and labor; and for consultants and client's staff
- Sanitation facilities at the site; and
- All necessary staff and equipment for testing and quality control including site office laboratories.

Contractors will be responsible for executing and completing the works in accordance with the specified standards and specifications, within the contractual time allowed, and within the contract price for these works.

11.1.2QUALITY ASSURANCE/QUALITY CONTROL DUTIES

The contractor's QA/QC duties are summarized in Table 15.5 Other duties shall be performed as stipulated in the contract documents or directed by the Engineer/PIU.

Contractors are responsible for executing and completing the works in accordance with the specified standards and specifications, within the contractual time allowed, and within the contract price for these works.

11.1.3QUALITY ASSURANCE/QUALITY CONTROL DUTIES

The contractor's QA/QC duties are summarized below in Table other duties shall be performed as stipulated in the contract documents or directed by the Engineer/PIU.

List of Contractor's QA/QC Duties is given below in Table 44:

Table 44 List of Contractor's QA/QC Duties

Activity / Item	Contractor's QA/QC Duties

Activity / Item	Contractor's QA/QC Duties
Designs for item-rate contracts	• Maintain design register at site • Use only approved drawings for construction
Test laboratory and equipment	• Intimate DSC/PIU the details, date of completion with requisite manufacturers' and calibration certificates • Maintain the equipment in good condition and calibrate as necessary
Material receipts	• Enter receipts in material register • Intimate DSC/PIU in writing
Materials testing	• Prepare mix designs as required by contract and submit test results to DSC/PIU • Take test samples in presence of DSC/PIU when requested • Perform materials tests • Submit test reports to PIU and DSC with monthly reports • Maintain test log
Rejected materials	• Enter in material register at site • Intimate PIU and DSC in writing the proposed date of removal from site and confirm after removal
Material consumption	• Enter daily consumption of materials in material register and indicate balance quantity
Construction equipment	• Intimate PIU and DSC the details, date of mobilization along with requisite insurance certificate • Maintain equipment in good working condition
Construction	Intimate PIU and DSC in writing when construction is going to commence and what activities are proposed to be undertaken. Intimate PIU and DSC in advance when critical works, such as concreting, embankment, paving, pipeline laying and jointing, testing, etc., would be undertaken, along with the test certificates of the materials proposed to be used in these works. No critical activity shall start unless the material test certificates are verified and approved by the Engineer. Provide necessary QA/QC
Daily work progress	Maintain in daily log
Testing of works in progress	Perform tests as per contract requirements Submit test reports to PIU and DSC

Activity / Item	**Contractor's QA/QC Duties**
	Maintain test log
Rejected work items	• Intimate PIU and DSC in writing the proposed date of removal from site and confirm after removal, or (if so agreed by PIU and DSC) • Rectify defective work and invite PIU and DSC for re-inspection.
Instructions from Engineer	• Enter change orders, site instructions, letters and minutes of meetings issued by the Engineer in the Instruction Log
Inspection of Engineer	• Take instructions in Site Order Book. • Inform PIU and DSC of compliance
Progress scheduling and control	• Prepare and maintain project schedules and undertake work in accordance with approved schedule
Reporting	• Prepare and submit Monthly Progress Reports
Records	Maintain the following records on site: • Material Register • Site Order Book • Hindrance Register • Daily Log • Design Register • Test Log • Instruction Log • Equipment Register • Labor Register • Approved Construction Drawings • Test Reports • Site Laboratory Record • Permissions Issued by Departments • Correspondence Record • Copies of Monthly Progress Reports • Any other records as specified in the Contract and/or as instructed by the Engineer

11.2 INTRODUCTION TO THE QA/QC MANUAL

This section of the Quality Assurance/Quality Control Manual presents the Project's background, defines quality-related terms and gives an outline of the Manual.

11.2.1 BACKGROUND

Bihar Urban Infrastructure Development Corporation has undertaken the implementation of Gaya Water Supply Project.

The overall Project objective is to rehabilitate and upgrade the water supply system of Gaya to 24x 7 continuous water supply systems by supplying water from Tube wells to the part of the town by constructing new Distribution system. Rehabilitating existing tube-wells, OHSRs, GLSRs and constructing new reservoirs are done through other packages.

The project is being implemented for the initial and ultimate design years 2018 and 2047 demand, respectively.

The Design of the entire system has already been done by Design and Supervision consultant (DSC) appointed by BUIDCo for this project.

11.2.2 QUALITY DEFINITIONS

Quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy a given need. The term 'given need', in case of project works, can be interpreted as the functional requirements. The quality of outputs is always agreed upon between the supplier and the client (in project works, contractor and the owner), and the quality objective must be to achieve zero defects within acceptable tolerances. It can be made possible only by ensuring the quality at all stages of project works.

The following are some definitions pertaining to quality and how to achieve it:

- Quality: Conformance to requirements.
- Quality Control (QC): The operational techniques and activities (such as reviewing, checking, inspecting, testing, etc.) that are used to fulfill requirements for quality.
- Quality Assurance (QA): The planned and systematic actions necessary to provide adequate confidence that the work will satisfy quality requirements.
- Quality System (QS): A set of documented processes, which seek to provide confidence that the project outputs will fulfill the functional requirements. The Quality System should encompass the organization, responsibilities, human resources, materials, equipment, processes, inspections, testing and other parameters of the project. A key element of QS is the QA/QC Manual.
- Quality Surveillance: This normally covers two aspects:
  - At the project level, a review to ensure that the quality practices are implemented and documented in relation to the quality system; and
  - At the contract package level, inspection and testing to ensure that the works executed meet the required quality standards.

11.2.3 QA/QC MANUAL

This QA/QC Manual focuses on the implementation activities of the project following contract award, and primarily on supervision and quality control of construction works. Other aspects of project implementation are also covered but in less detail. The QA/QC Manual is intended to be used primarily by the project staff of the CSQC and the Contractors.

The QA/QC Manual for the Project does not attempt to suggest technical specifications, since these are stated in the contract documents. Its aim is to ensure that the works are executed as per specifications, i.e. it is looked at as a means to achieve the end results. Quality control and test results shall be interpreted as applicable for different packages, in accordance with the contract conditions.

The subsequent sections of this Manual are as follows:

- Organization
- Construction Quality Control – General
- Control of Materials and Equipment Components
- Control of General Civil and Structural Works
- Control of Canal Works
- Control of Road and bridge Works
- Control of Pipeline Works
- Document Control
- Reporting

11.3 ORGANIZATION, RESPONSIBILITIES AND AUTHORITIES

This section of the QA/QC Manual describes the organizational arrangements for project implementation and outlines the responsibilities of each organization.

11.3.1PROJECT IMPLEMENTATION ARRANGEMENTS

a) The Water Supply Facilities will be executed through the Project Implementation Unit (PIU) of BUIDCo. The State has appointed a Project Director for the Project. PIU has the overall responsibility for coordination and management of the Project activities, including Project design, implementation, budgeting and financial planning, benefit monitoring and evaluation, socioeconomic surveys, environmental assessment and protection, institutional and policy development, community participation and coordinating the work of all consulting services under the Project.

b) Project Implementation Units (PIU) have been established to support the project works. They have the primary responsibility for planning and implementing all the Project components in time, within cost estimates, and to the quality standards specified in the contract documents within their respective areas.

c) BUIDCo has appointed a Design and Construction Supervision Consultant for Design and supervise the Project related activities. DSC is responsible for assisting the PIU and PMU in implementing, managing and monitoring Project activities, recommend ways to accelerate Project implementation.

d) The DSC responsible for Construction Supervision and Quality Control activities for the project along with the PIU.

The scope of QA &QC is broadly categorized into following key activities:

1. Technical scrutiny/ review of Contractor’s drawings, plans, and method statements, manuals

2. Analyse construction planning, schedule / programme, resource mobilization and progress monitoring
3. Quality control

Inspection of Materials, Machinery and Equipment

Monitoring Quality and Performance of Works and Equipment

4. Measurement of works, Bills verification and recommendation
5. Review and recommend variation
6. Review and recommend claims
7. Coordination with line agencies and other consultants

e) The details of the individual responsibilities of each wing related to various activities are laid down as below to avoid any misunderstanding. The list of responsibilities as enumerated below may all not appear to be of direct bearing on the quality, but they do contribute to clarity of responsibility and hence help organize the works better. This is only to facilitate smooth functioning and is not meant in any way to dilute the responsibilities and authority various wings have in their respective jurisdiction under the contract documents.

Table 45 Responsibilities of Key Agencies

Sl. No.	Task	Responsibility	Unit
1.0	**Design of works and Contract Packaging**		
1.1	Detailed Design of works for Contracts with drawings and estimates of item wise contract	Preparation Review Approval	DSC PIU/PMC PMU
1.2	Modification of scope of works	Recommend Approval	DSC PMU/PIU
2.0	**CONTRACT ADMIINISTRATION AND CONSTRUCTION SUPERVISION GENERAL**	**PRIMARY** **SECONDARY**	**DSC/PIU**
2.1	Overall administration and management of the contract including interpretation of the technical specifications and other contract documents as may be required;	Primary Secondary	DSC PMU/PIU
2.2	Review and revise construction drawings as may be necessary from time to time, either to suit site conditions, changes in construction strategy or changes in design, and provide clarifications / explanations on	Preparation Review	DSC PIU/PMC

	the designs and drawings to the contractor.	Approval	PMU
2.3	Review and recommend acceptance or modification of the construction drawings and designs prepared by the DSC for the project	Review Approval	PIU/PMC PMU
2.4	Giving level and layout for those items of work where dimensional accuracy has a direct bearing on the quality and performance of the finished work to ensure conformity with the quality requirements stipulated in the contract;	Primary Secondary	Contractor DSC
2.5	Assess the adequacy of the inputs such as materials, labor and equipment provided by the contractor and the construction methods proposed and ensure that they are satisfactory with reference to the technical requirements, implementation schedule, environmental aspects, and safety of the works, project personnel, and general public welfare should be only in case a dispute arises.	Primary Secondary	DSC PIU
2.6	Proper inventories and accounts are maintained of all dismantled materials, particularly for those materials which are to be re-used in the works;	Primary Secondary	contractor PMU/PIU
2.7	The work site is maintained in a neat, orderly and safe manner;	Primary Secondary	Contractor DSC/PIU
2.8	Any inconvenience to the public is minimized; and Payments are made to the Contractor in a timely manner.	Primary Secondary	Contractor PIU/DSC
2.9	Necessary assistance to solve any contractual dispute and sort out issues requiring external interdepartmental coordination, which has an overall obligation to ensure the successful implementation of the project, works.	Primary Secondary	PIU/PMU DSC
2.10	Providing continuous on-site supervision during construction and ensuring the safety of the works;	Primary Secondary	DSC PIU
2.11	Supervising and monitoring the	Primary	DSC

	progress of the works, including identifying cause(s) of delays, determining remedial actions to correct such delays, and issuing instructions to contractors;	Secondary	PIU
2.12	The contractor fulfills his obligations under the contract and satisfactorily completes all contractual obligations and complies with all applicable statutes, regulations, contract conditions, specifications and instructions;	Primary Secondary	DSC PIU/PMU
2.13	The contractor completes the work within the scheduled time	Primary Secondary	Contractor DSC/PIU
2.14	Ensuring that Site Order Books, Daily Work Records, Labor, Material and Machinery Logs are properly maintained	Primary Secondary	Contractor DSC/PIU
2.15	Making test records and results available to the DSC/PIU for review and assessment in case of dispute only.	Primary Secondary	Contractor DSC/PIU
2.16	Acting on project issues and problems as they arise, and promptly issuing written instructions to the contractors to address the problems;	Primary Secondary	DSC PIU
2.17	Ensuring that the contractor properly prepares the "As Built" drawings for the completed works;	Primary Secondary	Contractor DSC/PIU
2.18	Ensuring that the contractor prepares and submit Monthly Progress Report in the approved format and on time	Primary Secondary	Contractor DSC/PIU
3.0	**QUALITY ASSURANCE AND INSPECTIONS**	Primary Secondary	**Contractor** **DSC/PIU**
3.1	Prepare a simplified Quality Control Manual for use of the field staff, and assist in providing on-the-job training to PIU and Contractor staff	Primary Secondary	PMC DSC
3.2	Provide effective supervision of the	Primary	DSC

	works in order to ensure the quality and conformity with the standards and specifications prescribed in the contract	Secondary	PIU
3.3	Regular and frequent inspections of all work sites should be made to check the nature and quality of work being done, to verify the materials, equipment and labor engaged at the site, to review the quality control tests and test results, and to ensure that the work is being implemented in accordance with the approved standards and that the quality control procedures set forth under the contract are being followed.	Primary Secondary	DSC PIU
3.4	Witness all quality control sampling and testing done by the contractor. Compile and review all quality control data obtained from tests conducted by the contractor or by others and verify the accuracy of the test data by checking the procedures used in the field for sampling and testing of the materials and works. Instruct & Supervise independent sampling and testing wherever considered necessary, or as may otherwise be required to check and verify the accuracy of the test results conducted by the contractor. Assess the test results and recommend on acceptance of the materials supplied and on the works completed. To ensure that proper records of the tests conducted are maintained.	Primary Secondary	DSC PIU
3.5	Periodic inspections on an as-required basis to inspect and accept interim work completion stages (i.e., completion of excavation in order to permit the contractor to proceed with further works. All approvals should be entered into the site order book and signed by all parties, and no work on further stages should be permitted until the earlier stage work has been inspected and accepted. In the event that the work fails to meet the required standards, any removal and replacement or other remedial measures which may be required should be clearly explained along with a time schedule for completing such work.	Primary Secondary	DSC PIU

3.6	Joint inspection(s) of the completed works by DSC, PIU,PMU and contractor, preparing a statement of exceptions for any works which may remain to be completed, approving and accepting the completed works, issuing the Certificate of Acceptance and making final payment to the contractors.	Primary Secondary	DSC PIU/PMU
3.7	Inspections of the completed works, ensuring that any defects in materials or workmanship are properly identified in a timely manner.	Primary Secondary	DSC PIU
3.8	Participate in monthly inspections and site coordination meetings of PIU, DSC and Contractor for all works to review the overall progress and quality of the works, review the problems which may have arisen, the instructions which were issued to the contractor to address these problems and the contractor's compliance with these instructions, and to agree on any further actions which may be required to be taken to improve either the progress of quality of the works. The DSC shall be responsible to prepare the minutes of the site coordination meetings in order to maintain a permanent record of all agreements reached, instructions issued and actions to be taken.	Primary Secondary	DSC PIU
3.9	Following expiration of the Maintenance Period/defect liability period, inspecting the works, identifying any defects in materials or workmanship, issuing the Completion Certificate and releasing the security deposit or balance of security deposit following satisfactory correction of all defects.	Primary Secondary	DSC PIU/PMU
4.0	**CONTRACT VARIATIONS**	**Proposal** **Recommendation** **Approval**	**Contractor** **DSC** **PIU/PMU**
4.1	Make a monthly assessment of the progress and quality of the works and recommend to the PIU/PMU on any necessary variations to the contracts, including work programs, work procedures, inputs, safety, quality,	Proposal Approval	DSC/PIU PMU

	variation orders, completion dates, and/or any other matters which may affect the timely and satisfactory completion of the work. Propose and present for approval any changes in the plans which may be deemed necessary, and indicate any effect such changes may have on the contract. Assist the SIU in preparing any required variation orders and obtaining necessary approvals from the SIU prior to issuance to the contractor where required.		
4.2	Examining all proposed variation orders or claims from the contractor for time extensions, extra compensation, or expenses or other similar matters, preparing variation orders and obtaining necessary approvals from SIU prior to issuance to the contractor where required.	Proposal Recommendations Approval	Contractor DSC/PIU PMU
5.0	**MEASUREMENT AND PREPARING BILLS AND PAYMENTS**	**Preparing** **Approval and Payment**	**Contractor** **DSC/PIU and PMU**
5.1	Conducting with contractor joint measurement of the works in the stipulated format for payment	Preparation /measurement of bills	DSC & PIU
5.2	Record Measurement for such measurements which cannot be verified subsequently	Measurement and record	DSC
5.3	Preparing necessary payment release order of security and payment thereof after completion of the defect liability period as per the contract.	Verification of bills & recommendation for payment	DSC
5.4	Passing of the bills for supplies received under the material procurement packages after due inspection and checking and payment thereof. The CSQC, and SIU will provide a certificate regarding full confirmation of the goods to the specifications and being in good condition.	Verification of bills & recommendation for payment Review & Approval	DSC PIU/PMU
6.0	**REPORTING**		

6.1	Monthly Progress report to DSC	Submission	Contractor
6.2	Preparing Monthly Progress Reports in the approved format, including physical and financial progress, problems encountered and actions taken and submitting to the PIU in a timely manner incorporating the contractor's report.	Submission	DSC
6.3	Submit a quarterly Progress report for submission to DSC, PIU/PMU	Submission	Contractor
6.4	Reporting to PIU from time to time regarding overall physical and financial progress of work, with specific mention of problems encountered and actions taken or remedial measures recommended, variation orders approved, anticipated slippage in any item of work, rectification measures recommended, and any specific assistance required from PIU	Submission Review/Comments /approval	DSC PIU
6.5	Submission of the contract completion report summarizing the construction activities and indicating, among other things, contract changes, claims or disputes, or any other substantive matters having an effect on the cost and progress of the works and accurate and complete "As Built" drawings (to be submitted by the contractor) for the completed works	Submission Review/Comments/approval	DSC PIU/PMU
6.6	Assist the PIU in preparing the Project Completion Report	Preparation Review & finalize	DSC PMU/PIU
7.0	**BUDGET**		
7.1	Annual plan of work and forecast of funds requirement for each component of the Project.	Submission Review	Contractor DSC
7.2	Annual Project plan and forecast of funds requirement for the Project	Submission Review	DSC PIU/PMU
8.0	**FINANCE AND MAINTAINANCE OF**		

	ACCOUNTS		
8.1	Financial Management Control and maintenance of Project Accounts	Primary Secondary	PMU PIU
8.2	Preparation and submission of disbursement claims	Primary Secondary	PMU PIU
8.3	Compilation, disbursement preparation and submission of reimbursement claims for the Project to the ADB	Primary Secondary	PMU PIU
9.0	**INTER DEPARTMENTAL AFFAIRS**		
9.1	Land acquisition	Identification & Acquisition	PMU/Land Deptt.
9.2	Identification of Power Connection, Railway crossing, and Road crossings. Pipe/Sewer interconnections with existing systems, permission for use of Forestland, etc.	Primary Secondary	Contractor/DSC PIU/Line Agency
9.3	Obtaining permissions from other departments and organizing the works as required through them.	Primary Secondary	PIU/Line Agency Contractor/DSC
10.0	**TRAINING**		
10.1	Review and assess training needs / requirements of the SIU.	Primary Secondary	PMC DSC/PMU
10.2	Development of a comprehensive training plan to meet identified needs.	Primary Secondary	PMC DSC/PIU/PMU
10.3	Preparation of Training manuals and modules.	Primary Secondary	Contractor PMC
10.4	Providing on the job training and conducting training for PIU & PMU Staff	Primary	Contractor

		Secondary	PMC/DSC

Note: The above procedures are prepared with a view of ensuring a smooth action in various activities, which generally have an overlapping responsibility. They are only a clarification on the responsibilities as prescribed in the respective contract documents. In case of variance, the contract documents will precede over the above stipulations. **Wherever the responsibilities are shown to more than one agency, the order of precedence of responsibility is from left and that of authority is from right.**

Contractors are responsible for the execution of the works in conformance with the requirements of the Employers documents.

11.3.2 GENERAL RESPONSIBILITIES

Contractor is responsible for providing:

- all necessary plants, labors, equipment and construction materials to be used in the works;
- all plants, equipment, materials and labors for temporary and auxiliary works;
- all equipment and components to be installed or incorporated in the works;
- Transportation and storage facilities for all materials and equipment.
- office and accommodation for staff and labors; and for consultants and employer's staff
- sanitation and other basic facilities at the site; and
- All necessary staff and equipment for testing and quality control including site office laboratories.

Contractors are responsible for executing and completing the works in accordance with the specified standards and specifications, within the contractual time allowed, and within the contract price for these works. On water supply turnkey contracts, contractors are also responsible for preparing detail design documents, drawings and obtaining their approval.

11.3.3 QUALITY ASSURANCE/QUALITY CONTROL DUTIES

The contractor's QA/QC duties are summarized in Table 2.1. Other duties shall be performed as stipulated in the contract documents or directed by the Engineer/PMU/PIU.

Table 46 List of Contractor's QA/QC Duties

Activity/Item	Contractor's QA/QC Duties
Activities for the Contract	• Maintain design document and drawings register at site • Use only approved drawings for construction
Test laboratory and equipment	• Intimate DSC the details, date of completion with requisite manufacturers' and calibration certificates • Maintain the equipment in good condition and calibrate as necessary and on completion of project the Laboratory equipment shall be handed over to GMC/any other independent body to be created by GoB.
Material receipts	• Enter receipts in material register • Intimate DSC in writing
Materials testing	• Prepare mix designs as required by Employer and submit test results to DSC • Take test samples in presence of DSC/PIU when requested • Perform materials tests • Submit test reports to DSC with monthly reports • Maintain test log
Rejected materials	• Enter in material register at site • Intimate DSC in writing the proposed date of removal from site and confirm after removal
Material consumption	• Enter daily consumption of materials in material register and indicate balance quantity
Construction equipment	• Intimate DSC the details, date of mobilization along with requisite insurance certificate • Maintain equipment in good working condition
Construction	• Intimate DSC in writing when construction is going to commence well in advance and what activities are proposed to be undertaken. • Intimate DSC/PIU in advance when critical works, such as concreting, embankment, paving, pipeline laying and jointing, testing, etc., would be undertaken, along with the test certificates of the materials proposed to be used in these works. No critical activity shall start unless the material test certificates are verified and approved by DSC. • Provide necessary QA/QC

Activity/Item	Contractor's QA/QC Duties
Daily work progress	• Maintain in daily log
Testing of works in progress	• Perform tests as per contract requirements • Submit test reports to PIU and DSC • Maintain test log
Rejected work items	• Intimate DSC in writing the proposed date of removal from site and confirm after removal, • Remedify/Rectify defective work and invite PIU and DSC for re-inspection.
Instructions from Engineer-in-charge	• Enter change orders, site instructions, letters and minutes of meetings issued by the DSC in the Instruction Log
Inspection of Engineer-in-charge	• Take instructions in Site Order Book. • Advise PIU and DSC of compliance
Progress scheduling and control	• Prepare and maintain project schedules and undertake work in accordance with approved schedule
Reporting	• Prepare and submit Monthly Progress Reports
Records	Maintain the following records on site: • Material Register • Site Order Book • Hindrance/Encumbrances Register • Daily Log • Test Log • Instruction Log • Equipment Register • Labor Register • Approved Construction Drawings • Test Reports • Site Laboratory Record • Permissions Issued by Departments • Correspondence Record • Copies of Monthly Progress Reports • Any other records as specified in the Contract and/or as instructed by the Engineer

11.3.3.1 *Construction quality control – general*

This section provides an overview of construction quality control activities, including testing and site inspection. Materials control requirements are presented in detail in Section 4, while specific testing and inspection requirements for each category of works are presented in Sections 5 to 8 of this Manual.

11.3.3.2 *Introduction*

Construction quality control (CQC) is intended to provide a comprehensive, common and consistent framework for quality control across various contract packages. CQC comprises two main elements of quality control:

- Testing
- Inspections

Testing control covers the type of tests to be carried out, frequency of testing and stage of testing. Inspection control covers the timing of inspections, what has to be inspected and the inspection procedures.

CQC should be affected at five stages:

- Input Materials and Equipment Components
- In-process Activities
- Stage Completion
- Interfacing (of special importance in water supply and drainage contract packages)
- Final Completion

11.3.4 TESTING

Various site tests on materials and works are required to be carried out by the contractor during construction. A well-equipped and properly operating site test laboratory is an important element of the quality assurance plan. A checklist showing typical testing equipment to be provided in the contractor's site laboratory is presented as Table 3.1.

The contractor shall set-up the site laboratory at the start of his project and inform the PIU and the DSC for conducting inspections. Laboratory equipment shall be properly calibrated, and calibration certificates should be kept at the laboratory for review by PIU and DSC, as necessary. Specialized tests at outside laboratories shall only be undertaken with the prior approval of the PIU.

Third party inspections will be carried out for all important procurements and witnessed by DSC/PIU/PMU. For which Third party inspecting agency/agencies will be engaged by the Employer.

Tests should be performed in accordance with the contract documents, as described in Sections 4 through 7 of this Manual. The control of test reports shall be done as stipulated in Section 9 of this Manual. All test samples should be preserved, with proper identification numbers, test log reference, test date, and other applicable information until otherwise instructed by DSC/PIU. These samples must be stored on site by the contractor.

Checklist of Site Testing Laboratory Equipment

Contract Package No: ______Name of Work:___________Contractor Name:____________

Table 47 Checklist of Site Testing Laboratory Equipment

Testing Equipment	**Type of Test**	**Yes** (1)	**No** (1)
Balance (2 type) volume measuring apparatus & hand tools etc.	General laboratory test		
Oven	Drying and moisture content determination		
Sieves, sieve shaker and hydrometer	Grain size analysis and classification of soil and aggregates		
Atterberg limit apparatus	*Plasticity of Soil*		
Procter/modified proctor (IS heavy) density equipment	Soil compaction test		
Sand replacement cylinder and core cutter	In-situ density test for field compaction control		
Compression testing machine 100 MT and 5 MT capacity	Compressive strength of cement, concrete, brick, etc.		
Cylinder and cube moulds	Concrete sampling		
Slump test	Workability and control of water in concrete casting		
Vicat apparatus	Setting time determination of cement		
Laboratory CBR equipment	Determination of strength of road pavement and layers		
Dynamic cone penetration test equipment	Determination of strength of road pavement and layers		
SPT equipment and hand auger	Boring, sampling and soil strength test		
Unconfined compression testing machine	Determination of shear strength of cohesive soil		
Direct shear equipment	Determination of angle of internal friction of soil		

Testing Equipment	**Type of Test**	**Yes** (1)	**No** (1)
Consolidation test equipment	Determination of settlement /compressibility of soil		
Los Angles Abrasion test/ Impact Testing Machine	Los Angeles Abrasion test/ Impact Test		
Core drilling equipment	In-situ sampling		
Bitumen test equipment	Ductility test and Penetration test		
Measuring instruments	Measurement of sizes		
Leak test equipment	Pipeline jointing		
Marshal stability test equipment	Road works. To be available at Hot Mix Plant site.		
Metallic Contact Digital Thermocouple	Checking temperature of bitumen		
Leveling instruments	Tolerances of roads surfaces		
Any Others, Specify			

Note: 1. Yes or No to be tick marked by CSQC to indicate the equipment at the site laboratory)

In addition to tests performed on site, the contractor is responsible for specialized tests which are performed at approved laboratories, and for factory inspections and tests performed by manufacturers or third parties during the manufacturing of various materials and equipment components, as stipulated in the contract documents.

11.3.4.1***Site Inspections***

Site inspections shall be carried out to ensure that the materials and construction activities conform to the prescribed standards. Site inspections can be divided into day-to-day supervision and periodic quality inspection. The suggestions in respect of these two have been elaborated herein.

11.3.4.2***Day-to-day supervision***

The day-to-day site supervision of all construction activities shall be carried out by the DSC. This includes checking of lines, levels and layouts and on-site checks. Progress monitoring and expediting shall also be carried out by the DSC. The supervisory team of the DSC shall ensure that materials that have been rejected or for which a conformance report has not yet been issued are not used in works.

Construction equipment is a major component of quality assurance system. The equipment requirements have been laid out in the Contract documents. It is necessary that the DSC check the adequacy of the equipment used by the contractor for construction as per the prescribed standards and specifications. The equipment used for construction shall be recorded in the daily logs.

11.3.4.3***Periodic quality inspections***

The Deputy Construction Manager DSC & PIU (Engineer in charge) shall carry out periodic quality inspections during in-process, stage completion, interfacing and final completion, and during all critical activities as per the following examples:

- excavation
- formation of embankments
- placing of reinforcing steel
- concrete batching and pouring
- hot mix operations
- laying of pavement layers
- laying and jointing of pipes
- installation of electrical and mechanical equipment
- testing, trial runs and commissioning of electro-mechanical equipment and plants

The PIU and DSC shall also inspect the materials certified by manufacturers and materials and equipment components approved by third parties upon delivery to the site. The contractor shall give advance notice to the PIU and DSC when critical activities are proposed or major equipment items are to be delivered.

On completion of one stage of the construction and before proceeding to the next stage (such as from steel binding to concreting for RCC works) the DSC where necessary shall inspect and certify the quality of the works completed before granting approval for the next stage of the works to start. The final inspection shall encompass tests on completion and trial runs. The certification of quality will be based on the documents and the periodic site visits.

11.3.4.4***Squad checks***

The concept of Squad Checks has been adopted to have an external review of quality of works executed. The squad checks should be conducted jointly by the PIU and DSC. A fixed timetable is not suggested for this. The tentative agenda for the squad checks is described as follows:

- Physical inspection of the works under execution and inspection of quality of workmanship;
- review of site documentation and contractor compliance;
- sample verification of test reports and quality certificates;
- review of issues, constraints and lacunae in quality system implementation;
- preparing of action plans for improving the quality; and
- Performance appraisal of the contractors.

Formats for recording minutes of progress review meetings and for recording interim evaluations of contractor’s performance are included in Appendix C, as Format F-16 and F-17 respectively.

11.3.4.5 *Quality Certification and Acceptance*

The DSC shall be responsible to certify that the items included in the contractor's Interim Payment Certificate satisfy the required quality of works and are acceptable with regard to the specifications and standards prescribed under the contract before the progress bill is passed for payment. PIU should signify acceptance of the DSC's quality certification by countersigning it. A format for this quality certification and acceptance is included in Appendix C, as Format F-18.

11.3.4.6*Control of materials and equipment components*

This section provides an overview of control requirements for materials and equipment components, including site testing, manufacturers' certification and third party inspection.

11.3.4.7*General*

Control and approval of construction materials and equipment components to be incorporated in the works shall be based on the following:

- Test reports for materials tested at site, such as cement, sand, water, and aggregates. The contractor will perform all tests. The designated DSC representative & PIU representative shall witness the tests respectively. They shall sign the report in token of witnessing.
- Manufacturer's certificates and IS mark for manufactured items indicated in table 4.3 or as stipulated in the contract; and
- Third party inspection for various items as per contract documents.

11.3.4.8 *Materials Tested on Site*

The materials to be tested on site include cement, water, aggregates for concrete, bricks and stones, soil for embankments, and aggregates and bituminous materials for road works. For aggregates and soil, the contractor shall obtain the approval of the borrow source or quarry from the PIU and the DSC before extracting material. The list of materials to be tested on site is given in Table 48 below. Test procedures are presented in Table 49, under the referenced procedure numbers. Test report formats are included in Appendix A. The reports are to be maintained in a bound register, where in 3 copies of report will be prepared, two copies to be submitted with monthly report to DSC & PIU and third copy to be retained by contractor.

Table 48 List of Materials Tested on Site

Sl. No.	*Material*	*Test Procedure No.*
1	Cement	QC-M-01
2	Sand	QC-M-02
3	Water for Construction Works	QC-M-03
4	Bricks	QC-M-04
5	Size Stone	QC-M-05
6	Coarse Aggregate for Concrete Work	QC-M-06
7	Soil/Earth/sub-grade material	QC-M-07

Sl. No.	*Material*	*Test Procedure No.*
8	Granular Sub-base (GSB) Material	QC-M-08
9	Material for WBM / WMM	QC-M-09
10	Metal for BM/DBM/BC/Surface Dressing/MSS/Premix Carpet	QC-M-10
11	Binder for WBM	QC-M-11
12	Fine Aggregate for DBM/BC	QC-M-12
13	Lime	QC-M-13
14	Bitumen	QC-M-14
15	Borrow Material	QC-M-15
16	Steel (to be procured directly from manufacturer along with his test certificates) This shall also be got tested in local authorized test laboratory (by EE-PIU).	

Table 49 Procedures for Testing Materials on Site

CEMENT			**QC-M-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	**Normal consistency**	TC-M-01-01	One for each source and when called for by the Engineer	On receipt of material at site and before using as directed by the Engineer. Test certificate to be produced to the Engineer before use.
2	Fineness	TC-M-01-01		
3	Setting time – Initial / final	TC-M-01-01		
4	Compressive strength - 72 hrs, 168 hrs, 672 hrs.	TC-M-01-01		
For sulphate resistant cement as per IS-12330 OPC 43/53 shall conform to IS 8112/ 12269 and both 56 and 90 days strength shall be tested.				

SAND			**QC-M-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**

1	Sieve analysis	TC-M-02-01	One test for 15 m^3	On receipt at site and test certificate to be produced to the Engineer before use.
2	Fineness modulus	TC-M-02-01	One test for 15 m^3	
3	Deleterious constituents	TC-M-02-01	One test for 15 m^3	
4	Bulking test	TC-M-02-01	One test per Source	

WATER FOR CONSTRUCTION WORKS			**QC-M-03**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Alkalinity and acidity as per IS-3025	TC-M-03-01	Once per source of supply and when called for by the Engineer	Before use of water from that source
2	Solids	TC-M-03-01		

BRICKS			QC-M-04	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength	TC-M-04-01	One test per 50,000 bricks or part thereof	On receipt at site
2	Physical properties	TC-M-04-01		
3	Water absorption test	TC-M-04-01		

SIZE STONE			QC-M-05	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Water absorption test	TC-M-05-01	One test per source and when called for	On receipt at site
2	Dimension check	Lab format	As directed by the Engineer	
3	Type of rock	Lab format		

COARSE AGGREGATE FOR CONCRETE			QC-M-06	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact or Los Angeles Abrasion Value as per IS-2386 Part-IV	TC-M-06-01/1 TC-M-06-01/2	One for each source of supply and when called for by the Engineer	On receipt of material at site
2	Soundness as per IS-2386 Part-V	TC-M-06-02		
3	Alkali Aggregate Reactivity as per IS-2386 Part-IV	Lab Format		
4	Flakiness Index	TC-M-06-03		
5	Gradation by wet sieve analysis	TC-M-06-04		
6	Water Absorption	TC-M-05-01		
When required, the contractor shall furnish the mix design along with material properties at least 15 days in advance.				

SOIL/EARTH/SUB-GRADE MATERIAL			QC-M-07	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1.	Swelling index IS 2720 part XL	TC-M-09-01	Two sets for 3000 m^3 or part thereof	On receipt at site
2.	Liquid limits and plasticity index	TC-M-09-02		
3.	Deleterious material IS 1498	Lab format		
4.	OMC & MDD Test	TC-M-09-03		
5.	Chemical properties	Lab format		
6.	Grain Size Distribution Graph (by wet sieve analysis)	TC-M-09-04		
7.	Void ratio gradation	Lab format		
8.	Soaked CBR test (optional)	TC-M-07-01	Two sets for 3000 m^3 or part thereof and as directed by the Engineer	

GRANULAR SUB-BASE MATERIAL			QC-M-08	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	California Bearing Ratio Test	TC-M-07-01	As required	On receipt at site
2	Material combinations	Daily log		
3	Moisture content as per IS-2270	TC-M-07-02	1 test per 250 m3 or part thereof	Prior to compaction
4	Fineness value BS 812 Part III	Lab format	As required	On receipt at site
5	Soundness of material	TC-M-06-02		
6	Air voids content	Lab format		

7	Gradation by wet sieve analysis	TC-M-06-04	1 test per 200 m3 or part thereof	
8	Atterberg limits	TC-M-09-02		
9	Deleterious constituents	Lab format		
10	OMC and MDD	TC-M-09-03		
The contractor shall furnish the GSB design mix along with material properties and test results at least 15 days before laying GSB at site.				

MATERIAL FOR WBM / WMM			**QC-M-09**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact Value	TC-M-06-01/1	One test for 200 m^3	On receipt at site
2	Grading by wet sieve analysis	TC-M-06-04	One test for 100 m^3	
3	Flakiness Index and Elongation Index	TC-M-06-03	One test for 200 m^3 of aggregate	
4*	Atterberg limits of binding material *(Only for WBM)	TC-M-09-02	One test for 25m^3 of binding material	
5	Atterberg limits of portion of aggregate passing 425 micron sieve.	TC-M-09-02	One test for 100 m^3 of aggregate	
6	Water Absorption Test	TC-M-05-01	Initially one set of 3 representative specimen for each source of supply and subsequently, when warranted by changes in the quality of aggregate	
7	Soundness Test	TC-M-06-02	One for each source of supply and when called for by the Engineer	On receipt at site and when absorption value is more 2%

MATERIAL FOR WBM / WMM			QC-M-09	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
8*	Density of compacted layer of WMM *(Only for WMM)		One test for 500 m^3	

METAL FOR BM / DBM / BC / SURFACE DRESSING / MSS / PRE-MIX CARPET			QC-M-10	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact Value	TC-M-06-01/1	One test for 50 m^3 of aggregate or part thereof	On receipt at site and before using in the hot mixing
2	Flakiness Index and Elongation Index of aggregates	TC-M-06-03		
3	Water absorption of aggregates	TC-M-06-06	Initially one set of 3 representative specimen for each source of supply and subsequently, when warranted by changes in the quality of aggregate	
4	Stripping value	TC-M-11-01		
5	Gradation by wet sieve analysis	TC-M-06-04	As directed by the Engineer for individual component and for combined coarse, fine aggregate and filler.	
6	Soundness Test	TC-M-06-02	One for each source of supply and when called for by the Engineer	On receipt at site and when absorption value is more than 2%
For DBM and BC, the contractor shall furnish the material properties and proposed job mix formula at least 20 days in advance.				

BINDER FOR WBM			QC-M-11	
Sl.	**Type of Test**	**Test Report**	**Frequency of Test**	**Timing of Test/**

No.		Format No.		Inspection
1	Atterberg Limit Test	TC-M-09-02	One test for 100 m^3 of binding material	On receipt at site

FINE AGGREGATE FOR DBM/BC			QC-M-12	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Passing 2.36 mm sieve and retained on 75 micron sieve	Daily log	As directed by the Engineer	Before use
2	Deleterious matter	Daily log	Visual observation of lot before use	
LIME			**QC-M-13**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Chemical properties as per IS: 6932, 1514	Lab format	3 final test samples for a lot size up to 100 tons as per Table 3 in IS 712-1984.	On receipt at site.
2	Physical properties as per IS: 6932	Lab format		

BITUMEN			**QC-M-14**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Grade of bitumen as directed/defined (Penetration Test)	TC-M-10-01	Two samples per test subject to all or some tests as directed by the Engineer	On receipt of material at site before unloading from the truck
2	Ductility Test	TC-M-10-02		
3	Flash and Fire Point Test	Lab format		
4	Viscosity Test	Lab format		
5	Softening Test	Lab format		

BORROW MATERIAL *(Soil to be used in Embankment / Subgrade / GSB)*			**QC-M-15**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Digging of borrow area for sampling	No format	25 m c/c or closer depending upon soil strata variation	Before material is extracted for use in construction.
2	Sand Content	TC-M-15-01 (use relevant test report formats and summarize results in TC-M-15-01)	2 sets of observation per 3000 m^3 of soil and in each 6 observations required.	Before material is extracted for use in construction
3	Wet Sieve Analysis			
4	Plasticity Index			
5	Modified Proctor Density			
6	Soaked CBR Test			
7	OMC			
8	MDD			
Borrow material source must be approved before extracting material.				

11.3.4.9 ***Materials and Equipment Certified By Manufacturer***

Acceptance of certain manufactured materials and equipment components, as stipulated in the contract, shall be based on test certificate(s) from the manufacturer conforming to IS and on visual inspection. These items shall bear the IS mark. PIU and DSC shall review the manufacturers' certificates for conformance to contract requirements before these items are delivered to the site. Upon their delivery and before their installation or otherwise incorporation in the works PIU and DSC shall inspect the condition of these items. Inspection criteria shall be decided jointly by PIU and DSC. They may decide to have the material additionally tested in Laboratory. The cost of such tests will be borne by the contractor. Materials and equipment subject to manufacturer's certification are listed in Table

List of Materials and Equipment Certified by Manufacturer

- Steel/Reinforcing Steel
- Paint, Primers and Protective Coatings
- Glazing
- Water Proofing Compound
- GI, DI and PVC Pipes for general civil works
- Glazed Stoneware Pipes (GSW) for general civil works
- Gratings & Plates
- Manhole Covers
- Sanitary Fittings
- Metal Works such as windows, barbed wire, MS ladder, footrest, rolling shutters, etc.
- Joint Filler Material
- Pre-fabricated Water Tanks
- Traffic Signs
- Flow Measuring Devices – General
- Foot Rests
- Electrical Conduits
- Electrical Wires/Cables
- Switches & Sockets
- Distribution Boards
- Lights, Fans and Fixtures
- Earthing Material
- Lightening Arrestor
- Fire Fighting Equipment
- Laboratory Equipment
- All other items as specified in the contract documents

11.3.4.10 ***Materials and Equipment to be inspected by Third Party***

Materials and equipment to be inspected by a third party vary from package to package, as stipulated in the contract documents. Third party inspection would normally take place at the factory during or upon completion of manufacture. Before site delivery, SIU and CSQC shall review the third party inspection certificates for conformance to requirements. Upon delivery and before installation or incorporation in the works, SIU and CSQC shall inspect the physical condition of these items and, if necessary, test them on site. Inspection criteria should be stipulated in the contract document. A list of materials and equipment suggested for inspection by third party is as follows:

11.3.4.11***List of Materials and Equipment to be inspected by Third Party***

- Flow Measuring Devices – Special
- Electrical Cables – Special
- Butterfly Valves
- Sluice Valves
- Reflux Valves
- Air Valves
- Control Valves
- Gauges
- NP Pipes
- GSW pipes
- DI, and PVC pipes
- All specials and fittings for Rising main
- In-situ Lining of Pipes
- All other items as specified in the contract documents

11.3.4.12 ***Control of general civil and structural works***

This section of the QA/QC Manual covers the testing of works and the inspection of workmanship for general civil and structural works. The key elements to be inspected in these works are concreting, stone masonry, and brickwork and finishes. The requirements for testing and control of materials for these works are outlined in Section 4.

11.3.4.13 ***Construction Sequence and Control Flow Charts***

Flow charts indicating the construction sequence and control points for cement concrete and mortar works are shown in Figure 1and Figure 2 respectively.

11.3.4.14 ***Testing of Works***

The works to be tested on site include excavation, cement concreting, and stone and brick masonry. All the materials proposed to be used in these works must have been tested by the contractor and approved by the DSC well in advance of these works. The contractor shall submit the concrete pouring report to the PIU and DSC as and when concreting is done, and shall obtain the approval of the DSC when a particular stage is completed and before proceeding to the next stage.

Tests for general civil and structural works are listed in Table 50. Test procedures are presented in Table 51, under the referenced test numbers. Required materials tests are also indicated (materials testing procedures are presented in Section 4). Test report formats are included in Appendix A. The contractor shall conduct tests as stipulated. The Representative of DSC and PIU will witness the test conducted.

11.3.4.15***Inspection Checklists***

Inspection checklists for concreting, stone masonry, and brick masonry work and finishes, and building services and finishes are presented in Appendix B.

Table 50 List of Tests for General Civil and Structural Works

Sl. No.	Process	Material		Test Ref. No.
		Name	Format No.	
1	Embankment Formation	Soil/Earth	QC-M-07	QC-G-01
2	Excavation/Backfilling			QC-G-02
3	Concreting	Steel	MC (1)	QC-G-03
		Cement	QC-M-01	
		Coarse Aggregates	QC-M-06	
		Sand	QC-M-02	
		Water	QC-M-03	
4	Size Stone Masonry	Size stone	QC-M-05	QC-G-04
		Cement	QC-M-01	
		Sand	QC-M-02	
		Water	QC-M-03	
5	Brick Masonry	Bricks	QC-M-04	QC-G-04
		Cement	QC-M-01	
		Sand	QC-M-02	
		Water	QC-M-03	

Note: 1. MC = manufacturer certified.

Table 51 Procedures for Testing General Civil and Structural Works

Embankment Formation			**QC-G-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for each 250 m^3 of soil	In-process

Embankment Formation			QC-G-01	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
2	Field density test as per IS-2720	TC-M-09-03	5-10 density tests for each 1000 m^2 compacted area, or as directed by Engineer	
3	Compaction	Daily log	As per required number of passes	While compacting

Excavation/Backfilling			QC-G-02	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Layout, slopes of excavation, benching and over-burden	Daily log	As directed by the Engineer	After excavation
2	Sub-soil water, shoring and strutting	Daily log		
3	Bottom levels and compaction	Daily log		
4	Soil classification	Daily log		
5	Backfilling and compaction	Daily log		After backfilling

Concreting			QC-G-03	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-516	TC-G-01-01	One test for 1-5 m^3 of concrete Two tests for 6-15 m^3 of concrete Three tests for 16-30 m^3 of concrete Four tests for 31-50 m3 + one set every 50 m^3 of additional concrete work.	Test samples to be taken while pouring. Testing to be done as specified in contract.

Embankment Formation			**QC-G-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
2	Slump test per IS-1199	TC-G-01-02	Random checks throughout concreting as directed by the Engineer	Before pouring concrete
3	Inspection of steel reinforcement placement and bending, and formwork	Daily log	Before pouring concrete	Before pouring concrete
4	Concrete Pour Report	TC-G-01-03	When pouring is done	Immediately after pouring
Mortar			**QC-G-04**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-2250	TC-G-01-01	One sample for every 2 m^3 of mortar subject to a minimum of three samples for a day's work	Test samples to be taken while before mortaring. Testing to be done as specified in contract.
2	Consistency as per IS-2250	TC-G-02-01		

11.3.4.16 *Control of road works*

This section of the QA/QC Manual covers the testing of works and the inspection of workmanship for road works, including earthworks, placement of sub-base and WBM layers, application of prime and tack coats, and placement of bituminous layers. The requirements for testing and control of materials for road works are outlined in Section 4.

11.3.4.17 *Construction Sequence and Control Flow Charts*

Flow charts indicating the construction sequence and control points for road works are shown in Figures 1 to 8.

11.3.4.18 *Testing of Works*

The works to be tested on site include earthworks, placement of granular sub-base and WBM layers, application of prime and tack coats, and placement of bituminous layers. All the materials proposed to be used in these works must have been tested by the contractor and approved by the DSC well in advance of the works. The contractor shall obtain the approval of the DCC when a particular stage is completed and before proceeding to the next stage. Surface regularity and alignments shall be checked by leveling instrument.

Hot mix designs shall be submitted by the contractor to PIU and DSC for review and approval well before the planned start of hot mix operations. The hot mix plant shall be inspected by PIU and DSC and approved by PIU before commencing operations. Temperature tests on bitumen shall be carried out at the hot mix plant before delivery to the site, and immediately before placing and after compaction. Temperature tests shall be carried out by using metal contact digital thermocouple based temperature measuring device. The Contractor shall provide such devices as part of his site laboratory, and in sufficient quantity so that all required testing can be carried out as-and-when required. The contractor shall take the temperature readings in the presence of the DSC, and shall submit his test reports on a daily basis.

Tests for road works are listed in Table 52. Test procedures are presented in Table 53, under the referenced test numbers. Required materials tests are also indicated (materials testing procedures are presented in Section 4). Test report formats are included in Appendix A.

11.3.4.19*Inspection Checklists*

An inspection checklist for road works is presented in Appendix B.

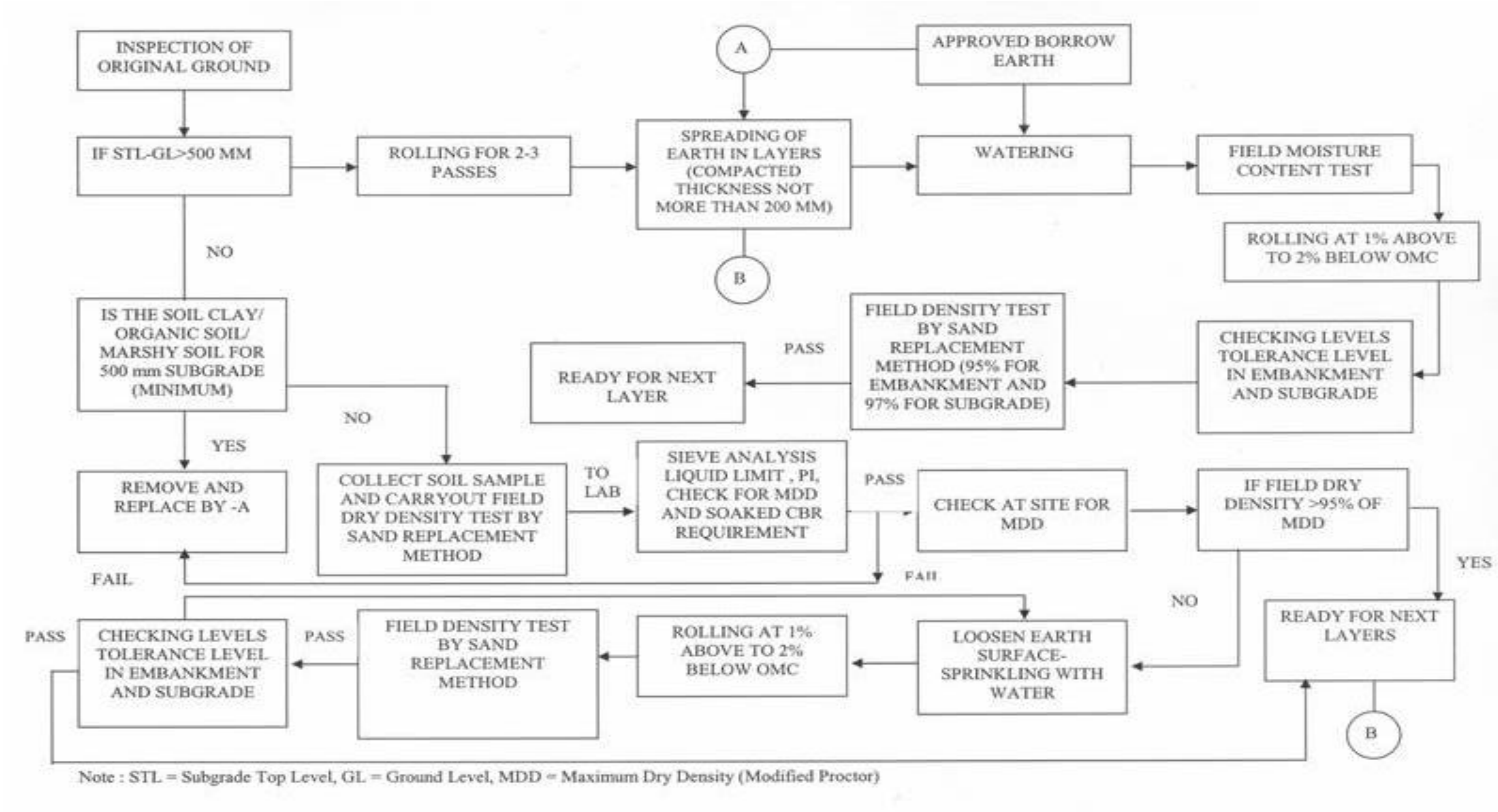
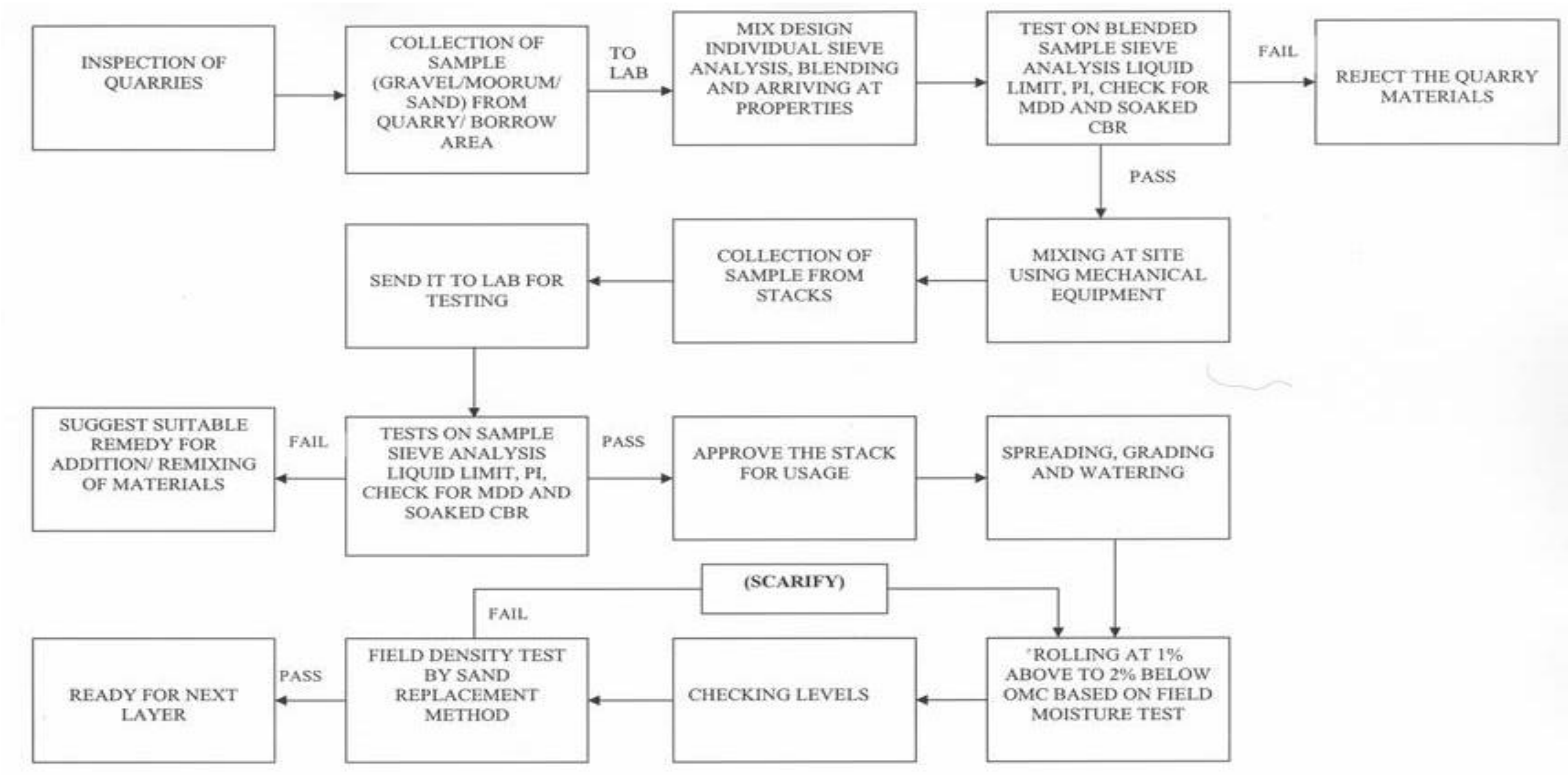


Figure 1 Flow Chart for the Construction of Embankment and Subgrade



Note : MDD = Maximum Dry Density (Modified Proctor)

Figure 2 Flow Chart for the Construction of Granular Sub-base

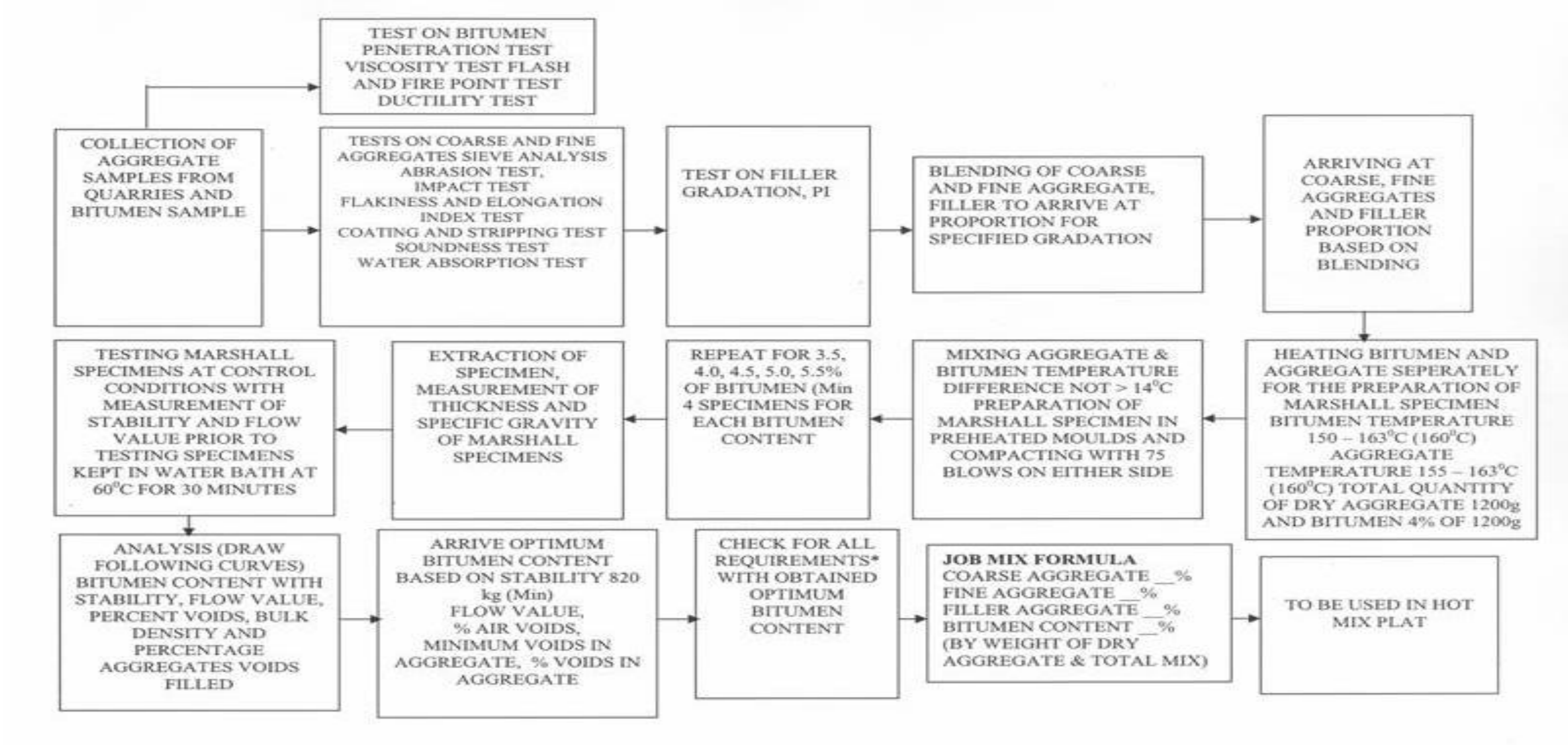


Figure 3 Flow Chart for Bituminous Mix Design (BC)

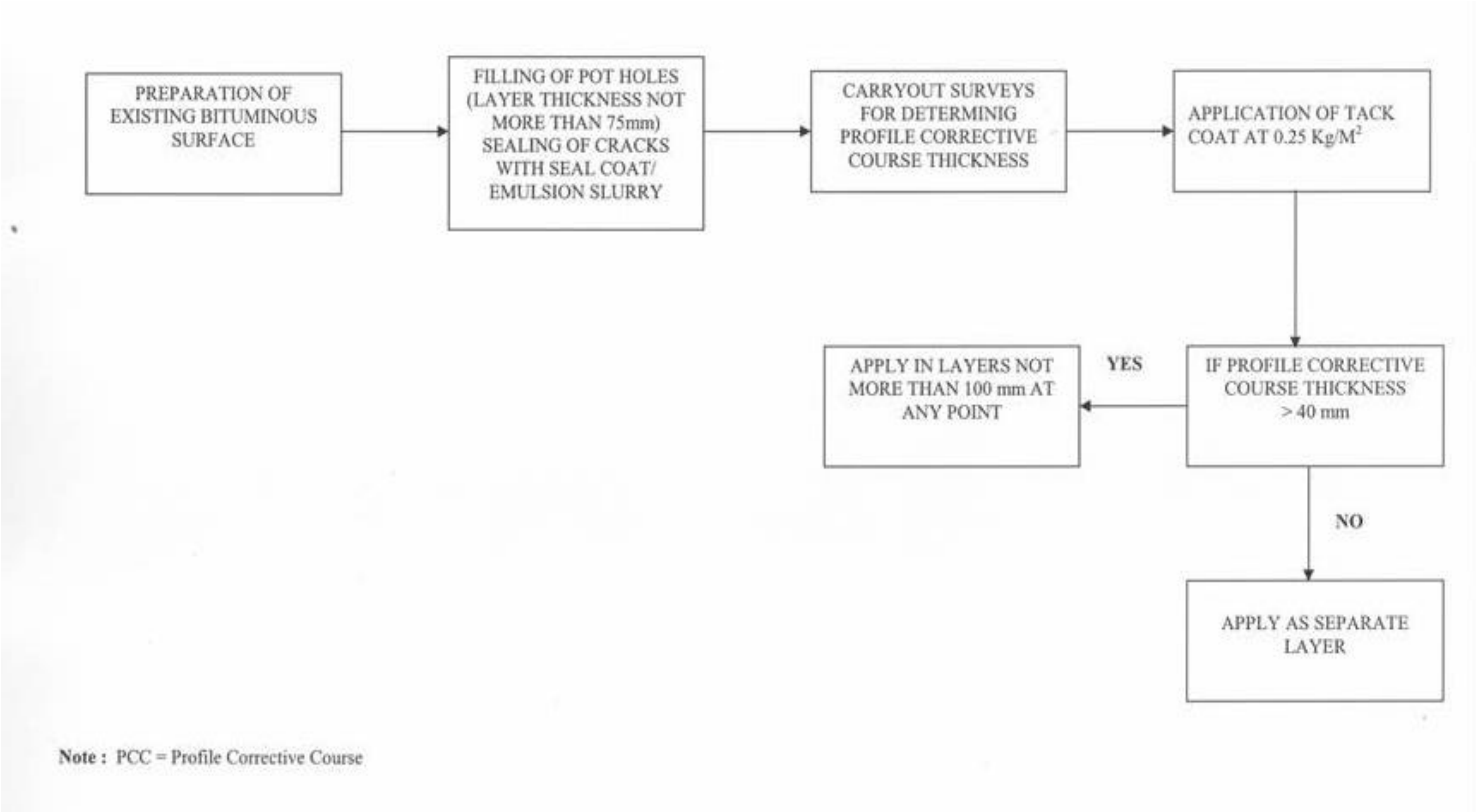
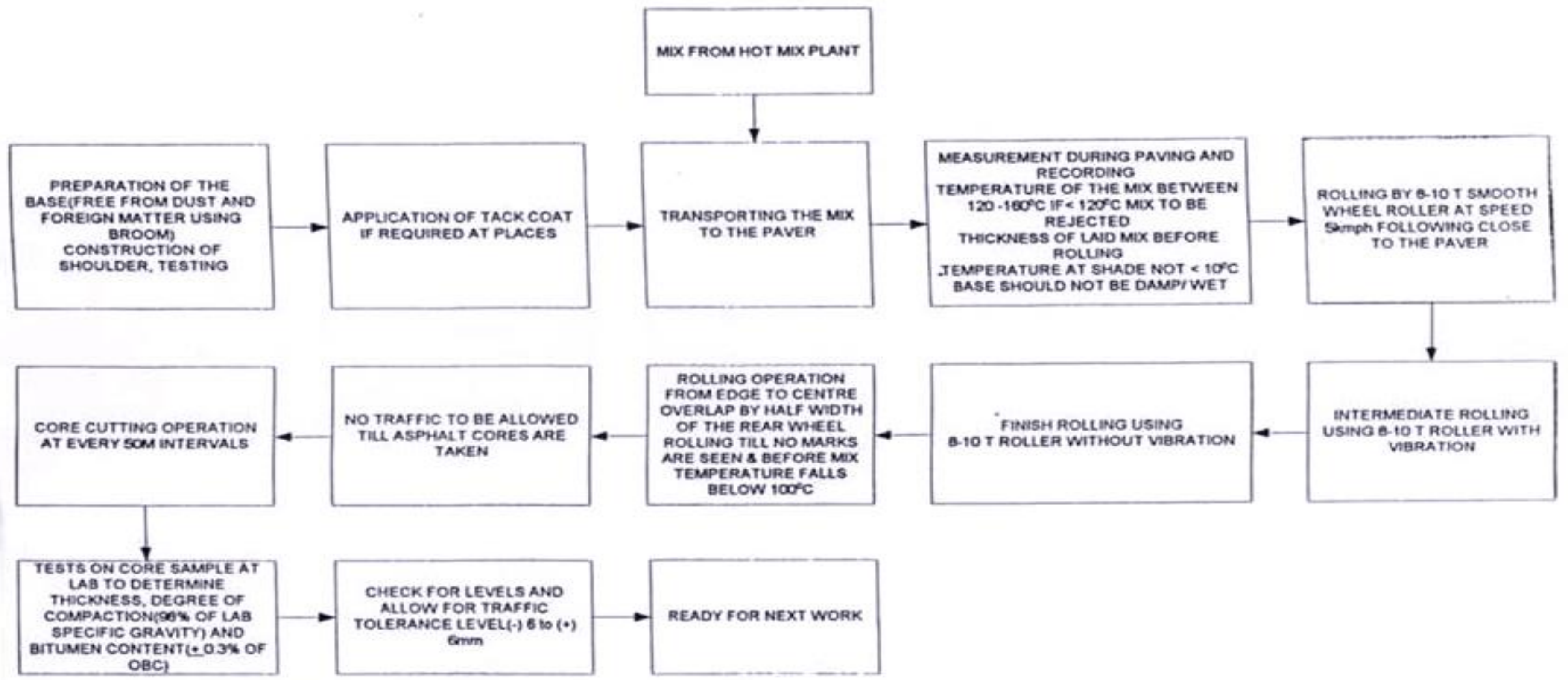


Figure 4 Flow Chart for Laying Profile Corrections Course



Note: DBM = Dense Bituminous Macadam
BC = Bituminous Concrete
OBC = Optimum Bitumen Content

Figure 5 Flow Chart for Construction of DBM/BC Layers

Table 52 List of Tests for Road Works

Sl. No.	Process	Material		Test Ref. No.
		Name	Format No.	
	Embankment Formation	Soil/Earth	QC-M-07 QC-M-15	QC-R-01
	Excavation			QC-R-02
	Granular Sub-base Laying	Granular Sub-base	QC-M-08	QC-R-03
	WBM Laying	WBM	QC-M-09	QC-R-04
		Binder	QC-M-11	
	Prime Coat Application	Bitumen	QC-M-14	QC-R-05
	Tack Coat Application	Bitumen	QC-M-14	QC-R-05
	Surface Dressing	Bitumen	QC-M-14	QC-R-06
		Metal	QC-M-10	
	Bituminous Macadam Laying	Bitumen	QC-M-14	QC-R-07
		Metal	QC-M-10	
	DBM Laying	Bitumen	QC-M-14	QC-R-08
		Metal	QC-M-10	
		Fine Aggregates	QC-M-12	
		Filler (Lime)	QC-M-13	
	Mix Seal Surfacing	Bitumen	QC-M-14	QC-R-06
		Metal	QC-M-10	
		Fine Aggregates	QC-M-12	
	Bituminous Concrete Laying	Bitumen	QC-M-14	QC-R-08
		Metal	QC-M-10	
		Fine Aggregates	QC-M-12	

<table>
<tr><th rowspan="3">Sl. No.</th><th rowspan="3">Process</th><th colspan="2">Material</th><th rowspan="2">Test Ref. No.</th></tr>
<tr><th>Name</th><th>Format No.</th></tr>
<tr><td>Filler (Lime)</td><td>QC-M-13</td><td></td></tr>
<tr><td></td><td>On Completion of Laying of BM / DBM / BC</td><td colspan="2">Stage completion test</td><td>QC-R-09</td></tr>
</table>

Table 53 Procedures for Testing Road Works

Embankment Formation			**QC-R-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for each 250 m3 of soil	In-process
2	Field density test as per IS-2720	TC-M-09-03	For earthwork in embankment/cutting 5-10 density tests for each 1000 m^2 compacted area For earthwork in sub grade/GSB and shoulders, 10 density tests for 500 m^2 compacted area	
3	Rolling operation	Daily log	As per required number of passes	While rolling
Excavation			**QC-R-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Layout, slopes of excavation, benching and over-burden	Daily log	As directed by the Engineer	After excavation
2	Sub-soil water, shoring and strutting	Daily log		
3	Bottom levels and compaction	Daily log		
4	Soil classification	Daily log		
Granular Sub-Base Laying			**QC-R-03**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for 500m2 of compacted soil (3 observations per test)	In-process

2	Field density test as per IS-2720	TC-M-09-03	10 observations selected randomly for every 500m2 of compacted area	
3	Rolling operation	Daily log	Required No. of passes	While rolling
WBM Laying			**QC-R-04**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Field Density Test by sand replacement method	TC-R-06-01	As directed by the Engineer	In-process
Prime Coat/Tack Coat Application			**QC-R-05**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Temperature Test	Daily log	At regular close intervals	In-process
2	Rate of spreading	TC-R-02-01	Three tests for every 50 m length	

Surface Dressing/Mix Seal Surfacing/ Pre-mix Carpet			**QC-R-06**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Rate of spread of mix material	TC-R-02-01	One test for every 500 m^3 of mix with 6 observations	In-process
Bituminous Macadam Laying			**QC-R-07**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Temperature Test	Daily log	At regular close intervals	In-process
2	Rate of spread of mix material	TC-R-02-01	2-3 observations at every 10 m interval during paving	
DBM/BC Laying			**QC-R-08**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Temperature Test	Daily log	At regular close intervals	In-process
2	Rate of spread of mix material	TC-R-02-01		
3	Stability of Mix/Marshal Stability Test	TC-R-05-01	3 samples for each 400 tons of mix produced subject to a minimum of 2 tests per plant per day.	While hot mixing

On Completion of BM / DBM / BC Layers Stage Completion Test			QC-R-09	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Core test for compacted layer (bitumen content, density and voids)	TC-R-07-01	One test for 250 m^2 of compacted area	On completion of stage and before proceeding to next stage
2	Surface regularity and control of alignment	TC-R-07-02	One test for every 300 m of road length	

11.3.4.20***Guidelines for Pavement Layers***

Guidelines for gradation and placement of WBM layer are given in Table 54 and Table 55 respectively; guidelines for application of prime and tack coats are given in Table 56; and requirements of bituminous mixes are given in Table 57. (These guidelines are provided for easy reference. The standards and specifications stipulated in the contract shall be adhered to.)

Table 54 Gradation for WBM Layers

Grade-II (Size: 63 mm to 45 mm)		Grade-III (Size: 53 mm to 22.4 mm)		Screening Material (Size: 11.2 mm)	
IS Sieve Designation (mm)	**% by weight passing**	**IS Sieve Designation (mm)**	**% by weight passing**	**IS Sieve Designation (mm)**	**% by weight passing**
90	100	63	100	11.2	100
63	90-100	53	95-100	5.6	90-100
53	25-75	45	65-90	0.18	15-35
45	0-15	22.4	0-10		
22.4	0-5	11.2	0-5		

Table 55 Guidelines for Placement of WBM Layers

Quantity Required for 10 Sq. m Area (Compacted thickness 75mm)		
Grading	**Size (mm)**	**Loose Quantity (m^3)**
II	63-45	0.91-1.07
III	53-22.4	0.91-1.07
Screening Material for II	11.2	0.20-0.22
Screening Material for III	11.2	0.18-0.21
Binding Material (II/III)	---	0.06-0.09

Table 56 Guidelines for Prime/Tack Coat Application

Particulars	**Standard Specified Rate (kg/m2)**
Granular surface treated with primer	0.25-0.30
Granular base not primed	0.35-0.40
Normal bituminous surfaces	0.20-0.25

Table 57 Requirements of Bituminous Mixes

Minimum stability (kN at 60^o C)	9.0
Minimum flow (mm)	2
Maximum flow (mm)	4
Compaction level (Number of blows)	75 blows on each of the two faces of the specimen
Percent air voids	3-6
Percent voids in mineral aggregate (VMA)	See Table 58
Percent voids filled with bitumen (VFB)	65-75

Table 58 Minimum percent voids in Mineral Aggregate (VMA)

Nominal Maximum Particle size (mm)	**Minimum VMA, percent Related to Design Air Voids, Per cent**[2]		
	3.0	4.0	5.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0

Notes: 1. Nominal maximum particle size is one size larger than the first sieve to retain more than 10 per cent.

2. Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed.

11.3.4.21 ***Tolerances***

Requirements for surface regularity and tolerances are given below. (These requirements are for easy reference; the standard and special technical specifications as per the contract must be referred.)

11.3.4.22***Horizontal alignment tolerances***

The horizontal alignment with respect to the centre line of the carriageway shall have a tolerance of ±10 mm at the edges of roadway and of ±25 mm lower layers.

11.3.4.23***Surface levels tolerances***

Surface level tolerances are shown in Table 59

Table 59 Surface Level Tolerance

Type of Surface	**Tolerance in Level Compared with Longitudinal and Cross Profile**
Sub-grade	+ 20 mm/- 25 mm
Sub-base	+10 mm/- 20 mm
Base Course (a) Machine laid (b) Manually laid	 ±10 mm ±15 mm
Wearing Course (a) Machine laid (b) Manually laid	 ±6 mm ±10 mm

Type of Surface	**Tolerance in Level Compared with Longitudinal and Cross Profile**
Cement concrete pavement	+5 mm -6 mm*

* This may not exceed -8 mm at 0-30 cm from the edges.

11.3.4.24***Surface regularity of pavement courses***

The maximum allowable difference between the road surface and a straight line parallel with or at right angles to the centre line of the road at points shall be:

- For bituminous surface: 3 mm
- For GSB/base courses : 8 mm

The maximum permitted number of surface irregularities measured under a 3 m long straight edge at the middle of each traffic lane along a line parallel to the center line of the road shall be as shown in Table 60.

Table 60 Maximum Number of Surface Irregularities

Maximum Number of Surface Irregularities on Bituminous Road and Shoulders				
Irregularity	4 mm		7 mm	
Length (m)	300	75	300	75
National/State Highways	20	9	2	1
Town Roads	40	18	4	2

11.3.4.25 *CONTROL OF PIPELINE WORKS*

This section of the QA/QC Manual covers the testing of works and the inspection of workmanship for pipeline works (i.e. water) and liquid retaining structures. The requirements for testing and control of input materials are outlined in Section 4.

11.3.4.26 *Construction Sequence and Control Flow Charts*

Flow charts indicating the construction sequence and control points for materials used in pipeline work and for pipeline works are shown in Figure 6 and Figure 8 respectively.

11.3.4.27 *Testing of Works*

The works to be tested on site include bedding for pipelines, pipeline laying and jointing, and hydrostatic, leakage and water tightness tests after completion. All the materials proposed to be used in these works must have been tested by the Contractor and approved by the DSC well in advance of commencing works. The contractor shall obtain the approval of the DSC when a particular stage is completed and before proceeding to the next stage.

Tests for pipeline works and liquid retaining structures are listed in Table 61. Test procedures are presented in Table 62, under the referenced test numbers. For excavation, back-filling and re-paving works refer to Sections 5 and 6 of this Manual. Required materials tests are also indicated (materials testing procedures are presented in Section 4). Test report formats are included in Appendix A.

11.3.4.28 *Inspection Checklists*

An inspection checklist for pipeline works is included in Appendix B.

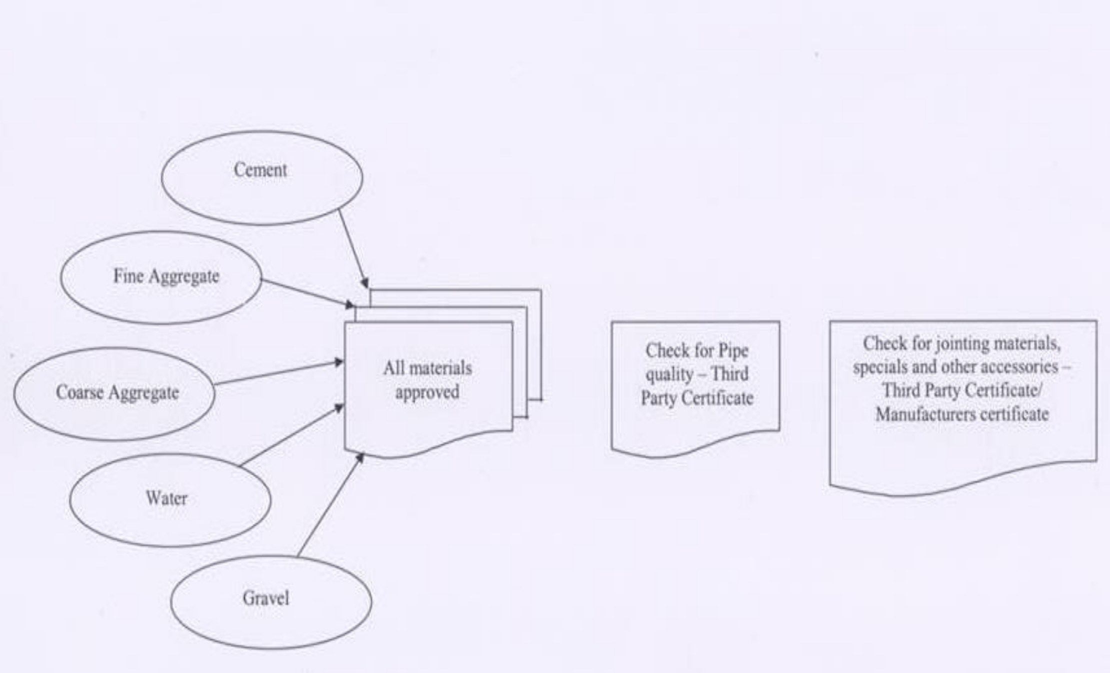


Figure 6 Checks for Materials used in Pipeline work

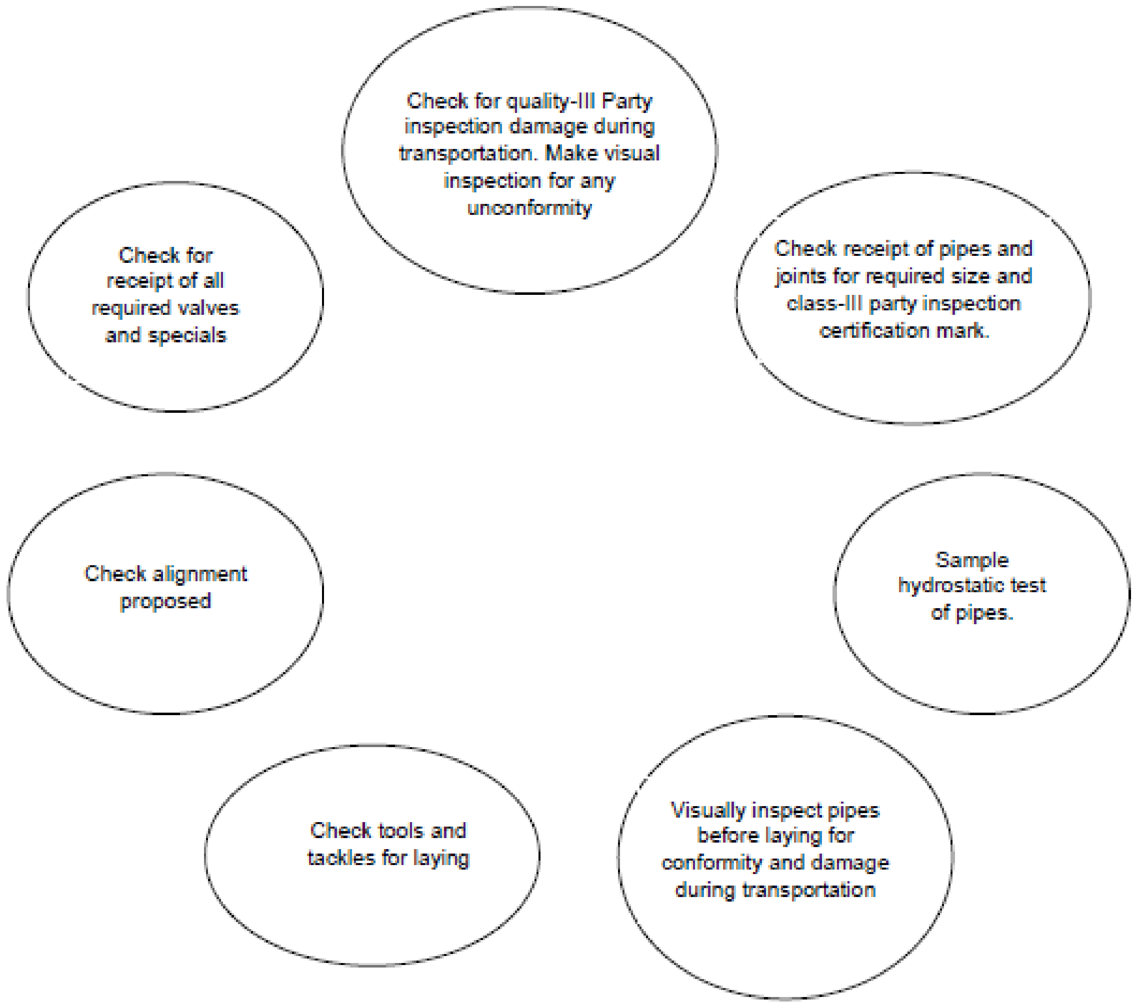


Figure 7 Checks for Preparation works before laying water supply pipe lines

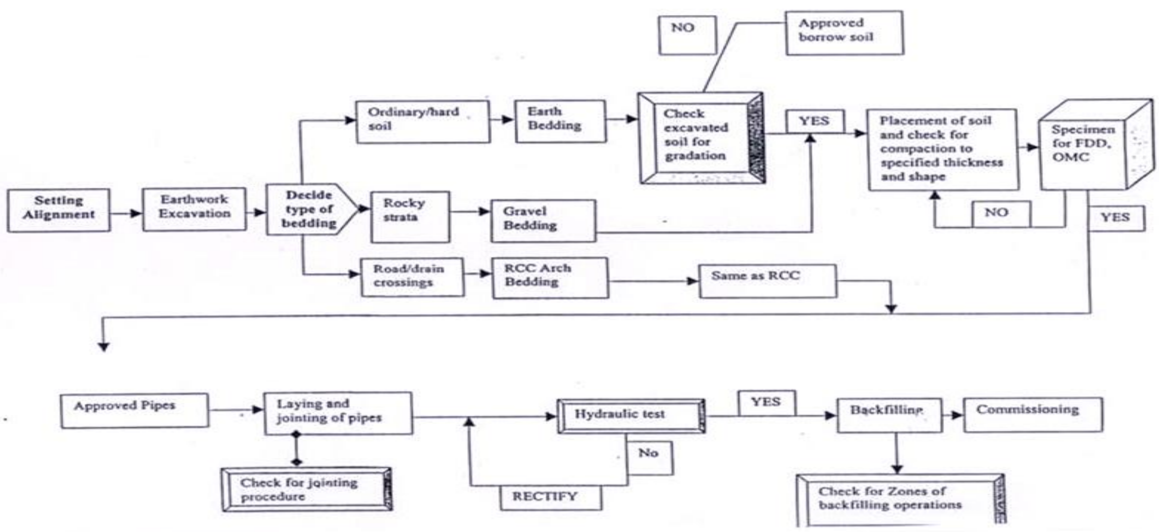


Table 61 List of Tests for Pipeline Works and Liquid Retaining Structures

Sl. No.	Activity	Material		Test Ref. No.
		Name	Format No.	
1	Bedding for Pipeline			
1.1	Earth Bedding	Earth/Soil	QC-M-07	QC-P-01
1.2	Gravel Bedding	Gravel	QC-M-08	
1.3	Concrete Bedding	Cement	QC-M-01	QC-P-02
		Sand	QC-M-02	
		Water	QC-M-03	
		Aggregate		
		Steel	MC (1)	
2	Pipeline Laying and Jointing			
2.1	GSW Pipe	Cement	QC-M-01	QC-P-03
		Sand	QC-M-02	
		Water	QC-M-03	
		Pipes	MC (1)	
2.2	RCC and CI Pipes	Pipes	TPI/MC (1)	QC-P-02
		Gaskets	TPI/MC (1)	
2.3	Coated and Lined Steel/PSC Pipes	Coated and lined steel/ PSC pipes	TPI (1)	
3	Manhole/Valve Chamber Construction	Cement	QC-M-01	QC-P-02 QC-P-03
		Sand	QC-M-02	
		Water	QC-M-03	
		Bricks	QC-M-04	
		Coarse Aggregate	QC-M-06	

Figure 8 Process Chart for Pipeline works with Stages of Inspection

Sl. No.	Activity	Material		Test Ref. No.
		Name	Format No.	
		Cover	TPI (1)	
		Frame/Vent shaft etc.	MC (1)	
		Steel	MC (1)	
4	Completion of Pipeline Laying and Jointing	Stage Completion Test		QC-P-04
5	Completion of Manhole/ Valve Chamber Construction	Stage Completion Test		QC-P-05
6	Completion of Liquid Retaining Structures (Wet Wells, Storage Reservoirs, Pre-treatment Units, RCC Open Channels, etc.)	Stage Completion Test		QC-P-06

Note: 1. MC = manufacturer certified; TPI = third party inspection.

Table 62 Procedures for Testing Pipeline Works and Liquid Retaining Structures

Earth Bedding			**QC-P-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for each 250 m3 of soil	In-process
2	Field density test as per IS-2720	TC-M-09-03	One test for each 100 m^2 of compacted area	
Concreting			**QC-P-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-516	TC-G-01-01	One test for 1-5 m^3 of concrete Two tests for 6-15 m^3 of concrete Three tests for 16-30 m^3 of concrete Four tests for 31-50 m3 of concrete + one set every 50 m^3 of additional concrete work.	Test samples to be taken while pouring. Tests to be done as specified in the contract.
2	Slump test per IS-1199	TC-G-01-02	Random checks throughout concreting period as directed by the Engineer	Before pouring concrete
3	Steel reinforcement placement and bending	Daily log	Before pouring concrete	Before pouring concrete
4	Concrete Pour Report	TC-G-01-03	When pouring is done	Immediately after pouring
Mortar			**QC-P-03**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-2250	TC-G-01-01	One sample for every 2 m^3 of mortar subject to a	Test samples to be taken while

2	Consistency as per IS-2250	TC-G-01-02	minimum of three samples for a day's work	placing. Tests to be done as specified in the contract.

Completion of Pipeline Laying and Jointing			QC-P-04	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Hydrostatic test for NP pipes	TC-P-04-01	One test for defined stretch	On completion of stage
2	Hydrostatic test for pressure pipes	TC-P-04-02	One test for defined stretch	On completion of stage

Completion of Manhole/Valve Chamber			QC-P-05	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Leakage Test	TC-P-05-01	100% inspection	On completion of stage

Completion of Liquid Retaining Structures			QC-P-06	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Water tightness for underground structures	TC-P-06-01	One test per structure	On completion of stage
2	Water tightness for elevated structures	TC-P-06-02	One test per structure	

11.3.5 DOCUMENT CONTROL

Document control is intended to provide a consistent framework for transmittal, receipt, recording, processing, filing and retrieval of documents, and to ensure commonality in formats. The most important documents for QA/QC are final design documents, test reports and instructions. Document control procedures, including guidelines for correspondence control, are outlined below.

11.3.5.1 *Introduction*

As discussed earlier (See Section 2), detail documents (drawings, calculations, estimates, etc.) are generated at two separate levels, depending on the contracting procedure and type of work. These factors have been considered in suggesting the document control system.

The flow of detail documents submitted by the contractor in contracts shall be as follows:

1. The contractor shall submit three copies of any documents to DSC for review, using the Request for Approval (RDA) Format F-1 of Appendix C.
2. After review, the DSC shall return the documents with its comments or documents signed 'Approved' and return them to the contractor (using a format similar to F-4).,

11.3.5.2***Test Report Controls***

All the tests and field checks are to be carried out as per the applicable quality control requirements. The flow of test report documentation shall generally be as follows:

1. Test reports shall be submitted by the contractor to the DSCC.
2. The DSCC shall forward a copy of the test reports to PIU for its review in its monthly report along with contractor's monthly report.
3. The DSC shall issue a Conformance/Non-Conformance Report (CNC Report) to the contractor after review of test results by the DSC, using Format F-10 of Appendix C. The CNC reports will have a running serial number for each contract package.
4. The CNC report shall be entered in the Test Report Log by the contractor at the site, using Format F-11 of Appendix C. The details of input materials will be recorded in the Material Register, using Format F-12 of Appendix C. The contractor shall maintain all test records properly.

Other approvals given to the contractor will be recorded in the daily logs of the contractor which should form part of the contractor's monthly report. A recommended format for Daily Work Record/Site Order Book is illustrated in Format F-13 of Appendix C.

Similar procedures shall be followed for the transmittal and review of test reports for tests performed at outside laboratories, for manufacturers' certificates, and for third party inspection reports.

11.3.5.3***Tracking of Instructions***

During the process of construction, different agencies are expected to conduct site visits and instruct the relevant agency to ensure quality and timely construction within the costs to the extent possible. The multiplicity of agencies is a special feature of the Project. Hence there may be some ambiguity in the instruction flow if these are not transmitted and recorded properly.

All the instructions to the contractor shall flow through DSC/PIU. The instructions are of the following types:

1. All instructions related to the contract administration including approval of the contract variation orders, time extensions, notices related to rate of progress etc.
2. The instructions regarding quality, testing, monitoring and work scheduling shall be issued by the DSC.
3. Instructions issued during site visits or inspections of the PIU and DSC, which are normally recorded in the contractor's Site Order Book, shown in Format F-13 of Appendix C; and
4. Instructions issued during review meetings in the form of minutes, letters, etc.

All instructions to the contractor noted above are to be recorded by the contractor in the Instruction Log, using Format F-15 of Appendix C. Instructions also include notices of rejection of work inspected because it was found to be non-conforming to requirements and which has to be redone or rectified.

11.3.5.4***Site Order Book***

The Contractor shall be responsible to maintain a Site Order Book in duplicate at the site of works at all times and shall be open for inspection by authorized representatives of the PIU and DSC.

The Site Order Book has two primary purposes – to record day-to-day instructions to the Contractor and Contractor's compliance with these instructions and to record the inspection and acceptance of work completion stages along with issuing approvals to the Contractor to proceed with next stage of construction.

As noted above the status of the Contractor's compliance with instructions issued is to be summarized in the Instruction Log (Format F-15 of Appendix C), and reviewed monthly by the DSC/PIU and during the periodic Squad Checks. In cases, where the Contractor has failed to comply with the instructions the reasons therefore shall be determined and necessary remedial actions be taken. The Construction Supervisor of DSC may also maintain a parallel site order Book to ensure compliance.

11.3.5.5***Correspondence Control***

Out-going letters (including transmittal letters and notes) originating from various organizations involved in the Project (PIU, DSCs, contractors, manufacturers, etc.) shall be signed only by the designated project executive of that organization (for example PMU Director or person authorized on his behalf, PIU Project Director, Team Leader, DSC).

All letters should have a reference code and number, and should refer to a single subject only, which shall be clearly stated on top of the letter, after the recipient's address. All outgoing letters should be numbered sequentially. All replies should refer to the originator's reference code and number and subject.

Incoming correspondence should be stamped and dated, and preferably given an internal reference code and number. All incoming and outgoing correspondence should be logged chronologically, either in computer correspondence registers or in manual correspondence logs.

Copies of outgoing correspondence and originals of incoming should be filed in chronological files at the document center of each project organization. There should be only one chronological file for all outgoing correspondence. Regarding incoming correspondence, there could be more than one chronological file, based on the volume of correspondence expected to be received from project related organizations.

11.3.5.6***Inspection of Site Documentation***

During site visits and inspections, DSC and PIU will check and follow up with the documentation maintained on site by the contractor, as follows:

- Check the Drawing Register and ensure that the approved designs and drawings are being used during construction.
- Check the Test Report Log and ensure that a Conformance Report has been issued by the DSC for the materials being used.
- Check the Material Register and cross-check the material test reports with inward and consumption entries of the Material Register.
- Check the Instruction Log and the Daily Work Record/Site Order Book and ensure that the instructions, as recorded in these registers and issued through any letters or minutes of meeting, are being implemented by the contractor.
- Check the Daily Logs and the standard of works and documentation is of acceptable quality.
- Deviations, if any, are to be recorded in the Site Order Book and a copy circulated by the contractor to the PIU, PMU and DSC.
- The registers that are verified by the PIU and DSC are to be signed by them.

12 GENERAL REQUIREMENTS IN OPERATIONS

12.1 STANDARD MANUALS GOVERNING THE OPERATIONS

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

i. Manual on Water Supply and Treatment published by Government of India;
ii. Ministry of Urban Development, CPHEEO as amended up to date;
iii. Manual on Operations and Maintenance of Water Supply Systems, published by Government of India, Ministry of Urban Development, CPHEEO, January 2005 and as amended up to date.

12.2 EQUIVALENCY OF STANDARDS AND CODES

Except where otherwise specified the Operation and Maintenance under this Contract shall comply with the requirements of the referenced or relevant Indian Standards (IS), British Standards (BS), AWWA standards, ISO standards AWS standards, ASTM standards, etc. Other equivalent national or international standards or similar other organizations may be considered at the sole discretion of the Engineer or as may have been agreed in the Agreement. All standards used shall be the latest versions.

The Contractor shall obtain at least one copy of each IS, BS or other approved standards or reference material which are referred to in the specification and a copy of all other standards which apply to materials which are being supplied to, or workmanship executed. These standards and reference material shall be available to the Contractor or TPA at all reasonable times.

Where the requirement of any such standard specifications or regulation conflict with the Employer's Requirements, then the Contractor should refer to the Auditing Body.

13 OPERATION PROCEDURES

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

13.1 TUBE WELLS

i. Flow measurements
ii. Selection of withdrawal level
iii. Collection and analysis of water quality
iv. Checking operation of all pumps and valves
v. Checking operations of electrical & mechanical equipment

13.2 WATER PUMPING STATIONS, TRANSMISSION MAINS AND RESERVOIRS

i. Check operation of all pumps
ii. Take all relevant meter readings
iii. To ensure compliance with agreed withdrawals and to bring to notice of the Employer any excess or short withdrawal.
iv. Check operation of all valves along the transmission main
v. Flow and pressure measurement
vi. Checking operations of electrical & mechanical equipment
vii. Check the power factor and power consumption

13.3 NON ROUTINE DUTIES

In addition to the routine operational tasks in the process, the Contractor shall undertake the following non-routine and maintenance tasks:

i. Carry out minor maintenance and repair works
ii. Emptying the water reservoirs and inspection of the mechanism
iii. Removal of submersible pumps for checking seals/glands etc.
iv. Site audits and surveys
v. Test alarms
vi. Safety and process risk assessment
vii. Budgetary inputs and assistance

14 MAINTENANCE AND REPAIRS

To ensure that the Water Supply system delivers desired output at all times, a proper maintenance management plan shall be formulated, which shall have following arrangements:

1. Routine inspection and maintenance of all equipment
2. Planned and scheduled maintenance (preventive)
3. Unscheduled maintenance (breakdown)
4. Cost and budget planning

14.1 ROUTINE INSPECTION AND MAINTENANCE OF EQUIPMENT

The Contractor shall carry out routine monitoring of the equipment and ensure that the equipment is properly maintained to meet the desired output. Typical tasks that shall be undertaken are:

A. Mechanical

i. Checking the lubrication and necessary follow-up
ii. Replacing of glands that are leaking
iii. Servicing as per suppliers instructions
iv. Stripping down of pumps to observe clogging if any
v. Checking for unusual vibrations and noise

B. Electrical

i. Checking electrical contacts and wiring
ii. Checking motor heating and noise level
iii. Assessing efficiency of electrical equipment

C. Instrumentation

i. Cleaning and calibration of probe / sensors
ii. Fault diagnosis

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

14.2 PLANNED AND SCHEDULED MAINTENANCE (PREVENTIVE)

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

The overall yearly plan schedule shall be issued to all parties to enable forward planning of anticipated manpower requirement and equipment down time.

14.3 BREAKDOWN MAINTENANCE

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

14.4 SUB-CONTRACTED MAINTENANCE SERVICE

Additional resources to support the Contractor more specialized skills or where the maintenance and routine jobs require skills above those available in-house shall be carried out through suitable sub-contractor services. The Services which the Contractor may plan to subcontract at his own cost are illustrated below. The final decision on this rests with the Contractor.

i. Pump repairs which may require specialist equipment:
ii. Rewinding of motors
iii. Vehicle maintenance
iv. Maintenance of the premises, cleaning, gardening etc.
v. Analysis of certain parameters which are not routinely carried out
vi. IT maintenance
vii. Maintenance of civil structures including concrete and steel, water retaining structures, air conditioning, plumbing etc.
viii. Inspection of high voltage equipment requiring specialist skill and training
ix. Replacement of electrical, instrumentation items and improvement works such as providing capacitors.

14.5 SPARE PARTS

The Contractor shall store spares of all the critical equipment on respective Sites and the inventory shall be assessed according to anticipated usage and in conformity with Annual Operations and Maintenance Plan and Annual Budget. The Contractor shall make available specialized spares to the contracted service firms as necessary. The cost of spares will be met by the Contractor.

The Contractor shall obtain consumable items required for maintenance, as and when required, at his cost.

The Contractor shall operationalize a computer based inventory management system to enable effective control of spares and consumables. This system shall use standard proprietary software and shall be linked to MIS.

14.6 MAINTENANCE REPORTS

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

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

i. Details of number of jobs completed
ii. Frequency of breakdown, time required repairing and costs involved.
iii. Personnel involved / contractors used

Input data along with the base data and license, if assignable, shall be made available to the Engineer.