



Bihar Urban Infrastructure Development Corporation Limited
A Government of Bihar Undertaking

TENDER DOCUMENT FOR

FOR

**SETTING UP SOLID WASTE PROCESSING FACILITY AND
LANDFILL FACILITY FOR MUZAFFARPUR & DARBHANGA
MUNICIPAL CORPORATIONS AND ITS OPERATION AND
MAINTENANCE FOR 10 YEARS**

VOLUME-5: General Material Specification

**Bihar Urban Infrastructure Development Corporation Ltd
(BUIDCO)**

a. 1.GENERAL SPECIFICATION OF MATERIALS

- (1) All materials to be used shall conform to the relevant specifications as per the latest edition of Indian Standard, unless otherwise stated in the detailed specifications of items of work.
- (2) Wherever a reference to any Indian Standard appears in the specification, it shall be taken to mean as a reference to the latest version of the standard.
- (3) Test for material shall be invariably is carried out by the contractor, when the same are specified in the specifications. Tests shall also have to be carried out, even though the same are not specifically mentioned in the specifications but in the opinion of the Engineer-In-Charge, the same are required to be carried out. All such tests shall be carried out in Government Lab or laboratories approved by the Engineer-in-charge and cost there of shall be entirely borne by the Contractor.
- (4) No collection of materials shall be made before it is got approved from the Engineer-In-Charge.

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- (5) Collection of approved materials shall be done at site of work in a systematic manner. Materials shall be stored in such a manner as to prevent deterioration or intrusions of foreign matter and to ensure the preservation of their quality and fitness for the work.
- (6) Materials, if rejected by the Engineer-In-Charge, shall be immediately removed from the site of work. If they are not removed within twenty four hours of receiving such intimation, Engineer-In-Charge shall get the same removed at contractor's cost. The Engineer-In-Charge shall dispose off such materials in a manner as he chooses and the contractor shall not be entitled to any compensation for the cost of such materials.
- (7) Approval to the samples of various materials given by the Engineer-In-Charge will not absolve the contractor from the responsibility of replacing the defective material brought on site or materials used in the work found defective at a later date. The contractor shall have

no claim to any payment or compensation whatsoever on account of any such materials rejected by the Engineer-In-Charge.

- (8) The contractor shall be responsible for observing the laws, rules and regulations imposed under the “Mineral Acts” and such other laws and rules prescribed by Government from time to time

Sr. No.	Description
	PART –I- MATERIALS
M1	Water
M 2	Cement
M 3	Sand
M 4	Black Trap Grit(Stone Grit)
M 5	Black Trap Stone Coarse Aggregate for plain and Ordinary Reinforced Concrete
M 6	Black Trap Stone Coarse Aggregate for controlled Reinforced Concrete
M 7	Bricks Bat Aggregates
M 8	Bricks (A) I st Class (B) II nd Class
M 9	Stone for U.C.R. Masonry
M 10	Mild Steel Bars
M 11	TMT Steel Bars
M 12	C.R.S. Bars
M 13	Mild Steel Binding Wire
M 14	Structural Steel
M 15	Shuttering
M 16	Drawn Wire
M 17	Aluminum section

M 18	Teak Wood I ST Class and II nd Class Teak Wood
M 19	Non Teak Wood
M 20	Ply Wood
M 21	Flush Shutter
M 22	Glass
M 23	Fixtures and Fastening
M 24	Indian type Water Closet
M 25	Foot Rest
M 26	Paint
M 27	French Wood Polish
M 28	Rolling Shutter
M 29	Rough Kota Stone
M 30	Polished Kota Stone
M 31	Barbed Wires
M 32	Cement Mortar

1.2 WATER (M 1):

1.1.1 Water shall conform to IS: 456.

1.1.2 Water shall not be salty or brackish and shall be clean, reasonably clear and free from objectionable quantities of silt and traces of oil and injurious alkalis, salts, organic matter and other deleterious material, which will either weaken the mortar or concrete or cause efflorescence or attack the steel in RCC. Container for transport, storage and handling of water shall be clean.

1.1.3 If required by the BUIDCO it shall be tested by comparison with distilled water. Comparison shall be made by means of standard cement tests soundness time of setting and mortar strength as specified in IS-269-1976. Any indication of unsoundness, change in time of setting by 30 minutes or more or decrease of more than 10 percent in strength of mortar, prepared with water sample when compared with the results obtained with mortar prepared with distilled water shall be sufficient cause for rejection of water under test.

1.1.4 Water fit for drinking will generally be found suitable for mortar or concrete.

1.1.5 Water for curing of mortar, concrete or masonry should not be too acidic or too alkaline. It shall be free from elements, which significantly affect the hydration reaction or otherwise interfere with the hardening of mortar or concrete or produce objectionable stains or other unsighting deposits on concrete or mortar surfaces.

1.1.6 Hard and bitter water shall not be used for curing. Potable water will generally be found suitable for curing of mortar or concrete.

1.3 CEMENT(M 2):

Cement shall be ordinary Portland cement as per IS 269 or Pozzolana cement as per IS 1489. The Grade of cement should be of 43 grade or higher grade.

The contractor shall take every precaution to store the cement properly so that it is not spoiled by dampness etc. Cement required for use shall be fresh as far as possible and stored on planks raised 15 to 20 cms above the floor and stacked 30 cms away from the wall in suitable closed weather proof go down at the site of work. Cement shall be stored in such a way so as to allow the removal and use of cement in chronological order of receipt i.e. first received being first used. Not more than 15 bags shall be stacked vertically in one pile and maximum width of the piles should not be more than 3 meters. Any cement, which has deteriorated, caked or which has been set or partially set shall not be used. When temporarily stored in open for use, it shall be kept on a suitable platform and suitably protected as necessary.

Different brands of cement or cement of the same brand from different factories shall be stored in separate groups and shall not be mixed during use. Cement shall be kept in a store under double locking arrangements. A board indicating stock and daily transactions of cement shall be kept in each room of the cement store. Daily account of receipt and use of cement bags shall be maintained by the Contractor in the preformed prescribed by the BUIDCO.

The cement shall be measured by no. of bags for all use in concrete (except otherwise stated) and masonry etc. In no case, cement shall be measured by boxes or other means for the volumetric proportion of concrete and mortar. For calculation for the proportion, the volume of the cement bag shall be taken as 0.0342 cu.m. (1.20 cft.) and measuring box of size of 30 cm x 30 x 38 cms for concrete works. If weigh-batch concrete is to be used, the cement shall have to be used as per actual weight and the contractor shall not be entitled for any compensation for loss in weight due to shifting of bags or on account of any other reasons. The cement should be brought from Major Plants

1.4 SAND (M 3):

Sand shall be natural, clean, well graded, hard, strong, durable and gritty particles free from injurious amounts of dust, clay, kankar nodules, or of flaky portion, alkali, salts, organic matter, loam, mica or other deleterious substances and shall be got approved from the BUIDCO. If sand is covered with dust, it shall be washed with water to make it clean.

- (A) The sand to be used in cement mortar for masonry works and first coat of plaster should generally satisfy the following grading.

I.S. Sieve	Percentage by weight passing sieve
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480	100
230	80-95
120	70-90
60	40-85
30	5-50
15	0-10

The fineness modulus shall not exceed 3.0

- (B) Sand to be used in cement mortar for lining work, pointing and second coat of plaster may have the following gradings:

I.S. Sieve	percentage by weight passing through
480	100
240	100
120	75-100
60	40-85
30	5-50
15	0-10

The fineness modulus shall not exceed 1.6

- (C) Sand to be used for concrete works shall of grades as specified in I.S. 383. Fineness modulus varying from 2.6 to 3.6 as per requirement.

1.5 BLACK TRAP GRIT (STONE GRIT) (M 4):

Grit shall consists of crushed or broken stone and be hard, strong, dense, durable, clean of proper gradation and free from skin or coating likely to prevent proper adhesion of Mortar. Grit shall generally be cubical in shape and as far as possible flaky elongated pieces shall be avoided. It shall generally comply with the provision of IS-383-1970. Unless special stone of particular quarries is mentioned, aggregate shall be broken from the best black trap stone as approved by the BUIDCO. Grit shall have no deleterious reaction with cement.

The grit shall conform to the following gradation as per sieve analysis.

I.S. Sieve Designation	Percentage passing for sieve
12.50mm	100%
10.00mm	85-100%
4.75mm	0-20%
2.36mm	0-5 %

The crushing strength of grit will be such as to allow the concrete in which it is used to built-up the specified strength of concrete.

The necessary test for grit shall be carried out as per the requirements of IS: 2386 or as revised from time to time as per instructions of the BUIDCO.

1.6 BLACK TRAP STONE COARSE AGGREGATE FOR PLAIN AND ORDINARY REINFORCED CONCRETE (M 5):

Coarse aggregate shall be of machine crushed stone of black trap and be hard strong, dense durable, clean and free in skin and coating likely to prevent proper adhesion of mortar. The aggregates shall generally be cubical in shape. Unless special stones of particular quarries are mentioned, aggregates shall be machine crushed from the best black trap stone as approved by the BUIDCO. Aggregate shall have no deleterious reaction with cement. The size of the coarse aggregate for plain cement concrete and ordinary reinforced cement concrete shall generally be as per the table given below. However, in case of reinforced cement concrete the maximum limit may be restricted to 6 mm less than the minimum lateral clear distance between bars or 6 mm less than the cover whichever is smaller

TABLE - SIZE OF COARSE AGGREGATE

I.S. Sieve Designation	Percentage Passing for single and nominal sized aggregate		
	40 mm	20 mm	16 mm
40 mm	85-100	100	-
20 mm	0-20	85-100	100
16 mm	-	-	85-100

12.5 mm	-	-	-
10 mm	0.5	0-20	0-30
4.75 mm	-	0-5	0-5
2.36 mm	-	-	-

Note: This percentage may be varied somewhat by the BUIDCO who considered necessary for obtaining better density and strength of concrete.

Single size coarse aggregates confirming to the requirements in table No.1 above, or following nominal sizes shall be used at site with the other ingredients of concrete as indicated below. The mixing shall be in a mixture or on the 1:2:4 and C.C. 1: 1 ½:3 mixing with the other ingredient of concrete shall be done in the mixture only except for small work.

- (1) C.C. 1:5:10 - Nominal size of aggregate 40 mm
- (2) C.C. 1:4:8 - Nominal size of aggregate 40 mm
- (3) C.C. 1:3:6 - Nominal size of aggregate 40 mm
- (4) C.C. 1:2:4 - Nominal size of aggregate 20 mm
- (5) C.C. 1:1 ½:3 - Nominal size of aggregate 20 mm

The grading test shall be taken in the beginning and at the change of the source of materials.

The necessary test indicated in IS – 383 and IS – 456 shall have to be carried out to ensure the acceptability. The aggregates shall be stored separately and handled in such a manner to prevent the inter-mixing of different aggregates. If the aggregates are covered with the dust, it shall be washed with water to make it clean. The course/aggregates for plain and reinforced concrete shall be measured by volume in the steel or wooden boxes prepared as per the direction of the BUIDCO.

1.7 BLACK TRAP STONE COURSE AGGREGATES FOR CONTROLLED REINFORCED CONCRETE (M 6):

Coarse aggregate shall be of machine-crushed stone of black trap and be hard / strong, dense, and durable clean and free from skin and coating likely to prevent proper adhesion of mortar. The aggregates shall generally be cubical in shape. Unless special stones of particular quarries are mentioned, aggregates shall be machine crushed from the best, black trap stone as approved by the BUIDCO. Aggregate shall have no deleterious reaction with cement.

In proportion concrete, the quantity of coarse aggregates shall be determined by weight only. The grading of coarse aggregate shall be controlled by obtaining the aggregate in different sizes and blending them in the right proportions as per concrete mix design approved by the BUIDCO. The different sizes shall be stocked in separate stockpiles; the grading of aggregates shall be checked as frequently as possible. The frequency for verification of the grading shall be as directed by the BUIDCO to ensure that the grading is maintained uniform with that of the samples used in the preliminary tests.

The necessary test indicated in IS - 383 and IS - 456 shall have to be carried out to ensure the acceptability of the material.

If aggregate is covered with dust it shall be washed with water to make it clean.

1.8 BRICKS BAT AGGREGATES (M 7):

Brick bat aggregate shall be broken from well burnt or slightly over burnt and dies brick. It shall be homogeneous in texture roughly cubical shape, clean and free from dirt of any other foreign material. The brick bats shall be of 40 mm. to 50 mm. size unless otherwise specified in the item. The unborn or over burnt brick bats shall not be allowed. The brick bats shall be measured by volume by suitable boxes or as directed.

1.9 M-8 BRICKS (M 8):

(A) First Class Bricks

The bricks shall be hand or machine molded and made from suitable soils and kiln burnt. They shall be free from cracks and flaws and modules of free lime. They shall have smooth rectangular faces with sharp corners and shall be of uniform color.

The bricks shall be molded with a frog of 100 mm x 40 mm and 10 mm to 20 mm deep on one of its flat sides. The bricks shall not break when thrown on the ground from a height of 600 mm.

The size of modular bricks shall be 190 mm x 90 mm x 90 mm. The standard size of bricks shall be $8\frac{3}{4}'' \times 4\frac{1}{4}'' \times 2\frac{5}{8}''$. Bricks conform to I.S. 1077 in respect of tolerance for sub-class A bricks.

The size of the conventional bricks shall be 225 mm x 110 mm x 75mm.

The crushing strength of the bricks shall not be less than 35 kg/sq.cm. The average water absorption shall not be more than 20 percent by weight. A necessary test for crushing strength and water absorption shall be carried out as per IS: 3495 (Parts I to IV) as directed by the BUIDCO

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(B) Second Class Bricks

The second class bricks shall be similar to first class bricks except that they may be permitted to have slight distorted and rounded edges provided no difficulty shall arise on this account in laying of uniform courses.

1.8-A FLY-ASH LIME BRICKS :

The fly ash lime bricks shall conform to Grade-1 or Grade-2 of IS-3812-1981. The frog of the 80 to 100 mm x 40 mm x 10 to 20 mm size.

The size of modular bricks shall be 190 mm x 90 mm x 90 mm.

The size of conventional brick shall be 225 mm x 110 mm x 75 mm.

Only bricks of one standard size shall used on one work. The following tolerances shall permitted in the conventional size adopted in a particular work:

Length : + 3 mm

Width : + 3 mm

Height : + 2 mm

The physical characteristic of bricks shall be as follows.

The minimum compressive strength of fly ash lime bricks shall not be less than 75 Kg/Sq.Cm. and the test shall be conform to IS-3495 (Part-I):1992.

The average drying shrinkage of the brick when tested by the method described in IS 4139-1989 being shall not exceed 0.15 percent.

The averages water absorption not more than 20 percentage by mass and the test shall conform to IS-3495 (Part-3):1992.

1.10 UNCOURSED RUBBLE MASONRY (M 9):

Stone to be used for masonry work such as un-coursed course, R.R. Ashlars etc. shall be try, granite, and Ballast, and stone, etc. if any other type of good stone. Any good stone available in the region shall be utilized. The Building Stone shall be through hard, dense, sound, durable, resistance to weathering action reanobly fine grained, uniform in color and free form beams, creaks and other defects. The exposed face shall be free from discoloration.

Stones when immersed in water for 24 hrs. Shall not absorb water more than 5% of its dry weight when tested according to I.S. 1124-1974 sand stone shall be fine grained good color and free from salt slabs and tiles of limestone shall confirm to I.S. 1128-1974.

Fare Stone shall be rashly quarried. With clean faces and short edges. It shall be of such character, that it can be brought to required line, carved surface etc. Rubble stone for hearting shall be approved quality. Free from regenerative etc. Royalties, composition, Octroi duties etc. payable in connection with securing stone shall be paid by the contractor.

The measurement shall be taken by volume length or number as the case may be with cubic meter, meter and one as the respective unit. In case rubble, the measurement shall be volume of stock, with cubic meter as unit without deduction of void.

In case of khandlides the measurement shall be numbers for specific size.

In case of stones such as quoins, the measurement shall be numbers for specific size.

In case of stones such as slabs coping stones etc. the measurement shall be by volume

with cubic meter as unit for specified dimensions.

1.11 MILD STEEL BARS (M 10):

Mild steel bars reinforcement for R.C.C. work shall conform to IS. 432 and shall be of tested quality. It shall also comply with relevant part of IS. 456. All the reinforcement shall be clean and free from dirt, oil, paint, grease, mill scale or loose or thick rust at the time of placing.

Reinforcement steel shall be stored such as to avoid distortion and sags of long length and shall be protected as far as possible from surface deterioration. All bars of the same designation shall be stacked separately as far as possible and distinctly marked.

For the purpose of payment the bar shall be measured correct up to 10 mm length and weight payable worked out at the rate specified below.

(1)	6 mm	0.22 Kg/Rmt.
(2)	8 mm	0.39 Kg/Rmt.
(3)	10 mm	0.62 Kg/Rmt.
(4)	12 mm	0.89 Kg/Rmt.
(5)	14 mm	1.21 Kg/Rmt.
(6)	16 mm	1.58 Kg/Rmt.
(7)	18 mm	2.00 Kg/Rmt.
(8)	20 mm	2.47 Kg/Rmt.
(9)	22 mm	2.98 Kg/Rmt.
(10)	25 mm	3.85 Kg/Rmt.
(11)	28 mm	4.83 Kg/Rmt.
(12)	32 mm	6.31 Kg/Rmt.
(13)	36 mm	7.99 Kg/Rmt.
(14)	40 mm	9.86 Kg/Rmt.

1.12 TMT BARS (M 11):

Scope of work:

The scope of work consists of providing and laying mild steel reinforcement and TMT reinforcement for RCC works of various components of the structure. This may be of Tiscon, Sulekhan, SAIL or Punjab Rolling Mill or any other Approved make. This includes cuttings, bending, binding, placing, with all Equipments and labour required for the work as directed by the BUIDCO and all operations covered within the intent and purpose of the Specification.

Bending of Reinforcement:

Reinforcing steel shall conform accurately to the dimensions shown on relevant drawings and conforming to the relevant IS codes (latest revision) Bars shall be bent cold to the specified shape

and dimensions or as directed by the BUIDCO using a proper bar bender, operated by hand or power to attain proper radii of bends. Bars shall not be bent or strengthened in a manner that will cause injury to the material. Bars bent during transport or handling shall be straightened before being used on work; they shall not be heated to facilitate bending.

The bending of the TMT bars shall be carried out as per the following:

Operation Size TMT Fe-415

1 Bend Up to 22 mm dia. 3d

Over 22 mm dia. 4d

2 Rebend Up to 10 mm dia. 4d

Over 10 mm dia. 5d

Placing of Reinforcement:

All reinforcing bars shall be accurately placed in the exact position shown on the drawings, and shall be securely held in position during placing of concrete by annealed binding wire not less than 1 mm. in size and conforming to IS : 280 and by using stays blocks or metal chairs, spacer, metal hangers, supporting wires or other approved devices at sufficiently close intervals. Bars will not be Neither allowed to sag between supports nor displaced during concreting or any other Operation over the work. All devices used for positioning shall be of no corrodible material. Wooden and metal supports will not extend to the Surface of concrete, except where shown on the drawings, Placing bars on layers of freshly laid concrete as the work progresses for adjusting bar spacing will not be allowed. Pieces of broken stone, brick or wooden blocks shall not be used. Layers of bars shall be separated by spacer bars, precast mortar blocks or other approved devices. Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in concrete. Special care shall be exercised to prevent any displacement of reinforcement in concrete already placed. To protect reinforcement from corrosion, concrete cover shall be provided as indicated on the drawings. All bars protruding from concrete to which other bars are to be spliced and which are likely to be exposed for an indefinite period shall be protected by a thick coat of neat cement grout. In the case of columns and walls, vertical bars shall be kept in normal position with timber templates having slots accurately cut in for bar position. Such templates shall be removed after the concreting has progressed up to a

level just below them. Bars crossing each other, where required, shall be secured by binding wire (annealed) of size not less than 1 mm and conforming to IS : 280 in such a manner that they do not slip over each other at the time of fixing and concreting. As far as possible, bars of full length shall be used. In case this is not possible, overlapping of bars shall be done as directed by the BUIDCO. When practicable, overlapping bars shall not touch each other, but be kept apart by 25 mm or 1 1/4 times the maximum size of the coarse aggregates whichever is greater, by concrete between them. Where this is not feasible, overlapping bars shall be bound with annealed steel wire, not less than 1mm thickness twisted tight in eight shapes around the lapped bars. The overlaps shall be staggered for different bars and located at fixed locations only along the span where neither shear nor bending moment is maximum.

Welding of Bars

33 per cent of the rods are welded. No pre-warming or post heat treatment is necessary. Interpose temperature should be limited to 200oC with low heat input and equivalent strength low hydrogen type electrode. Suitable means shall be provided for holding the bars securely in position Welding of TMT bars can be permitted if specified on the drawings, joints of Reinforcement bars shall be butt welded so as to transmit their full strength. Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum permissible stresses and welds so staggered that at any one section, not more than during welding. It must be ensured that no voids are left in welding and when welding is done in 2 or 3 stages, previous surface shall be cleaned property. Ends of the bars shall be cleaned of all loose scale, rust. Grease, paint and other foreign matter before welding. Only competent welders shall be employed on the work. Welded pieces of reinforcement shall be tested. Specimens shall be taken from the actual site and their number and frequency of tests shall be as directed by the BUIDCO.

1.13 C.R.S. BARS (M 12):

Scope of work:

The scope of work consists of providing and laying mild steel reinforcement and CRS Bars reinforcement for RCC works of various components of the structure. This may be of Tiscon, Sulekhan, SAIL or Punjab Rolling Mill or any other Approved make. This includes cuttings, bending, binding, placing, with all Equipments and labour required for the work as directed by the BUIDCO and all operations covered within the intent and purpose of the Specification.

Bending of Reinforcement:

Reinforcing steel shall conform accurately to the dimensions shown on relevant drawings and conforming to the relevant IS codes (latest revision)

Bars shall be bent cold to the specified shape and dimensions or as directed by the BUIDCO using a proper bar bender, operated by hand or power to attain proper radii of bends. Bars shall not be bent or strengthened in a manner that will cause injury to the material. Bars bent during transport or handling shall be straightened before being used on work; they shall not be heated to facilitate bending.

The bending of the CRS BARS shall be carried out as per the following:

Operation Size CRS BARS Fe-415

1 Bend Up to 22 mm dia. 3d

Over 22 mm dia. 4d

2 Rebend Up to 10 mm dia. 4d

Over 10 mm dia. 5d

Placing of Reinforcement:

All reinforcing bars shall be accurately placed in the exact position shown on the drawings, and shall be securely held in position during placing of concrete by annealed binding wire not less than 1 mm. in size and conforming to IS: 280 and by using stays blocks or metal chairs, spacer, metal hangers, supporting wires or other approved devices at sufficiently close intervals. Bars will not be neither allowed to sag between supports nor displaced during concreting or any other Operation over the work. All devices used for positioning shall be of no corrodible material. Wooden and metal supports will not extend to the Surface of

concrete, except where shown on the drawings, Placing bars on layers of freshly laid concrete as the work progresses for adjusting bar spacing will not be allowed. Pieces of broken stone, brick or wooden blocks shall not be used. Layers of bars shall be separated by spacer bars, precast mortar blocks or other approved devices. Reinforcement after being placed in position shall be maintained in a clean condition until completely embedded in concrete. Special care shall be exercised to prevent any displacement of reinforcement in concrete already placed. To protect reinforcement from corrosion, concrete cover shall be provided as indicated on the drawings. All bars protruding from concrete to which other bars are to be spliced and which are likely to be exposed for an indefinite period shall be protected by a thick coat of neat cement grout. In the case of columns and walls, vertical bars shall be kept in normal position with timber templates having slots accurately cut in for bar position. Such templates shall be removed after the concreting has progressed up to a level just below them. Bars crossing each other, where required, shall be secured by binding wire (annealed) of size not less than 1 mm and conforming to IS : 280 in such a manner that they do not slip over each other at the time of fixing and concreting. As far as possible, bars of full length shall be used. In case this is not possible, overlapping of bars shall be done as directed by the BUIDCO. When practicable, overlapping bars shall not touch each other, but be kept apart by 25 mm or 1 1/4 times the maximum size of the coarse aggregates whichever is greater, by concrete between them. Where this is not feasible, overlapping bars shall be bound with annealed steel wire, not less than 1mm thickness twisted tight in eight shape around the lapped bars. The overlaps shall be staggered for different bars and located at fixed locations only along the span where neither shear nor bending moment is maximum.

Welding of Bars

33 per cent of the rods are welded. No pre-warming or post heat treatment is necessary. Interpose temperature should be limited to 200oC with low heat input and equivalent strength low hydrogen type electrode. Suitable means shall be provided for holding the bars securely in position Welding of CRS BARS can be permitted if specified on the drawings, joints of Reinforcement bars shall be butt welded so as to transmit their full strength. Welded joints shall preferably be located at points where steel will not be subject to more than 75 percent of the maximum permissible stresses and welds so staggered that at any one section, not more than during welding. It must be ensured that no voids are left in welding and when welding is done in 2 or 3 stages, previous surface shall be cleaned property. Ends of the bars shall be cleaned of all loose scale, rust. Grease, paint and other foreign matter before welding. Only competent welders shall be employed on the work. Welded pieces of reinforcement shall be tested. Specimens shall be taken from the actual site and their number and frequency of tests shall be as directed by the BUIDCO.

Chemical Composition

CRS Bars should have of grade Fe-415, IS:1786 grade.

Chemistry	Unit	IS:1786 Fe-415
Carbon	%	0.3 max
Carbon equivalent (C+Mn/6)	%	0.38 max
Sulphur	%	0.060 max
Phosphorous	%	0.060 max
S & P	%	0.110 max
Nitrogen	ppm	100 max

Mechanical Properties

Mech. Properties	Unit	IS:1786 Fe-415
Yield Stress	N/mm	415 min
Tensile Stress	N/mm ²	10% over YS
Elongation	% min	14.5 min

Bond Strength

The rib pattern of CRS bars has been specially designed to ensure that excellent bond strength exists between the bar and the surrounding concrete. The ribs are cut by automated milling machines which produce uniform and concrete ribs.

While the specification stipulates that bond strength should be 40% higher than that of Mild Steel plain bars.

Standard Sizes and Useful Data

Section (mm)	Nominal Weight (kg/meter)
8	0.395
10	0.617
12	0.888
16	1.58
20	2.47
25	3.85
28	4.83
32	6.31
36	7.99
40	9.85

1.14 MILD STEEL BINDING WIRE (M 13):

The mild steel wire shall be of 1.63 mm or 1.22 mm (16 or 18 gauge) diameter and shall conform to IS-280 or as revised from time to time.

The use of black wire will be permitted for binding reinforcement bars. It shall be free from dust, oil paint, grease, loose mill scale or any other undesirable coating, which may prevent adhesion of cement mortar.

Storage: The wire coils shall be stored such as to avoid deterioration.

Measurement: No measurement will be taken of the wire used for tying reinforcement bars. The rate for reinforcement steel and its fabrication shall include the cost of binding wire.

1.15 STRUCTURAL STEEL (M 14):

All structural steel shall conform to IS-226 and IS-800 or as revised from time to time. The steel shall be free from the defects mentioned in IS. 226 and shall have a smooth finish. The Material shall be free from loose mill scale, rust pits or other defects affecting the strength and durability. Rivet bars shall be conforming to IS-1148.

Structural steel shall be stored such as to avoid distortion of section of long length and shall be protected as far as practicable from surface deterioration. It should be so stored and handled that material will not be subjected to excessive stress and damages. All deformed structural material will be properly straightened by methods, which are not injurious prior or being, and off, punched or otherwise worked in the shop. Sharp kinks and bends shall be caused for rejection.

When the steel is supplied by the Contractor test certificate of the manufactures shall be produced, if so required by the BUIDCO. If further test be necessary, they will be done according to IS-226 and IS-23 or as revised from time to time.

1.16 SHUTTERING (M 15):

The shuttering shall be either of wooden planking of 30mm minimum thickness with or without steel sheet lining or of steel plates stiffened by steel angles. The shuttering shall be supported on battens and beams and props of vertical bellies properly cross braced together so as to make the form work rigid.

The form work shall be sufficiently strong and shall have camber, so that it assumes correct shape after deposition of the concrete and shall be able to resist forces caused by vibration of live load of men working over it and other incidental loads associated with it. The shuttering shall have smooth and even surface and its joints shall not permit leakage of cement grout.

If at any stage of work during or after placing concrete in the structure the form work sags or budes out beyond the required shape of the structure, the concrete shall be removed and work redone with fresh concrete and adequate rigid form work. The complete formwork shall be got inspected by and approved from the BUIDCO before the reinforcement bars are placed in position.

If wooden props are used, the props shall consist of bellies having 100 mm minimum diameter measured at mid length and 80 mm at thin end and shall be placed at 1 to 1.20m spacing. These shall rest squarely on wooden sole plates 40 mm thick and minimum bearing area of 0.10 sq.m. Lay on sufficiently hard base.

Double wedges shall further be provide between the sole plate and the wooden props so as to facilitate tightening and easing of shuttering without jerking the concrete.

The timber used in shuttering shall not be so dry as to absorb water from concrete and swell budge nor so green or wet as to shrink after erection. The timber shall be properly swan and planned on the sides and the surface coming in contact with concrete. Wooden form work with metal sheet lining or steel plates stiffened by steel shall be permitted.

As far as practicable clamp shall be used to hold the forms together and use of nails and spikes avoided.

The surface of timber shuttering that would come in contact with concrete shall be well wetted and coated with soap solution before the concreting is done. Alternatively coat of soap solution or raw linseed oil shall be applied after thoroughly cleaning the surface.

The shuttering for beams and slabs shall have camber of 4 mm per meter (1 in 250) or as directed by the BUIDCO so as to offset the subsequent deflection. For cantilever the camber at free end shall be 1/50 of the projected length or as directed by the BUIDCO.

The period that shall elapse after the concrete has been laid before easing and removal of centering and shuttering as under taken shall be as follows.

Part of structure	Period
1. Sides of Foundation, Columns beams	24 to 48 hours.

& walls.

- | | | |
|----|--|--------------------|
| 2. | Undersides of slabs up to 4.5 m span. | 7 days. |
| 3. | -do- above 4.50 m and underside of
Beams and arches up to 6 m span. | 14 days. |
| 4. | -do- above 6 m span & up to 9 m. span | 21 days. |
| 5. | Inner sides of beams and arches over 9 m span. | 28 days. |
| 6. | Domes, shell & other structures of
Special nature. | as per instruction |

Work damaged through premature or careless removal of forms shall be reconstructed.

The period for striking the form work shall be 0.5 times more in case of Pozzolana Cement if used than that of the ordinary Portland cement and the contractor shall not entitle for any extra claim for the same.

1.17 DRAWN WIRE (M 16):

The Hard drawn steel wire should confirming to IS-432 (Part 2), Hard drawn steel wire shall be manufacture and its chemical composition should be as per para 3.0. The finished wire should be free from defects and finished in a workman like manner. Nominal sizes, Tolerances, Physical requirements are as per IS : 432 (Part-II) latest edition. Hard drawn steel wire should be tested as specified in IS : 432 (Part-II) latest edition.

1.18 ALUMINUM SECTION (M 17):

Aluminum alloy used in the manufacture of extruded window sections shall correspond to IS Designation HE-9-WP IS: 733-1956 Specification for wrought Aluminum and aluminum alloys, Bars, Rods and Section (for General Engineering Propose). Hollow Aluminum alloy section used shall conform to IS Designation HE-9-WP of IS: 1285-1958 Specification for Wrought Aluminum and Aluminum Alloys, Extruded Round Tube and Hollow Sections (For General Engineering Purposes).

Dimensions and Weight per meter run of the extruded sections shall be as given in Fig. 5

Coupling Section:

Aluminum alloy coupling sections used shall conform to IS Designation HV9-WP of IS: 1285-1958 Specification For Wrought Aluminum and Aluminum alloys, Extruded Round Tube and Hollow Section (For General Engineering Proposes). They shall conform to the dimensions show in Fig-5.

Glass Panes:

Glass Panes shall be weigh at least 7.5 kg/m³ and shall be free from flaws, speaks, or bubbles. All Panes shall have properly squared corners and straight edges. The sizes of the class panes for use in doors, Windows and Ventilators.

Note: The metal doors and windows industry has follow the practice of the glazing industry in specifying size of glass. Accordingly, in the metal doors and windows, the practice hitherto has been to specify building industry and in the case of timber doors and windows the practice is to specify width first and Height afterwards. The committee responsible for the preparation of standard has considered it desirable to unify the practice in this regard and has adopted the building industry practice that is, to specify width first and height afterwards.

Screws:

Screw threads of machine screw used in the manufacture of aluminum doors, windows, and ventilators shall conform to requirement of IS: 1362-1959 dimensions for screw threads for general propose (Diameter range 0.25 to 39 mm). Other threads shall be permissible if agreed to between the purchaser and vendor.

1.19 TEAK WOOD (M 18):

The teak wood shall be of good quality as required for the item to be executed. When the kind of wood is not specifically mentioned, good Indian teak wood as approved shall be used.

Teak wood shall generally be free from large, loose, dead or cluster knots, flaws, shakes, warps, twists bends or any other defects. It shall generally be uniform in substance and of straight fibers as far as possible. It shall be free from rot, decay, harmful fungi and other defects of harmful nature which will affect the strength durability of its usefulness for the purpose for which it is required. The colour shall be uniform as far as possible. Any effort like painting, using any adhesive or resins materials made to hide the defects shall render the pieces liable to rejection by the BUIDCO.

All scantlings, planks etc. shall be sawn in straight lines and planes in the direction of grains and of uniform thickness.

The tolerances in the dimensions shall be allowed at the rate of 1.5 m.m. per face to be planed.

a) First class teak wood:

First class teak wood shall have no individual hard and sound knots, more than 6 sq. cm. sizes and the aggregate area of such knots shall not be more than 1% of area of piece. The timber shall be closed grained.

b) Second Class Teak Wood:

No individual hard and sound knots shall be more than 15 Sq. cms. in size and aggregate area of such knots shall not-exceed 2% of the area of piece.

1.20 NON-TEAK WOOD (M 19):

The non teak-wood shall be chemically treated, seasoned as per IS Specifications and of good quality. The type of wood shall be got approved before collecting the same on site. Fabrication of wooden members shall be started only after approval.

For this purpose wood of Bio, Kalali, Siras, Behda, Jamun, Sisoo will be used for door frames where as only Kalali, Siras, Halda, Kalam etc. will be permitted for shutters after proper seasoning and chemical treatment.

The non-teak wood shall be free from large, loose, and dead of cluster knots, flows, shakes warps bends or any other defect. It shall be uniform in substance and of straight fibers as far as possible. It shall be free from decay harmful fungi and other defects of nature which effect the strength, durability or its usefulness for the purpose for which it is required. The colour of wood shall be uniform as far as possible. The scantlings planks etc. shall be sawn in straight lines and planes in the direction of grain and uniform thickness.

The department will use the Agency to produce certificate from forest Department in event of Disputes and the decision of the Department shall be final and binding to the contractor.

The tolerance in the dimension shall be allowed as 1.5 mm. per face to be planed.

1.21 PLYWOOD (M 20):

The plywood for general purpose shall conform I.S. 303-1975. Plywood is made by cementing together thin boards or sheets of wood into panels. There are always an odd number of layers 3,5,7,9 plies etc. The plies are placed so that grain of each layer is right angle to the grain in the adjacent layer.

The Chief advantages of plywood over a solid board of the same thickness is the more uniform strength of the plywood, along the length and width of the plywood and greater resistance to cracking and splitting with change in moisture content.

Usually synthetic resins are used for gluing, phenolic resins are usually cured in a hot press which compresses and simultaneously heats the plies between hot plates which maintain a temperature of 90 degrees C. to 140 degrees C. and a pressure of 11 to 14 kg/sq.cm. on the wood. The time of heating may be anything from 2 to 69 minutes depending upon thickness.

When water glue are used, the wood absorbs so much water that the finished plywood must be dried carefully. When synthetic resins are used as adhesive finished by plywood must be exposed to an atmosphere of controlled humidity until the proper amount of moisture has been absorbed.

According to I.S. 303-1975 the plywood for general purpose shall be of three grades BWR, WWR and CWR, depending upon the adhesives used for bonding and veneers, and it will be further classified into six types namely AA, AB, AC, BB, BC and CC based on the quality of the two faces, each face being of three kinds namely, A, B and C, After pressing, the finished plywood should be reconditioned to a moisture content not less than 8 percent and not more than 16 percent.

Thickness of plywood Boards:

Board	Thickness	Board	Thickness	Board	Thickness	Board	Thickness
3 ply	3mm.	5 ply	5 mm.	7 ply	9 mm.	9 ply	16 mm.
	4mm.		6 mm.		13 mm.		19 mm.
	5mm.		8 mm.		16 mm.	11 ply	19 mm.
	6mm.		9 mm.	9 ply	13 mm.		22 mm.
							25 mm.

1.22 FLUSH SHUTTER (M 21):

The solid core type flush door shutters shall be decorative or non-decorative type as specified in the drawing. The size and thickness of the shutter shall be as specified in drawings or as directed. The timber species for core shall be used as per I.S. 2202- (Part-I) 1980. The timber shall be free from decay and insect attack. Knots and knot holes less than half the width of cross-section of the members in which they occur may be permitted. Pitch pockets, Pitch streaks and harmless pin holes shall be permissible except in the exposed edges of the core members. The commercial plywood, cross-bands shall conform to I.S. 303-1275.

The face panel of the shutters shall be formed by gluing by the hot press process on both faces of the core with either plywood or cross-bands and face veneers. The hopping rebating opening of glazing, Venetian etc. shall be provided if specified in the drawing.

All edges of the door shutters shall be square. The shutters shall be free twist or warp in its plane. Both faces of the shutters shall be sand papered to smooth even texture.

The shutters shall be tested for

(1) End immersion test:

The test shall be carried out as per I.S. 2202 (part-I) 1980. There shall be no delimitation at the end of the test.

(2) Knife test:

The face panel when tested in accordance with I.S. 1659-1979 shall pass the test.

(3) Glue adhesion Test:

The flush door shall be tested for glue adhesive test in accordance with I.S. 2202 (Part-I) 1980. The shutters shall be considered to have passed the test if no elimination occurs in the glue lines in the plywood and if no single delamination more than 80 mm. in length and more than 3 mm. in depth has occurred in the assembly glue lines between the plywood face and the style and rail. Delamination at the corner shall be measured continuously around the corner. Delamination at the knots, knots holes and other permissible wood defects shall not be considered in assessing the sample.

The tolerance in size of solid core type flush door shall be as under:

In Normal thickness ± 1.2 mm. In Normal height ± 3 mm.

The thick of the shutters shall be uniform throughout with a permissible variation of not more than 0.8 mm. when measured at any two points.

1.23 GLASS (M 22):

All glass shall be of the best quality free from specks, bubbles, smokes, veins, air holes blisters and other defects. The kind of glass to be used shall be mentioned in the item or specification or in the special provisions or as shown in detailed drawings. Thickness of glass panes shall be uniform. The specifications of different kinds of glass shall be as under.

a) Sheet Glass:

In absence of any specified thickness or weight in the item or detailed specifications of the item of work, sheet glass shall be weighing 7.5 Kg/Sq.m. for panes upto 600 mm x 600 mm.

For panes larger than 600 mm. x 600 mm. and upto 800 mm. x 800 mm. the glass weighing not less than 8.75 Kg/Sq.m. shall be used. For bigger panes upto 900 mm. x 900 mm. glass weighing not less than 11.25 Kg/Sq.m. shall be used.

Sheet glass shall be patent flattened glass of best quality and for glazing and framing purposes shall conform to I.S.: 1761-1960. Sheet glass of the specified colours shall be used, if so shown on detailed drawings or so specified. For important buildings and for panes with any dimension over 900 mm. plate glass of specified thickness shall be used.

b) Plate Glass.

When plate glass is specified it shall be 'Polished patent plate glass' of best quality. It shall have both the surface ground flat and parallel and polished to obtain clear undisturbed vision and reflection. The plate glass shall be of the thickness mentioned in the item or as shown in the detailed drawing or as specified. In absence of any specified thickness the thickness of plate glass to be supplied shall be 6mm and a tolerance of 0.20mm shall be admissible.

c) Obscured Glass:

This type of glass transmits light so that vision is Partially or almost completely obscured. Glass shall be plain rolled, figured, ribbed or fluted or frosted glass as may be specified as required. The thickness and type of glass shall be as per details on drawings or as specified or as directed.

d) Wired Glass:

Glass shall be with wire netting embedded in a sheet of plate glass electrically welded 13 mm. Georgian square mesh may be used. Thickness of glass shall not be less than 6 mm. Wired glass shall be of type and thickness as specified.

1.24 FIXTURES AND FASTENINGS (M 23):

a) General

The fixtures and fastenings, that is, butt, hinges, tee and strap hinges sliding door bolts, tower bolts, door latch, bath room latch, handles, door stoppers, casement window fasteners, casement stays and ventilators catch shall be made of the metal as specified in the item or its specifications.

They shall be of iron, bras, aluminum, chromium plated iron chromium plated brass, copper oxidized iron, and copper oxidized brass or anodized aluminum as specified.

The fixtures shall be heavy, Medium or light type. The fixtures and fastenings shall be smooth finished and shall be such as will ensure ease of operation.

The samples of fixtures and fastenings shall be got approved as regards quality and shape before providing them in position.

Brass and anodized aluminum fixtures and fastenings shall be bright finished.

b) Holdfasts:

Holdfasts shall be made from mild steel flat 30 cm. lengths and one of the holdfasts shall be bent at right angle and two nos. of 6 mm. diameter holes shall be made in it for fixing it to the frame with screws. At the other ends. The holdfast shall be forked and bent at right angles in opposite directions.

c) Butt hinges:

Railway standard heavy type butt hinges shall be used when so specified.

The strap hinges shall be manufactured from M. S. Sheet.

d) Siding door bolt (Aldrops):

43 The Aldrops as specified in the item shall be used and shall be got approved.

e) Tower bolts (Barrel Type):

Tower bolts as specified in the item shall be used as shall be used and shall be got approved.

f) Door Latch:

The size of door latch shall be taken as the length of latch.

g) Bathroom Latch:

Bathroom latch shall be similar to tower bolt.

h) Handle:

The size of the handles shall be determined by the inside grip length of the handles. Handles shall have a base plate of length 50 mm more than size of the handle.

i) Door Stopper:

Door stoppers shall be either floor door stopper type or door catch type floor stopper shall be of overall size as specified as shall have rubber cushion.

j) Door Catch:

Door catch shall be fixed as height of about 900 mm from the floor level so that one part of the catch is fitted on the inside of the shutter and the other part is fixed in the wall with necessary wooden plug arrangements for appropriate fixate. The catch shall be fixed 20 mm inside the face of the door for easy operation of catch.

k) Wooden Door stops with highs:

Wooden door stop of size 100mm X 60 mm X 40 mm shall be fixed on the door frame with a high of 75 mm size at high of 900 mm from the floor level the wooden door stop shall be provided with 3 coats of approve oil paint.

l) Case meant window fastener:

Casement window fastener for single leaf window shutter shall be left or right handled as directed.

m) Casement stays (straight peg stay):

The stays shall be made from a channel section having three holes at appropriate position so that the window can be opened either fully or partially as directed as directed. Size of the stay shall be 250 mm to 300 mm as directed.

n) Ventilator catch:

The pattern and shape of the catch shall be as approved.

o) Pivot:

The base and socket plate shall be made from minimum 3 mm thick plate and projected pivot shall not be less than 12 mm length and shall be firmly riveted to the base plate in case of brass pivot.

1.25 INDIAN TYPE WATER CLOSET (M 24):

The Indian type white glazed water closet of first quality shall be of size as specified in the item and conforming to I.S. 771-1979 and I.S. 2556 (Part-II) 1981. Each pan shall have integral flushing ring of suitable type with adequate number of holes allround as directed to have satisfactory flushing. It shall also have inlet at back or front connecting flush pipe as directed. The inside of the bottom of the pan shall have sufficient slope from the front towards the outlet and surface shall be uniform and smooth.

Pan shall be provided with 100 mm. diameter 'P' or 'S' trap with approximately 50 mm. water seal and 50 mm. diameter vent horn.

1.26 FOOT RESTS (M 25):

A pair of white glazed earthen ware rectangular foot rests of minimum size 250 mm. x 130 mm 20 mm. shall be provided with water closet.

1.27 PAINTS (M 26):

(A) Oil Paints:

Oil Paints shall be of the specified colour and shade, and as approved. The ready mixed paints shall only be used. However, if ready mixed paint or specific shade or tint is not available, white ready mixed paint with approved strainer will be allowed. In such a case, the contractor shall ensure that the shade of the paint so allowed shall be uniform.

All the paints shall meet following general requirements:

- (i) Paint shall not show excessive setting in a freshly opened full can and shall easily be redispersed with a paddle to a smooth homogeneous state. The paint shall show no curing, leveraging, caking or colour separation and shall be free from lumps and skins.
- (ii) The paint as received shall brush easily, possess good leveling properties and show no running or sagging tendencies.
- (iii) The paint shall not skin within 48 hours in a three quarters filled closed container.
- (iv) The paint shall dry to a smooth uniform finish free from roughness, grit, unevenness and other imperfections.

Ready mixed paint shall be used exactly as received from the manufactures and generally according to their instructions and without any admixtures whatsoever.

(B) Enamel Paints:

The enamel paint shall satisfy in general requirements as mentioned in specification of oil paints. Enamel paint shall conform to I.S. 2933-1975.

1.28 FRENCH POLISH (M 27):

The French polish of requirement and shape shall be prepared with the below mentioned ingredients and other necessary materials:

(I) Denatured spirit of approved quality (ii) Chandra's (iii) Shellac (iv) Pigment.

The French polish so prepared shall conform to I.S.: 348-1968.

1.29 ROLLING SHUTTER (M 28):

- a)** The Rolling Shutter shall conform to I.S. 6248-1979. Rolling shutter be supplied of specified type with accessories. The size of rolling shutter Shall Be Specified In The Drawings .The shutter shall be constructed with interlocking lath sections formed cold rolled steel strips not less than 0.9 mm. thick and 80 mm. wide for shutter up to 3.5mm., width not less than 1.25 mm. thick and 80 mm. wide for shutter 3.5mm in width and above unless otherwise specified.
- b)** Guide channels shall be mild steel deep channel section and of rolled pressed or built up (fabricated) joint less construction. The thickness of sheet used not be less than 3.15mm.
- c)** Hood covers shall be made of M.S. Sheets not less than 0.92 mm. thickness. For shutter having width 3.5 Meter and above the thickness of M.S. Sheet for the hood cover shall be not less than 1.25mm.
- d)** The spring shall be of best quality and shall be manufactured from tested high tensile spring steel wire or strip of adequate strength to balance the shutter in all position. The spring pipe shaft etc. shall be supported on strong M.S. Or Malleable C.I. Brackets. The Brackets shall be fixed on or under the lintel as specified with raw plugs and screws bolts etc.
- e)** The rolling Shutter shall be of self rolling type up to 8 Sq.m. clear areas without ball bearing. If the rolling Shutter are larger, then gear operated type shutter shall be used.
- f)** The locking arrangement shall be provided at the bottom of shutter at both ends. The Shutter shall be opened from outside.

- g)** The Shutter shall be completed with door suspension shafts, locking arrangement, pulling hooks, handles and other accessories.

1.30 ROUGH KOTA STONE (M 29):

- a)** The kotah stones shall be hard, even, sound, and regular in shape and generally uniform in colour. The colour of the stone shall generally be green. Brown colour stones shall not be allowed for use. They shall be without any soft veins, cracks or flows.
- b)** The size of the stones to be used for flooring shall be of size 600 mm x 600 mm and/or size 600 mm x 450 mm, as directed. However smaller sizes will be allowed to be used to the extent of maintaining required pattern. Thickness shall be as specified.
- c)** Tolerance of minus 30 mm. on account of chisel dressing of edges shall be permitted for length as well as breadth. Tolerance in thickness shall be +/- 3 mm.
- d)** The edges of stones shall be truly chiselled and table rubbed with coarse sand before paving. All angles and edges of the stone shall be true, square and free from chipping and the surface shall be true and plain.
- e)** When machine cut edges are specified, the exposed edges and the edges at joints shall be machine cut. The thickness of the exposed machine cut edges shall be uniform.

1.31 POLISHED KOTA STONE (M 30):

Polished kotah stone shall have same specifications as per rough kotah stone except as mentioned below:

The stones shall have machine polished smooth surface. When brought on site, the stones shall be single polished or double polished depending upon its use. The stones for paving shall generally be single polished. The stones to be used for dado, skirting, platforms, sink, veneering, sills, steps, etc. Where machine polishing after the stones are fixed in situ is not possible, shall be double polished.

1.32 BARBED WIRE (M 31):

The barbed wire shall be of galvanized steel and it shall generally conform to I.S. 278-1978. The barbed wire shall be if type-I whose nominal diameter for line wire shall be 2.5 mm. and point wire 2.24 mm. The nominal distance between two bars shall be 75 mm. unless otherwise specified in the item. The barbed wire shall be formed by twisting together two line wires, one containing the barbs. The size of the line and point wires and barb spacing shall be as specified above. The permissible deviation from the nominal diameter of the line wire and point wire shall not exceed ± 0.08 mm.

The barbs shall carry four points shall be formed by twisting two point wires each two turns, lightly round one line wire, making altogether four complete turns. The barbs shall be so finished that the four points are set and locked at right angles to each other. The barbs shall have a length of not less than 13 mm. and not more than 13 mm. and not more 18 MM. The points shall be sharp and cut at an angle not greater than 35 degree of the axis of the wire forming the barbs.

The lined and point wire shall be circular section free from scale and other defects and shall be uniformly galvanized. The line wire shall be in continuous length and shall not contain any weld other than those in the rod before it is drawn. The distance between two successive splices shall not be less than 15 meters.

The lengths per 100 Kg. of barbed wire I.S. type I shall be as under

Nominal 1000 meter Minimum 834 Meter Maximum 1066 Meter.

1.33 CEMENT MORTAR:(M32)

Water shall conform to specification M-1, Cement shall conform to specification M-2, Sand shall conform to specification M-3. Proportion of Mix: Cement and sand shall be mixed to specified proportion. Sand being measured by measuring boxes. The proportion of cement will be by volume on the basis of 50 kg. /bag of cement being equal to 0.0342 cu.m. The mortar may be hand mixed or machine mixed as directed by the Engineer-In-Charge.

Preparation of Mortar: In hand mixed mortar, cement and sand in the specified proportion shall be thoroughly mixed dry on a clean impervious platform by turning over at least 3 times or more till a homogeneous mixture of uniform colour is obtained. Mixing platform shall be so arranged that no deleterious extraneous material shall get mixed with mortar or mortar shall flow out. While mixing, the water shall be gradually added and thoroughly mixed to form a stiff plastic mass of uniform colour, so that each particle of sand shall be completely covered with a film of wet cement. The water cement ratio may be adopted as directed by the Engineer-In-Charge. The mortar so prepared shall be used within 30 minutes of adding water. Only such quantity of mortar shall be prepared as can be used within 30 minutes. The mortar remaining unused after that period or mortar which has partially hardened or damaged shall not be re-tempered or remixed. It shall be destroyed or thrown away.

CODE OF PRACTICE

GENERAL:

- (1) The method of the execution of the items shall conform to the relevant specifications as per the latest version of the Indian Standard, List of applicable Indian Standards **annexed** below, unless specified otherwise and as far as is applicable.
- (2) Wherever a reference to any Indian Standard appears in the code, it shall be taken to mean as a reference to the latest version of the Standard.
- (3) Work Tests shall invariably be got carried out by the Contractor, when the same are specified in this Code. Tests shall also have to be carried out, even though the same may not have been specifically mentioned in the Code, if in the opinion of the Engineer-In-Charge, they are required to be carried out. All the tests shall be got carried out in Government or approved laboratories and cost there of shall be entirely borne by the Contractor.

All moulds, equipments, etc. required of preparing specimens for tests shall be kept in sufficient numbers and in good state, as directed by the Engineer-In-Charge, on the site of work.

Specimen for tests shall be, sent to the Laboratory along with the representative of municipality/ consultant in time and the results thereof shall be promptly obtained and reported to the Engineer-In-Charge.

- (4) Satisfactory test results shall not absolve the Contractor, from dismantling and re-doing any work revealed to be defective at a later date. The contractor shall have no claim for any payment or compensation whatsoever on account of replacement of such defective work. Contractor shall take all precautions and care during dismantling and re-doing the work to ensure that any other work, so far executed does not get damage or affected.
- (5) The work shall be carried out in true line and level, and in conformity with the detailed drawings and specified patterns.
- (6) All work shall be carried out in a workman-like manner and as per the best techniques for the particular item.

- (7) All tools, templates, equipments etc. for correct execution of the work, as well as for checking lines, levels alignments of the works, during execution shall be kept in sufficient numbers on the site of work.
- (8) All installations pertaining to water supply and drainage lines fixtures as well as and sanitary fittings shall be deemed to be completed only after giving satisfactory test by the Contractors.
- (9) Scaffolding shall be provided by the Contractor at his own cost for such of the items for the execution of which it is essential

CODE OF PRACTICE		
List of I S (Indian Standard) For DRAINAGE WORKS		
Sr.No	IS number	Particulars of Code
1	651-1980	Code of Practice for Stone Ware Pipes and Fittings
2	4127-1983	Code of practice for laying of Stone ware pipe
3	458-2003	Code of practice for Concrete Pipe (with & without reinforcement)
4	783	Code of practice for laying of Concrete pipe
5	784-1978	Pre Stressed Concrete Pipe
6	3597- 2003	Method of test of Concrete Pipe
7	8329-2000	D.I. Pipe centrifugally cast (spun) for water, Gas Sewerage.
8	12288-1987	Laying of D I Pipe.
9	9523- 2000	D I Fittings/Specials
10	1539-&1536-1989	C I pipe Centrifugally casted (spun) iron pressure pipe for water, Gas, and Sewage.
11	3114-1985	Laying of C I pipe
12	5531-1977	C I Fittings/Specials

CODE OF PRACTICE		
List of I S (Indian Standard) For DRAINAGE WORKS		
Sr.No	IS number	Particulars of Code
13	3486-1966	C I Spigot and Sockets drain pipe
14	5455-1969	C I Steps
15	1726	C I Man Hole and Frame Cover
16	1729	Sand C I spigot and sockets soil fittings
17	780-1980	C I Sluice Valve up to 300 mm Dia.
18	2906-1980	C I Sluice Valve above 300 mm Dia.
19	14333-1996	H D P E pipe for sewerage.
20	7634 (Part-2) 1973	Laying and Jointing HDPE Pipe
21	8360 (pat 1 to 3)	HDPE fabricated fittings
22	8008 (part 1 to 7)	HDPE fitting injection molded
23	7328-1992	H D Polyethylene material for molding & extrusion
24	4985-1988	P V C Pipe
25	1239	Code of practice for G I Pipe
26	7634	Code of Practice for Plastic pipe
27	1592-2003	Code of practice for A C pressure pipe
28	12709-& 14402	G R P Pipes used for water & Sewerage
29	1592-2003	code of practice for A C pipes & Fittings.
30	6530	Code of practice for laying of A C pressure pipes
31	3589	Electrically Welded steel pipe
32	5504-1969	Spiral Welded pipe
33	5822-1986	Laying of Steel Welded pipe
34	6392-1971	Steel pipe flanges.

CODE OF PRACTICE		
List of I S (Indian Standard) For DRAINAGE WORKS		
Sr.No	IS number	Particulars of Code
35	8062	Code of practice for Cathodic protection
36	4111-1986 Part 1	Code of practice for Man Hole Chamber construction
37	4111-1986 (Part 1 to 4)	Code of practice for Ancillary Structure in Sewage system Man Hole, Invert Syphon, Flushing Tank, Pumping Station. & pumping Main.
38	12592-1991 Part 1 & 2	Precast Man Hole Frame & Cover specification
39	1538-1976 (part 1 to 10)	General Requirements.
40	3764-1966	Safety code for Excavation Works
41	5382-1985	Rubber Ceiling Ring for Water, Gas & Sewerage
42	12820-1989	Dimensional requirements for Rubber Ring Gaskets
43	4883-1988	Specification for Sewer Bricks
44	2212-1962	Code of practice for Brick works.
45	6280-. 2001	Sewerage Screen.
46	11117-1984	Requirements for High pressure Jetting Machine for Sewerage
47	11397-1985	Attachment Tools for Power Driven Roding Machine.
48	5600-1970	Sewage and Drainage Pumps.
49	6279-1971	Equipment for Grit removal device.
50	10037-1981 (part 1 to 3)	Requirements for Sludge dewatering equipment.
51	11972-1967	Code of practice for Safety precaution to be taken when entering in a Sewage system.
52	10261-1982	Requirements for settling Tank.
53	10552-1983	Buckets to be use in power driven bucket type sewage cleaning machine.

CODE OF PRACTICE		
List of I S (Indian Standard) For DRAINAGE WORKS		
Sr.No	IS number	Particulars of Code
54	10595-1983	Requirements for power driven Bucket type of sewage cleaning machine.
55	210	Specification for Grey Iron Casting
56	269	Specification for ordinary and low heat Portland Cement
57	383	Specification for Coarse and fine aggregates from natural sources for concrete
58	432	Specification for Mild Steel and Medium tensile steel bars and Hard drawn steel wire for concrete reinforcement.
59	456	Code of practice for Plain and reinforcement concrete.
60	516	Methods of tests for strength of concrete
61	554	Dimension for pipe threads where pressure tight joints are required on the threads.
62	774	Flushing Cisterns for Water closets and urinals (Valve less symphonic type)
63	775	C I brackets & Supports for wash basin and sink.
64	1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
65	1742	Code of practice for building drainage works
66	3370 (Part 1 to 5)	Code of practice for concrete structures for storage of liquids
67	269	Specification for 33 Grade ordinary Portland Cement.
68	10262	Recommended guidelines for concrete mix design.
69	12269	Specification for 53 Grade ordinary Portland cement.
70	455	Specification for Portland Slag Cement
71	12330 or 6909	Specification for Sulphate resisting Portland Cement.

CODE OF PRACTICE		
List of I S (Indian Standard) For DRAINAGE WORKS		
Sr.No	IS number	Particulars of Code
72	3696	Safety Code for scaffolds and ladder.(Part1 &2)
73	2720	Method of test for soils (Part 1 to 38)
74	8989	Safety Code for erection of concrete framed structures.
75	6587	Specification for spun hemp yarn.
76	5611-.2002	Code of practice for Waste Stabilization Ponds (Facultative Type)
77	14846	C I Air Valve.
78	226 & 800-1975	Structural Steel
79	1538 P- i to xxii	C I Fitting for pressure pipe.



Bihar Urban Infrastructure Development Corporation Limited
A Government of Bihar Undertaking

TENDER DOCUMENT FOR
FOR
SETTING UP SOLID WASTE PROCESSING FACILITY AND LANDFILL
FACILITY FOR MUZAFFARPUR & DARBHANGA MUNICIPAL
CORPORATIONS AND ITS OPERATION AND MAINTENANCE FOR
10 YEARS

VOLUME-6: Electrical Work Specification

Bihar Urban Infrastructure Development Corporation Ltd (BUIDCO)

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**Technical Specification
for
Electrical Works**

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1.0. SCOPE OF WORK:

- 1.1. The scope of services covers the design, detailed engineering, preparation of construction drawing, manufacture, acceptance testing at manufacturer's works or at any accredited agency, supply, packing, forwarding and delivery from manufacturer's works/ place of storage to erection site including transit insurance, unloading, storage at site, moving from place of storage to place of installation, assembly, Cleaning/ lubricating, Touch up painting, erection, testing, commissioning & performance demonstration and handing over along with all necessary spares of original ratings & specifications on Design & O&M and defect liability as per tender basis. Inland and overseas transit insurance, transport, testing at site shall be Contractor's scope. Tender BOQ and drawings, if provided, are for reference purpose only which is the minimum requirements; Contractor shall ensure that design & equipment ratings shall be as design and per specification requirements.
- 1.2. The Contractor shall prepare design calculations based on parameters/ design criteria indicated in the specifications. The Contractor shall prepare detailed engineering and construction purpose drawings to make his/ her own estimate of ratings & quantities (minimum requirements as per price schedule, technical data sheets & other relevant details) for entire electrical & instrumentation systems including all items/ systems such as MCC/ PMCC Panel, local push button stations, power & control cables, cable trenches, cable supports, yard lighting poles, lighting system, building internal electrification, earthing, lightning protection, main & auxiliary power distribution, street light with suitable mounting structure and LED light fittings, required no. of sockets, instruments, civil works required for completion of Works for the Sanitary Landfill Facility at Gandhinagar.
- 1.3. Contractor shall take due care of the site Seismic conditions while design of all equipment/ components used in entire electrical & instrumentation systems covered in this specification. Contractor shall furnish list of additional design parameters considered in design to fulfil above requirement.
- 1.4. Design and detailed engineering of the materials procured by Contractor is included in scope. Contractor shall submit each document/ calculations of system which is included in scope to Purchaser/ Consultant for final review/ approval. All design documents/ calculations prepared by Contractor shall be with ISO documentation i.e. with duly signed by qualified authorities and stamped. Design documents/ calculations prepared by sub-Contractors shall be approved by Contractor and stamped copy of approval along with no-deviation sheet from sub-contractor shall be submitted by the Contractor to Purchaser/ Purchaser's representative for final review/ approval. In case of revised drawing proper compliance sheet shall be furnished.
- 1.5. Expert or manufacturer supervision for sub-contractor supplied material shall be provided by Contractor and included in offer.
- 1.6. Contractor shall be solely responsible for any shortages or damages in transit for his supply scope, handling and/ or in storage of any materials and erection of the equipment, supply of erection tools at site. Contractor shall ensure that it will not affect any activity or project schedule. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor.
- 1.7. Contractor shall identify activities and mile stones of the work forecasted for next month with optimistic and realistic dates of work completion. Contractor shall prepare program evaluation and review techniques to identify critical path of project and activity sequences. The project schedule shall be prepared and updated fortnightly in MS Project.

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- 1.8. Nothing in this specification shall relieve the Contractor of his/ her responsibilities towards following best engineering practices established in the country.
- 1.9. Obtaining approval including load sanction/ release from Uttar Gujarat Vij Company Ltd. (ELECTRICITY COMPANY), No Objection Certificates from ELECTRICITY COMPANY, Electrical Inspector (CEIG), relevant Government Agencies, and Statutory Authorities, as applicable is included in Contractor's scope.
- 1.10. All necessary legal fees required for various applications to ELECTRICITY COMPANY/ Electrical Inspector (CEIG), relevant Government Agencies, Statutory Authorities shall be paid by the Purchaser upon production of valid receipts. The ELECTRICITY COMPANY deposit required to be paid for Load Release shall also be borne by the Purchaser.
- 1.11. There shall be one Electrical Room for the SWM which shall be constructed by the contractor and shall have separate connection from Electricity Company.
- 1.12. The Contractor's scope shall also include complete electrical equipment/components/system for complete scope along with electrical room, area/ street lighting (within the yard)
- 1.13. The Contractor's scope shall also include measurement of soil resistivity at site by Wenner's four electrode method as per IS: 3043 – 1987 (Reaffirmed in 2006) at minimum four locations at site. The earthing system shall be designed for the actual mean soil resistivity value obtained.
- 1.14. Even if all components of a system included in this specification are not explicitly identified and/ or listed herein, these shall be supplied under this contract to ensure completeness of the system and facilitate proper operation and easy maintenance of the plant. Any and all other works not indicated above but necessary/ required to complete the job in all aspects, are included in the Contractor's scope.
- 1.15. The Contractor shall include start up spares, essential spares, recommended spares and a set of special tools necessary for operation, routine maintenance of equipment supplied for a period of five years.
- 1.16. Whether specifically called for or not, all accessories required for normal and satisfactory operation (as deemed by the Purchaser) of the equipment shall be considered to be a part of the Contractor's basic scope of supply and/ or work and no claims whatsoever, for extra payment on these grounds, will be accepted.
- 1.17. Contractor should visit site and get himself/ herself ascertained regarding the scope of work for the complete Electrical works before submission of quote/ offer.
- 1.18. Contractor's scope shall include design, engineering, manufacture, supply, testing, commissioning and handover of following electrical equipment/ systems as per tender specifications, BOQ & other relevant details. Voltage and fault level for supply shall need to be confirmed with ELECTRICITY COMPANY by Contractor before the commencement of design.
- 1.18.1. Tariff metering equipment as applicable (as per Electricity Company requirement) & electric supply connection including necessary liaison works (Tariff metering equipment & electric supply connection shall be provided by Electricity Company for which necessary liaison shall be done by the Contractor)

- 1.18.2. Switchyard Equipment- Two/ four pole structure/ LBS (required to receive incoming 11/ 33 kV power supply from overhead line/ cable and to extend out required feeders), Bus bars, Isolators (GOD) with operating mechanism, Earth Switches, Lightning Arrestors, Incoming point of supply Breaker/ Ring Main Units outdoor type (required where installed capacity of transformer(s) exceeds 800 kVA/ or as per statutory requirement) & Drop Out Fuses (wherever applicable for transformer(s) being fed directly from incoming power supply) etc. including necessary civil works, fence & gate etc.
- 1.18.3. Outdoor type, Oil type, ONAN, Dyn11, Distribution Transformers with OCTC/ OLTC + RTCC, AVR, Marshalling box along with foundations, trenches etc.
- 1.19. Outdoor type Diesel Generators with Acoustic Enclosure and Auto Mains Failure (AMF) Panel with necessary chimney, day tank, local control panel.
- 1.19.1. 415 V LV metal enclosed switchgears including Power and Motor Control Centre (PMCC) including starter feeders, equipment (as per electrical Single Line Diagram & technical specification requirements), PDBs, Sub DBs, Lighting DBs, Receptacles for utilities. Local Start/ Stop push button stations shall be provided near those motors which are not controlled from a local console/ panel.
- 1.19.2. LV capacitor banks with control panel consisting of automatic power factor correction (APFC) relay to improve the plant power factor up to 0.99. APFC panels shall be provided on both bus sections of the PCC/ MCC.
- 1.19.3. Cabling system shall consist of various earthed grade HV and 1.1 kV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power, control & instrumentation cables, GI ladder/ perforated type Cable Trays & associated accessories including support structures.
- 1.19.4. Provision for continuous monitoring of electrical Power & Energy parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-hours etc.
- 1.19.5. Earthing for HV/ LV equipment and lightning protection system for all buildings in the works locations. The general design shall be on the basis of IS, IEC and CEA regulations and standards (their latest amendments) in line with design criteria & specification requirements.
- a) IS 3043-2018 : Code of practice for Safety Earthing
 - b) IS/ IEC 62305- 2013 : Code of Practice for the protection of buildings and allied structures against lightning.
 - c) CEA guidelines 2010 : Measures related to safety & electric supply.
- 1.19.6. Lighting system for all indoor & outdoor areas of works. The lighting system will be controlled by lighting panels installed in respective plant/ station areas, which will be fed from the main lighting DB. All light fittings shall be of LED type.
- 1.19.7. DC System:

-
- a) 24/ 30V or 110V DC in built DC power pack unit shall be provided, wherever applicable.
 - b) 24/ 30V or 110V DC Battery & Battery Charger (with inbuilt DCDB) shall also be provided, wherever applicable.
- 1.20. All necessary and supplementary items & equipment required for completeness, safe & efficient operation of the system, even though these may not have been mentioned in this specification. Spares & consumables for successful commissioning, establishment of performance guarantee and five years of trouble-free & safe operation of the plant.
- 1.21. The scope of the contractor also includes supplying and installation of basic safety items like rubber mat, gloves, fire extinguishers, fire sand bucket and sand bucket stand.
- 1.22. Submission of drawings & documentation as specified under "General Technical & Particular Requirement" section for Electrical equipment/ systems.
- 1.23. Contractor's scope shall also include all civil works and structural works required for installation of all electrical equipment/ systems such as equipment foundations, indoor & outdoor trenches, equipment support structures, two pole structures, control rooms, all excavation works including those for earthing, cabling etc, de-tanking area, soak pits, burnt oil pits, chamber etc.
- 1.24. It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Electrical system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.
- 1.25. Purchaser reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

2.0. PROJECT INFORMATION:

2.1. SITE/ ENVIRONMENTAL CONDITIONS:

- 2.1.1. Ambient temperature : 50°C
- 2.1.2. Relative Humidity : 5 - 95%
- 2.1.3. Area Classification : Non Hazardous
- 2.1.4. Seismic Data : As per IS 1893 latest issue

2.2. NOMINAL SYSTEM VOLTAGE:

- 2.2.1. Incoming supply : 11 KV, 3 ph, 3 wire, 50 Hz AC (to be confirmed with ELECTRICITY COMPANY by Contractor)
- 2.2.2. Distribution supply: 415V, 3 ph, 4 wire, 50 Hz, AC
- 2.2.3. General lighting & space heating: 240V, 1 ph, 2 wire, 50Hz, AC
- 2.2.4. Control & protection & emergency lighting: 24 V or 30 V or 110V, 2 wire DC (as applicable) for HT switchgear; 240V AC for LT equipment.
- 2.2.5. Potential transformer secondary: 110 V, 3 ph, 50 Hz, AC
- 2.2.6. Voltage variation:
 - a. 11 kV supply : $\pm 10\%$
 - b. 415 V supply : $\pm 10\%$
- 2.2.7. Frequency variation : $\pm 5\%$
- 2.2.8. Combined voltage and frequency variation : $\pm 10\%$
- 2.3. SYSTEM EARTHING:
 - 2.3.1. 11 kV, 3 ph AC system : Neutral solidly earthed
 - 2.3.2. 415 V, 3 ph, AC system : Neutral solidly earthed
 - 2.3.3. 240 V, 1 ph, AC system : Neutral solidly earthed

3.0. DESIGN CRITERIA FOR ELECTRICAL EQUIPMENT/ SYSTEMS:

3.1. GENERAL:

- 3.1.1. The design criteria, given below has to be followed by the Contractor for designing/ sizing of electrical equipment covered under Contractor's battery limits; However it is to be noted by the Contractor that, following this design criteria does not relieve the Contractor from adherence to the standards, regulatory requirements & best engineering practices.
- 3.1.2. The design concept of electrical system as a whole shall be based on providing safe, reliable & stable power and efficient performance of electrical system.
- 3.1.3. The design standards described herein are generally in compliance with the latest Indian Standards and code of practices already established in the country.
- 3.1.4. All electrical installations shall conform to the latest Central Electricity Authority Regulations 2010.
- 3.1.5. The design ambient temperature for all electrical equipment shall be 50°C.

3.2. ESTIMATION OF LOAD/ MAX DEMAND: The following considerations are to be followed to arrive at the maximum electrical demand.

3.2.1. Load Factor

a. Main motors	:	0.9
b. Auxiliary load (valve actuators, Crane/ Hoist, etc.)	:	0.7
c. Lighting load	:	1.0
d. Dewatering Pump	:	0.9
e. Ventilation System	:	0.9

3.2.2. Diversity Factor

a. Main motors	:	1.0
b. Auxiliary load (valve actuators, Crane/ Hoist, etc.)	:	1.0
c. Lighting load	:	1.0

3.2.3. Power factor of Motors : As per the Manufacture's Data sheets

3.2.4. Efficiency of Motors : As per the Manufacturer's Data sheets

3.3. TRANSFORMER SIZING/ SELECTION:

3.3.1. Criteria 1:

- a. The capacity of the transformers will be calculated based on the total simultaneous maximum demand (calculated based on the load factors and diversity given above, PF, efficiency).
- b. Additional 10% contingency shall be considered for deriving transformer sizing.

-
- c. Similarly, after consideration of 10% contingency over maximum demand (MD), sizing of the selected transformer shall be such that maximum transformer loading shall not exceed 90% (of the MD + 10% Contingency) load.

3.3.2. Criteria 2:

- a. The adequacy of transformer sizing shall also be proved on the basis of % Voltage dip observed at the motor terminal. % voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running); the % voltage dip during starting at motor terminal shall not exceed 15%.
- b. The Voltage dip and fault level calculations needs to be calculated based on following actual data collected from nearest Substation and Grid.
 - i. The fault level of HV bus from which power supply will be taken to the plant.
 - ii. Impedance of HV Overhead Line Conductor/ HV Cable interconnecting the HV bus of Substation and HV switchboards of the Plant
- c. For the per unit calculation purpose, minimum starting current for various types of starter applications shall be considered as following:
 - i. DOL Starter – 6 times the rated current.
 - ii. Star- Delta Starter – 3 times the rated current.
 - iii. Auto Transformer Starter (ATS) – 3 times the rated current.
 - iv. Soft Starter – 3 times the rated current.

3.3.3. Power factor compensation (95%) shall be considered during sizing of the transformer.

3.3.4. Wherever HT supply (above 100 kVA / as per GERC rules prevailing at that time) is envisaged, 100% stand-by shall be provided for transformers. All the associated equipment/ accessories shall be provided for Stand-by transformer as well. In normal condition, both the transformers shall feed their respective bus sections by keeping bus coupler open & in case of failure of one transformer, the other transformer shall be able to take 100% load with bus coupler in close position.

3.3.5. The Load losses and No-load losses of transformer shall be within the values given in IS 1180-2014 (Energy efficiency Level 1).

3.4. SWITCHGEAR SIZING/ SELECTION:

3.4.1. Switchgear shall be sized/ selected considering the following:

- a. Rating suitable for carrying full load current of the equipment.
- b. Suitability for Short Circuit Rating for 1 sec duration.
- c. Switchgear for motors shall be suitable for motor duty application.

-
- 3.4.2. Switchgear for all the motor feeders shall be Type-2 co-ordination.
- 3.4.3. Motor starter selection shall be done as follows:
- a. Direct On Line (DOL) Starter – For motors rated up to 5.5 kW
 - b. Star- Delta Starter - For motors rated above 5.5 kW to 15 kW
 - c. Auto Transformer Starter (ATS) - For motors rated above 15 kW to 75 kW
 - d. Soft Starter – For all low/ medium voltage motors above 75 kW rating.
 - e. In-panel de-rating of minimum 20% or as provided in Manufacturer's catalogue, whichever is higher shall be considered.
- 3.4.4. Bus Bar Sizing:
- a. The Contractor shall furnish calculations after award of contract, establishing the adequacy of the bus bar sizes to meet the continuous and short time current ratings as calculated.
 - b. The bus-bars shall be sized considering the following criteria:
 - i. Sleeves made of insulating material on all bus bars.
 - ii. Design ambient temperature 50°C.
 - iii. Final temperature of the bus-bars complying with requirements of IS 8623 & IEC 60947. Reduced temperature rise limit by 5K (for indoor panels) & 10K (for outdoor panels) to that of mentioned in IS 8623 & IEC 60947 shall be considered to satisfy the final temperature.
 - iv. Bus bars being inside the panel; De- rating for enclosure and ventilation.
 - v. Bus bar suitability for carrying rated current continuously.
 - vi. Configuration of bus bars and Proximity effect
 - vii. Bus bars shall withstand the short time rating of the panel for 1 sec duration.
- 3.5. POWER FACTOR IMPROVEMENT: APFC Panel shall be sized considering following design criteria:
- 3.5.1. Minimum 8 steps in an APFC relay shall be considered with 2 steps as spare.
- 3.5.2. Capacitor shall be All Poly Propylene (APP), double layer type.
- 3.5.3. Fixed type capacitor bank, with manual & auto switching and components as indicated in reference electrical Single Line Diagram(s) shall be provided in each Mains incomer (LV) panel for transformer no load compensation.

3.5.4. For each bus section of the Main PCC/ MCC panel, separate APFC panel- based on above design criteria to be provided. Other requirements of APFC panel & its components shall be as per requirement provided in this specification.

3.5.5. Total Capacity & Capacitor bank sizes shall be as given in Table below:

Capacity	5 kVAr	10 kVAr	15 kVAr	25 kVAr	50 kVAr	100 kVAr
* kVAr	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.	# Nos.

* = Contractor has to calculate the capacitor rating based on the system power factor (0.85 or actual, whichever is lesser - to be corrected for 0.99. Rating of APFC panel shall be based on 50% of total running load for each bus section & not on the total connected load basis. Number of stages / steps in a particular APFC panel shall be decided by the Contractor such that minimum 8 steps & maximum 16 steps shall be provided in a particular panel.

3.6. CABLE SIZING: The Contractor shall ensure that cable and wires associated with the power distribution and control systems, plant wiring and all other installations throughout the Works are adequately rated for their use.

3.6.1. The following main aspects shall also be considered while deciding the final size of the cables-

- a. Supply voltage and frequency
- b. All cables shall be selected to carry the corresponding full load current under site conditions.
- c. Route length and disposition of cables
- d. Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).
- e. Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.
- f. For Cables emerging from ACB outgoing, fault clearing time shall be considered as 0.16 second (for Tie feeders if any it shall be 0.5 second)
- g. For Cables emerging from MCCB outgoing, fault clearing time shall be considered as 0.01 second
- h. For the HT incomer cables (metering kiosk to GOD, GOD to HT switchgear/ transformer) minimum fault clearing time shall be considered as 1 sec.
- i. For cable from HT panel outgoing to transformer, fault clearing time shall be considered as 0.16 second.
- j. Cable from transformer secondary to PCC incomer, fault clearing time shall be 1sec
- k. Contractor to note that, the above fault clearing times are minimum to be considered & fault clearing time shall be considered as per actual relay co-ordination study.

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- l. Appropriate de-rating factors as per cable manufacturer's catalogue and enlisted below shall be considered for sizing the cable:
 - i. Ambient Air Temperature (minimum 50°C).
 - ii. Ambient ground temperature (minimum 40°C to be considered)
 - iii. Laid in Air / ducts/ directly in ground etc.
 - iv. Depth of cable burial (minimum 750 mm for LT and 900 mm 11kV HT)
 - v. Thermal Resistivity of Soil (minimum 150°C Cm/ W to be considered)
 - vi. No. of cables in a group-touching each other or separated by a distance
 - vii. No. of cable trays in tier
 - viii. Any other de-ration factors as applicable & as per Manufacturer's catalog.
 - m. Permissible voltage dips at the time of starting the corresponding motor/ load. Contractor to ensure adherence to the Criteria-2 mentioned above.
 - n. In running condition, cumulative voltage drop (at 100% rated load) shall not exceed 5% (measured at load end) for the LV loads.
 - o. All the HV cables shall be Earthed grade (as per system requirement), multi-stranded Al conductor, XLPE insulated, inner/ outer extruded PVC sheath ST2, galvanized steel flat strip armoured cables.
 - p. The cables shall be 1.1 kV grade, multi-stranded Copper/ Al conductor, XLPE insulated, colour coded, inner and outer extruded PVC sheathed, galvanized steel round wire/ flat strip armoured cables.
 - q. Cables up to & including 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.
 - r. Single core cable shall have non magnetic material armouring.
 - s. Control cables shall be Cu multi-stranded conductor with galvanized steel round wire/ flat strip armoured. For cables above 7 cores, minimum two spare cores shall be considered.
- 3.7. ILLUMINATION SYSTEM: Illumination for various indoor & outdoor areas shall be conforming to the requirements mentioned below:
- 3.7.1. All Light fixtures shall be LED type only.
 - 3.7.2. The illumination levels to be considered for the design of lighting system for various areas shall be as following. These are the illumination levels achieved at Work plane. Work plane height shall be considered as 0.76 m from FGL.

Area	Illumination Level (Lux) - Average values	Type of Light Fixtures
Switchgear rooms	300 Lux	36W LED Tube Light Fitting
Roads	15 Lux	48W-60W LED Street Light Fitting
Toilets	100 Lux	12W-14W LED Tube Light Fitting
Parking Area	50 Lux	48W-60W LED Street Light Fittings
Outdoor plant areas	20 Lux	48W-60W LED Flood Light Fittings
Switchyard & Transformer Area		
- General	10 Lux	48W-60W LED Flood Light Fittings
- On Equipment	30 Lux	48W-60W LED Flood Light Fittings

- 3.7.3. Critical lighting shall be designed such that at all junctions, exit passages & strategic locations the Lux level shall be maintained above 15 Lux. Installite fixtures with built in battery backup shall be considered for electric room.
- 3.7.4. Lighting design shall be performed using latest version of DiaLux Software/ Original Equipment Manufacturer (OEM) validated software. The Validation Report along with software and data files shall be acceptable to Purchaser/ Purchaser's representative.
- 3.7.5. For street lighting proper mounting arrangement shall be considered to achieve desired lux level. Number of feeder pillars shall be decided in such a way that the voltage drop at the furthest luminaire shall not be above 5%.
- 3.7.6. Various design factors shall be considered as following:
- a) Maintenance Factor:
 - i) Outdoor area : 0.6 (0.7 for LED)
 - ii) Indoor areas : 0.7 (0.8 for LED)
 - b) Reflectance Factors (Indoor):
 - i) Wall : 30%
 - ii) Ceiling : 10%
 - iii) Floor : 30%
 - c) Uniformity (Min. / Avg.) : 50% Minimum for indoor and 30% for outdoor

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- d) Color Temperature of the lamp shall be:
- i. Indoor Areas : 6500K Minimum
 - ii. Outdoor Areas 5400K Preferably, but 4000K(minimum)

3.8. EARTHING & LIGHTNING PROTECTION SYSTEM:

3.8.1. The safety earthing and lightning protection system will be generally on the basis of following codes and standards (including their latest editions).

- a. IS 3043 -1987 (Reaffirmed in 2006): Code of practice for Safety Earthing.
- b. IEEE 80 - 2000.
- c. IS/IEC-62305, 2013: Code of Practice for the protection of buildings and allied structures against lightning.
- d. CEA Regulations - 2010: Measures related to safety & electric supply.

3.8.2. The fault levels considered shall be as follows:

System	Fault level in kA
a) 11kV System	26.4 kA for 1 sec
b) 415V System	As per utility.

(*) Contractor to design on the basis of actual impedance & adequacy calculations for sufficiency of earth conductor size shall be provided.

3.8.3. Following factors shall be considered for sizing the earthing conductor:

- a) Design Ambient Temperature : 50°C
- b) Allowable temperature rise for steel welded joints : 500°C
- c) Fault clearing time : 1 Second
- d) Overall earthing resistance : ≤ 1 Ohms

3.8.4. Measurement of soil resistivity shall be done using Wenner's 4 electrode method as described in IS 3043 -1987 (Reaffirmed in 2006) including its latest amendment.

3.8.5. The soil resistivity of the plant area has not yet been measured; the same should be carried out during detailed engineering by successful Contractor. Test reports shall be certified by Govt. Authorised Laboratory/ Institutes/ Agencies.

- 3.8.6. After soil resistivity measurement; length of conductor, no. of earth electrodes and no. of test pits shall be finalized based on these design criteria & the requirements specified in earthing requirements.
- 3.9. DRAWINGS/ DOCUMENTS FOR REFERENCE:
- 3.9.1. The BOQ form part of this specification and should be used for reference purpose only.
- 3.9.2. The equipment/ switchgear component ratings & requirements shown in the reference BOQ are minimum requirements & after award of contract, Contractor has to get approval for the equipment selection with the approval for sufficiency calculations.
- 4.0. GENERAL TECHNICAL & PARTICULAR REQUIREMENTS FOR ELECTRICAL, EQUIPMENT/ SYSTEMS:**

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4.1. SWITCHYARD EQUIPMENT:

The design, material, construction, manufacture and testing of HV two/ four pole structures shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards.

Two/ four pole structures shall conform to the latest applicable standards specified as under. In case of conflict between the standards and this specification, this specification shall govern.

Two/ four pole structures shall be erected in switchyard to receive HV power supply from power supply authority.

Each two/ four pole structure shall be inclusive of items listed below.

4.1.1. Structure:

- a) A two/ four pole structure shall be of a rolled steel joist of minimum ISMB 150 (150mm x 75mm) for 6 meter pole/ ISMB 175 (175 mm x 90 mm) for 9/ 11meter pole with 400 mm x 400 mm x 8 mm thick base plate welded at bottom end of all the poles of structure.
- b) Mild steel cross members of minimum ISMC 100 mm x 50 mm x 6 mm size channels of 3.5 mtr in length, 8 Nos. shall be provided with cross bracing angles of minimum ISA 50 mm x 50 mm x 6 mm size of 4.5 meter in length.
- c) Side clamps, stay clamps, cleats etc. shall be fabricated from minimum 50 mm x 6 mm size MS flats as per actual requirements. All bolts, nuts, washers, etc. shall be of minimum 15 mm size.
- d) All the members of two/ four pole structure should be galvanized.
- e) Excavation of pits even in hard soil shall be done up to a depth of about 1/ 6 the length of pole and refilling the same after erection of structure and concreting work. Compacting the bottom of pits, providing cement concrete to suit at bottom and side of poles up to at-least 150 mm above FGL curing and making it hard as per requirement.
- f) Erection of RSJ poles and fixing of all structural members as per requirement shall be in line, level and properly facing the incoming and outgoing lines. Cross members shall be firmly tightened.
- g) All members shall be fabricated to suit mounting/ fixing of Gang Operated Disconnectors/ Isolators, Lightning Arrestors, Pin/ Post insulators, cable end termination Kit/ Box etc.
- h) All MS parts shall be painted with two coats of red oxide and two coats of aluminum paints.
- i) Earthing terminals shall be provided by welding 15 mm size bolts or cleats of 50 mm x 6 mm size MS flat shall be welded in each joist with a hole of 15 mm size and galvanized nuts, bolts, washers shall be provided as earthing terminals.

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- j) Necessary hardware including stay wire and its accessories as required for completeness shall be supplied and erected.
 - k) All drawings/ documents such as GA drawing of two/ four pole structure showing all equipment mounted on the structure, technical particulars & Bill of Material etc shall be prepared and submitted to Purchaser/ Purchaser's representative for approval. Obtaining the approval from CEIG/ IMPD (GOG) and getting power released from supply authority are also included in the scope of work.

4.1.2. Gang operated offload disconnectors (GOD) with earth switch:

- a) The double break type isolator (GOD) shall be manually operated and suitable for the specified site conditions and shall be able to-
 - i. Carry rated current without excessive temperature rise.
 - ii. Withstand the short circuit forces developed during fault.
 - iii. Carry the inrush current of the transformer.
 - iv. Interrupt small inductive and capacitive currents.
- b) The operating rod shall be extended up to the operating level and shall have a handle with 'lock and key' arrangement. The operating handle shall be at a level of 1.0 meter from finished ground level.
- c) The operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided if necessary at appropriate height above ground level. Necessary accessories viz. brackets, angles, guides, guide bearings for attaching the operating mechanism and operating handles to the structure and part of the isolator, rust proof pins, ball or roller type bearings shall be provided and installed. All bearings shall be protected by means of covers and grease retainers. Bearings pressure shall be kept low to ensure long life and ease of operation.
- d) The operating mechanism design shall be such that, as soon as the moving blades reach the sparking distance during operation of isolator, springs shall take over to give a quick snap action closing so that the isolator closing is independent of manual effort. Similarly the springs must assist during opening operation to give quick breaking feature.
- e) All copper parts shall be Silver or Tin plated. All ferrous parts shall be hot dip galvanized to assure long protection against tropicalised weather.
- f) The contacts shall be of silver faced copper ensuring sufficient contact pressure. The male and female contacts shall be of self aligning type to ensure trouble free operation during opening and closing of isolator. Mild steel arcing horn capable of breaking the magnetizing current shall be provided. Earth mesh below GOD to be provided

4.1.3. Isolator Interlock:

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- a) Electrical interlock arrangement shall be provided among double break isolator (GOD) and respective 11 KV indoor type breakers.
 - b) Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.
 - c) Mechanical interlock between isolator & Earth switch shall be provided.

4.1.4. Insulators:

- a) Insulator shall be properly glazed with smooth surface without cracks etc. and dielectric property shall be properly co-ordinated with isolator voltage class. Porcelain used for the manufacturer of insulator shall be uniform, brown color, free from blisters, burns and other similar defects. Insulators of the same rating and type shall be interchangeable.
- b) Porcelain and metal parts shall be assembled in such a manner that any thermal expansion differential between the metal and porcelain parts throughout the range of the temperature variation shall not loosen the parts or create undue internal stresses which may affect the electrical or mechanical strength and rigidity. Each cap and base shall be of high grade cast steel or malleable steel casting and they shall be machine faced and smoothly galvanized. The cap and base of the insulators shall be interchangeable with each other.

4.1.5. ACSR Conductor:

- a) Aluminum conductor steel reinforced shall be hard drawn from 99.5% pure electrolytic aluminum rods. The Contractor shall specify the conductivity.
- b) Chemical composition of the material shall comply with the requirements of relevant standards.
- c) The surface of conductor shall be clean and dry and free from any excess grease that may be used in its fabrication. The surface strands shall be smooth and free from burrs and other projections which may be a cause for increasing corona losses.
- d) The Contractor shall provide necessary treatment for the bus conductor to make it free from corrosion.
- e) The steel wire strand of conductor and steel conductor shall be hot dip galvanized. Zinc coating shall be evenly and uniformly for heavily coated wires.
- f) The steel core and inner layer of aluminum wires where more than one aluminum layer exist shall be protected with special grease in order to provide additional protection against corrosion due to salinity. The grease shall fill the whole space between wires within circumscribed cylinder at inner aluminum layer or at steel core if the conductor has only one aluminum layer.

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- g) The grease shall be chemically neutral with respect to aluminum, zinc and steel. It shall withstand weather conditions given elsewhere and temperature of 85 degree centigrade without alternation of its properties.
 - h) Bare conductor shall be covered in Alkathene pipes of suitable insulation to avoid accidental contact.

4.1.6. Drop Out (DO) Fuse Unit:

- a) Drop Out Fuse shall be of approved make suitable for 11 kV supply and shall be mounted on two pole structure complete with 3 fuse elements of required ampere suitable for continuous current rating and shall offer protection against fault level of suitable ampere at 11 kV.
- b) The fuse link shall consists of iron channel base to stack insulators per phase, fuse carrier Bakelite tube, heavy duty non-ferrous metal parts and spring loaded phosphor bronze contacts.
- c) The insulator shall comply with impulse voltage in accordance with relevant IS.

4.1.7. Station Class Lightening Arrestors:

- a) The design, material, construction, manufacture, inspection and testing of lightning arresters shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- b) In case of conflict between the standards and this specification, this specification shall govern.
- c) The equipment covered in this specification shall conform to the latest edition of the following standards.

IS: 3070 (Part-3)	Lightning arresters for AC system – Specification (Metal Oxide Lightning Arrester without Gaps)
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IEC: 60099-4	Metal Oxide surge arresters without gaps for AC system
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d) Constructional Features:

- i. Lightning arrester shall be station class heavy duty and non- linear resistance type. The elements shall be in hollow cylindrical form, stacked together. Lightning arrestor shall be of class II, having non – linear voltage – current characteristic and having high discharge capability.
- ii. The entire arrester unit shall be housed in a porcelain insulating casing of high strength, made from brown glazed wet process porcelain, with metallic cover plates and terminal assemblies. The end castings shall be hermetically sealed and leak tested to protect the unit from moisture or breathing.

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- iii. Pressure relief diaphragm, vent pipe, etc. shall be provided on the LA for the escape of gases formed. In the event of failure of L.A., the pressure relief directional aperture should be directed away from adjacent apparatus to prevent damage, due to arc transfer.
 - iv. All hardware such as clamps, screws, bolts, nuts, washers etc. shall be electro galvanized.
- e) Insulators:
- i. The porcelain insulators used shall be made from wet process, and shall be homogenous, free from lamination, cavities and other flaws, which may impair its mechanical or dielectric strength. They shall be thoroughly vitrified, tough and impervious to moisture.
 - ii. The glazing of porcelain shall be uniform brown colour, free from blisters, burns, cracks and other defects. The glazing shall cover all the porcelain part of the insulators except that area which serves as support during glazing or are unglazed for the purpose of assembly.
 - iii. The minimum creepage distance shall be as stipulated in data sheets. The petticoats shall be spaced for natural cleaning action by wind and rain and avoid concentrated hot spots where local stress can precipitate flashover.
 - iv. All live metallic parts shall be suitably painted. All joints shall be fluid – tight and air tight. The design of insulators shall be such, as to produce uniform compression pressure joints.
 - v. All insulators of identical rating shall be interchangeable.
 - vi. Each bushing shall be provided with aluminium/ bimetallic terminal connectors suitable for inter – connection with aluminium tubular Bus bars or ACSR conductor as specified in data sheet.
- f) Accessories: Each lightning arrester shall be furnished complete with the accessories as listed below:
- i. Anti – contamination and pressure relief diaphragm complete with vent pipe.
 - ii. Two (2) grounding pads.
 - iii. Base plate suitable for mounting on G.I. / steel structure or concrete structure.
 - iv. Line side terminal suitable for specified conductor.
 - v. Other standard accessories which are not specifically mentioned but are usually provided with lightning arrester of similar type and rating for efficient and trouble free operation.
 - vi. Name plates fixed on lightning arresters giving full technical details.
 - vii. The clamps and connectors on arrester terminals for connection to Purchaser's line conductor and the connection between incoming transmission line and LA will be in the Contractors scope.
- g) Drawings/ documents to be furnished for Purchaser's approval:

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- i. Technical Particulars
 - ii. GA drawing of LA indicating weight and overall dimensions
 - iii. GA drawing of insulating base, discharge counter, terminal assembly
 - iv. Bill of Material
 - v. Mounting arrangement (base plate details) on the structure
 - vi. QAP for Lightning Arrester

4.1.8. Chain Link Fencing and Gravel Filling:

- a) The work of erecting chain link fencing includes excavation, brick wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure and white washing the walls. All materials, hard wares, labours etc. are in the scope of contractor.
- b) Fencing height shall be minimum 2.0 meter & shall be complying with CEA guide lines requirements.
- c) Gate for entry in the fenced compound shall be fabricated from pipes of heavy duty class. Design of gate shall be got approved from the engineer in charge before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self supporting type.

4.2. DISTRIBUTION TRANSFORMERS:

- 4.2.1. Applicable Standards: Transformer shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards and codes of practice specified as under. In case of conflict between the applicable reference standards and this specification, this specification shall govern.

former	IS 1180-2014, IS 2026, BS 171, IEC76, CBIP Pub No. 317
Fittings & Accessories	IS 3639
Climate proofing	IS 3202 BS-CP-1014 IEC 354
Loading of oil immersed	IS 6600 BS-CP-1010 IEC 296
Oil	IS 335 BS-148 IEC 137
Bushing for > 1000 V, AC	IS 2099 BS-223 IEC 144
Bushing for < 1000 V, AC	IS 7421 BS-223 IEC 144
Degree of protection	IS 13947 IEC 76
Tests	IS 2026 BS-171 IEC 76
Tolerance on guaranteed Particulars	IS 2026
Buchhloz relay	IS 3637
Electrical insulation classified by thermal Stability	IS 1271 BS 2727 IEC 85

Auxiliary Transformer	IS 1180
Code of practice for selection, Installation & maintenance of transformer	IS 10028

- 4.2.2. This specification is for complete design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, storage at site, shifting from the place of storage to place of installation, installation, testing and commissioning for two winding, three phase, 50 Hz, outdoor type, distribution transformer of * kVA, 11/0.433kV, ONAN cooled, connected in Dyn11 with OCTC/ OLTC on HV winding as per ELECTRICITY COMPANY requirements & other accessories as specified.

(*Transformer rating shall be finalized based on the transformer design criteria, specified in this specifications)

% Impedance shall be as per IS 1180-2014/ IS 2026: 1977 – (Part-1).

- 4.2.3. The values of Load- losses and No-load losses shall be as given in IS 1180-2014.
- 4.2.4. The Purchaser reserves the right to reject the transformer if the same does not meet the specification requirement as follows:
- No load loss exceeds the guaranteed value by 20% or more.
 - Load loss exceeds the guaranteed value by 20% or more.
 - Impedance value differs the guaranteed value by +10% or more (zero negative tolerance)
 - Oil or winding temperature rise exceeds the specified value by 5 deg C
 - Transformer fails on impulse test.
 - Transformer fails on power frequency voltage withstand test.
 - Transformer is proved to have been manufactured not in accordance with the agreed specification
- 4.2.5. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.
- 4.2.6. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Purchaser/ Client 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
- 4.2.7. Transformer Protections: The following protections shall be provided for a distribution transformer:

Over-current protection – Instant (50/ 51)	Trip (Relay In HT Panel)
Earth fault protection – Instant (50N)	Trip (Relay In HT Panel)
Oil temperature indicator (OTI - 490)	Alarm + Trip
Magnetic Oil level gauge (MOG)	Alarm
Oil Surge Relay (OSR) [For transformers with OLTC]	Trip – For OLTC

- 4.2.8. In case of 11kV Cable feeder, an air insulated cable box with air insulated disconnecting chamber shall be provided on 11 kV side of transformer.
- 4.2.9. For the pole mounted transformers (i.e. transformers \leq 100 kVA, 11/ 0.433 kV rating), suitable orientation of HV porcelain bushings shall be ensured for direct termination of ACSR conductor from 11 kV Double Pole Structure.
- 4.2.10. For transformers above 100 kVA rating, elevated foundation/ plinth of suitable height shall be provided.
- 4.2.11. All the Civil works such as, transformer foundation, Oil Soak Pit, Burnt oil pit as per CEA guidelines & IS 10028 requirements shall be considered in Contractor's scope.
- 4.2.12. Ambient temperature of 50°C shall be considered for transformer design. Temperature rise shall be 40°C for Oil temperature and 45°C for winding temperature. Hot spot temperature limits shall be complying with IS 2026, IS 6600 & IEC 60076-2:1993 & it shall be limited to 98 Deg. C.
- 4.2.13. The limits of hot spot temperature mentioned above will have to be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding 1.1 times the total losses at 75°C at highest current tap.
- 4.2.14. Neutral of LV winding shall be 50% rated.
- 4.2.15. Suitable dial type instruments/indicator with alarm and trip contacts shall be provided for monitoring of following parameters for the transformer. The settings shall be site adjustable.

Oil Temperature indicator (OTI)	1 No local + 1 No remote
Magnetic oil level gauge (MOG)	1 No local

- 4.2.16. The bushing CT required in neutral connection for back up earth fault protection shall be provided before bifurcation of neutral.
- 4.2.17. Accessories listed below shall be provided for the transformer as per IS standards unless noted otherwise.
- a) Anti-earthquake clamping device
 - b) Marshalling Box

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- c) All interconnection cables, cable accessories for connection between the transformer marshalling box & other devices mounted on the transformer and inter-connection cables for all the associated equipment/ panels including cable termination accessories such as glands, lugs etc.
 - d) Foundation bolts & hardware, mounting channel & support structures for marshalling boxes, junction boxes etc.
 - e) All MS components including steel bolts & nuts shall be hot dip galvanized.
 - f) Automatic self-resetting type pressure relief device with trip contacts wired up to marshalling box.
 - g) Additional neutral bushing.
 - h) Conservator with lifting lugs (for transformers 50 KVA and above with rated voltage up to 11 kV, and all rating above 11kV with oil filling hole with cap and a drain plug.) Conservator shall be complete with plug, sample and drain valve and a shut-off valve on the pipe connection between the transformer tank and conservator to permit removal of the conservator
 - i) Bushing Terminals or cable boxes complete with connectors for the Purchaser's external conductors or cable.
 - j) Neutral bushing terminal complete with connector for earth conductor.
 - k) Four plain rollers in place of fixing channels. The rollers shall be bidirectional, with suitable corrosion-free bearings, suitable for 90 degree rotation & lockable in both directions and of the detachable type.
 - l) Rating and terminal marking plates
 - m) Two earthing terminals for body earthing
 - n) Drain cum sampling valve with plug or cover plate.
 - o) Dehydrating Silica Gel Breather equipped with a silica gel dehydration capsule and oil seal to eliminate constant contact with the atmosphere.
 - p) Thermometer pocket with mercury in glass bulb thermometer.
 - q) Radiator with air release plug, lifting lug, drain valve and with shut off valves.
 - r) Conservator with lifting lugs, oil filling cap & drain plug.
 - s) Prismatic oil level gauge (on conservator) with minimum level marking.
 - t) Jacking Lugs (Transformers weighing above 3000 Kg)

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- u) Filter Valves
 - v) Explosion vent with diaphragm/ pressure relief valve (for transformers 50 KVA and above). The device shall be rain-proof after operation.
 - w) Base channels for fixing on a platform or plinth
 - x) Lifting lugs for top cover & active part.
 - y) Lifting lugs for lifting complete transformer with oil.
 - z) Lifting lugs for lifting core & coils.
 - aa) Pocket for O.T.I
 - bb) Neutral C.T with terminal box.
 - cc) Earthing bar with insulator support.
 - dd) All indicating lamps shall be multichip LED Type.
 - ee) Dial type thermometer (150 mm Dia.) with two contacts for oil temperature 'high' and 'very high' alarms. Each contact shall be electrically independent and brought out to separate terminals, rated 220 V.D.C; minimum 0.5A.
 - ff) Magnetic oil level gauge (150 mm dia. 240 degree scale) with low oil level alarm contact for transformers fitted with conservator. Contact rating suitable for 220V D.C., minimum 0.5A.
 - gg) Gas actuated Buchholz relay, double float type with a valve between the relay and the conservator.
 - hh) Gas sampling device at an accessible height and an air release cock for Buchholz relay.
 - ii) Winding temperature indicator, consisting of:
 - i. Temperature sensing element. Separate PT100 for digital signal shall be provided as temperature sensor
 - i. Turret mounted CT.
 - ii. Local Winding temperature indicating instrument (150mm Dia.) with electrically independent contact(potential free contact) brought out to separate terminals for winding temperature 'high' and 'too high' alarms. Contacts shall be suitable for 220V DC, rated minimum 0.5A.
 - jj) All digital outputs for control / remote annunciation shall be provided with at least two change-over contacts for alarm & two change-over contacts for trip conditions. Auxiliary relays, if required, to provide change-over contacts suitable for Purchaser's equipment are deemed to be included in the Contractor's scope.

kk) Valves: Valves shall be of Gun Metal material & of suitable diameter for their intended purpose. Following valves shall be provided for each oil immersed transformer.

- i. One (1) top filter valve with blanking plate.
- ii. One (1) bottom filter valve with blanking plate
- iii. One (1) bottom sampling valve with blanking plate
- iv. Two (2) Shut-Off / Gate Valve for OLTC Part of Conservator (on both sides of Oil Surge relay)
- v. Two (2) Shut-Off / Gate Valve for Main Conservator (on both sides of Buchholz relay)
- vi. One (1) Drain valve with blanking plate for Conservator
- vii. One (1) bottom drain valve with blanking plate for complete Transformer
- viii. One (1) top sampling valve with blanking plate
- ix. Radiator shut off valves with blanking plates between radiator head & tank.
- x. Oil filling valve with blanking plate for Main & OLTC conservator.

4.2.18. General Constructional Features of Transformer: All material used shall be of best quality and of the class, most suitable for working-under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. The transformer construction shall be suitable for Seismic Data (As per latest edition of IS 1893) or elsewhere in the specification.

a) Tanks:

- i. The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of a glossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.
- ii. Steel bolts and nuts exposed to the atmosphere shall be galvanized.
- iii. Vacuum & Pressure Tests-Variou Vacuum & Pressure Tests for tank, conservator, radiator, pipes etc. shall be as per mentioned in the CBIP Manual on Transformer – Publication no. 317: 2013 & latest edition thereof.
- iv. The material used for gaskets shall be cork neoprene or approved equivalent.

b) Core:

- i. The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain oriented silicon steel laminations and shall be of 'core' type.
- ii. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstands BIL & Lightning Impulse Voltage
- iii. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.
- iv. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated.

c) Windings:

- i. Windings shall be of electrolytic grade Copper of 99.9% purity unless specifically approved by the PURCHASER.
- ii. Windings shall be of insulated Copper wire or Copper strip.
- iii. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.
- iv. Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.
- v. The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.
- vi. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
- vii. Materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil, and shall not soften or be otherwise affected under the operating conditions.
- viii. Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuations of air and moisture and impregnation by oil.
- ix. Permanent current carrying joints in the windings and leads shall be welded or brazed. 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. Steel bolts, if used, shall be suitably treated.
- x. Terminals of all windings, and if stated also of stabilizing windings, shall be Brought out of the tank through bushings for external connections.
- xi. Windings shall be of copper and the conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.
- xii. The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
- xiii. Transformer shall operate without injurious heating at the rated KVA and at any voltage up to $\pm 10\%$ of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstands capability.

d) Internal Earthing: The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by Copper strap connection to the tank.

e) Terminations:

- i. Transformers shall be fitted either with bushing insulators or with air insulated cable boxes / air insulated cable box with disconnecting chamber, as per requirement based on transformer HV incomer.

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- f) The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. Bushings:
- i. Bushings shall be designed and tested to comply with the applicable standards specified in the specifications.
 - ii. Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
 - iii. Fittings made of steel or malleable iron shall be galvanized.
 - iv. Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the specified conductor/ cable.
- g) Bushing Current Transformers:
- i. Whenever applicable, bushing shall be supplied with current transformers.
 - ii. Secondary leads, including tappings, shall be brought to a weatherproof terminal box near the bushing.
 - iii. Bushing C.T. nameplate shall be mounted on the tank adjacent to the terminal box.
- h) Cable Boxes and Disconnecting Chamber:
- i. The cable boxes, wherever required as per the prescribed criteria, shall be complete with cable joint fittings or sealing ends as required, tinned copper lugs to suit specified cable, compound and all other accessories including compression type glands, armour earth clamps and body earth terminal.
 - ii. For Cable type of terminations, disconnecting chamber shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank. The disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors/ links and removable covers.
 - iii. Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required, including stress/ cones or other approved means for grading voltage stress on the terminal insulation of cables operating at voltages of 22 kV and above.
 - iv. Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or cable to be subjected separately to HV tests.
- i) Marshalling Box:
- i. Whenever fittings such as OTI/ WTI, temperature indicators with auxiliary contacts, Buchholz relay, bushing CTs etc. are provided the marshalling box shall be provided to marshal in it all the contacts/ terminals of electrical devices mounted on the transformer.
 - ii. It shall be in the Contractor's scope to provide interconnection cabling between the marshalling box and the accessory devices by either PVC insulated, FRLS wires in GI conduits and/ or XLPE insulated, inner & outer extruded PVC, armoured cable and necessary compression type brass cable glands at the marshalling box for the above mentioned cables as well as for terminating the incoming cables from remote panels.

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- iii. The marshalling box shall be tank mounted (at easily accessible location), outdoor type, IP 55 protected, weather-proof, sheet-steel (2 mm thick) enclosed, with hinged door having padlocking facility and painted as per paint shade approved by the Purchaser. All doors, covers and plates shall be fitted with Neoprene gaskets. Bottom shall be at least 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped.
 - iv. The marshalling box shall be provided with glass window so as to make the WTI and the OTI dials visible from the outside without opening the door.
 - v. All contacts for alarm, trip and indication circuits shall each be potential free, wired for auxiliary DC supply as specified and brought out to separate terminals at the terminal blocks in the marshalling-box. Terminals shall be rated for 10A. Wiring shall be 1.1 kV grade, with multi-stranded, copper conductors of sizes not smaller than 1.5 sq.mm for control and 2.5 sq. mm for CT circuits. CT terminals shall be provided with shorting facility and earthing.
 - vi. The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial), the oil temperature indicator (OTI, 150 mm dial), terminal block, 60W anti-condensation heater, 5/15A industrial type five pin socket and a 10W CFL with fixture, suitable for operating on 240 V AC. Contacts of Buchholz relay, WTI, OTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.
- j) Noise level of transformers shall be as per latest NEMA standard.
- k) Oil - Transformers shall be supplied complete with transformer oil. Transformer oil shall be as per IS-335:1993, BS 148 or IEC 296. 10% extra oil shall be supplied with transformer in non returnable drums.

4.2.19. Maintenance Requirements For Transformers & Associated Equipment:

- a) The construction of the transformer & location of the accessories like CTs, lower ends of bushings, terminals, tap-changers etc., shall be such as to afford easy access & permit replacement of auxiliaries without removing the tank cover.
- b) Instruments & wiring in the local marshalling box (cabinet) shall be completely accessible & sufficient working space shall be made available in the cabinet. Instruments, wiring & accessories in the cabinet shall be accessible from the front & the rear as well.
- c) The rating plate of the transformer shall be supplied as per latest version of IS: 2026.
- d) Transformer shall be capable of being used with any make of transformer oil complying with IS: 335.
- e) As far as practicable, transformer & accessories shall be so designed that no special tools are necessary for installation & maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with transformer.

4.2.20. Performance Tests:

- a) In addition to the routine tests specified in the latest edition of IS: 2026, tests listed out shall be carried out on the transformer and these shall be included in the quoted prices.
- b) The tests shall be carried out in the presence of the Purchaser/ Purchaser's representative. The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works
 - i. Measurement of resistance of windings at principal and extreme taps.
 - ii. Ratio at each tap, polarity and phase relationships
 - iii. Measurement of impedance voltage at principal and extreme taps
 - iv. Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110% rated voltage
 - v. Measurement of efficiency at $\frac{1}{2}$, $\frac{3}{4}$ and full load
 - vi. Measurement of insulation resistance
 - vii. Induced over voltage withstand test
 - viii. Separate source voltage withstand test
 - ix. Magnetic balance test
 - x. Vacuum & Pressure Test for the tank.
- c) In addition to the above tests, lightning impulse withstand test shall be carried out on one limb of HV winding of the transformer if impulse test has not been already carried out on transformer of similar or higher capacity in the last five years. Similarly heat run test shall also be carried out if the same has not been already carried out on transformer of similar or higher capacity in the last five years. Type test certificate shall be submitted along with the bid. if such a test has not been already carried out then same has to be carried out & witnessed by third party (such as CPRI) at the Contractor's expense without any cost and time implication to Purchaser.
- d) 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.
- e) If the transformer fails to pass the tests specified, the Client shall have the option to reject the unit. 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.

4.2.21. Drawings/ Documents Required: Contractor shall submit the following drawings/ documents for Purchaser's approval:

- a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, crane lift for untanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc

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- b) Rating, diagram and terminal marking plates, complete with polarity and vector group
 - c) Foundation drawing with position of foundation bolts and depth. In case of Soak pit/ Burnt oil pit requirements, the same shall also be included.
 - d) General arrangement of HV cable box with air insulated disconnecting chamber.
 - e) General arrangement of LV Cable Box or Bus Duct arrangement.
 - f) General arrangement of marshalling box & wiring diagram.
 - g) General arrangement of OLTC/ RTCC & wiring diagram
 - h) GTP for Transformer

4.2.22. Off Circuit Tap Changing Mechanism (OCTC) for Transformer ≤ 1000 KVA: OCTC shall be with + 5% to –10% taps in steps of 2.5 % on HV winding of transformer; It shall comprise:

- a) Operating handle or wheel, accessible from ground level. Tap changer operating switch mounted on the top of the transformer tanks will not be acceptable
- b) Tap position indicator.
- c) Pad locking arrangement without interfering with visual tap position indicator shall be provided.
- d) The tap-changer connections and contacts shall be accessible through an excess hole having a bolted cover with gasket.

4.2.23. On load Tap Changing Mechanism (OLTC) for Transformer ≥ 1000 KVA: OLTC shall be with + 5% to –15% taps in steps of 2.5 % or as per IS 1180 2014, on HV winding of transformer; It shall have following technical features:

- a) The OLTC gear shall be designed to complete successfully tap changes for current equal to 120% of current at minimum tap position of the transformer. Also, OLTC over loading capability shall be compatible with that of transformer specified in IS/IEC specification “Guide for loading of oil immersed transformers”. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
- b) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

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- c) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with the oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- d) Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments shall pass through the oil surge relay before entering the conservator.
- e) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.
- f) OLTC driving mechanism and its associated control equipment shall be mounted in an outdoor, weather proof cabinet conforming to degree of enclosure protection IP55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include:
- i. Driving motor (415 V, 3 phase, 50 Hz, AC squirrel cage)
 - ii. Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs.
 - iii. Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa will be provided in transformer marshalling box and one no. outgoing feeder extending to OLTC Driving Motor cabinet, with appropriate provision for receiving the same.
 - iv. Control switch: Raise/ off/ lower (spring return to normal type) or independent push buttons.
 - v. Emergency 'OFF' push button (maintained type).
 - vi. Remote/ local selector switch (maintained contact type).
 - vii. Mechanical tap position indicator.
 - viii. Limit switches to prevent motor over-travel in either direction or final mechanical stops.
 - ix. Appropriate scheme/ device to permit only one tap change at a time on manual operation.
 - x. Emergency manual operating device (hand crank or hand wheel).
 - xi. A five digit operation counter.
 - xii. Space heaters with thermostat and MCB.
 - xiii. Control transformers with MPCB/ MCBs on primary and secondary sides for each supply.
 - xiv. Interior lighting fixture with lamp, door switch/ ON-OFF switch and MCB.
 - xv. Hinged door with gasket with locking arrangement.
 - xvi. Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
 - xvii. Necessary relays, contactors, current transformers etc.
 - xviii. Transducers or any other appropriate device for remote tap position indication.
- g) Control Requirements for OLTC: The following electrical control features shall be provided:

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- i. Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
 - ii. Only one tap change from each taps change command even if the command is maintained.
 - iii. Cut-off of electrical control when manual operation is resorted to.
 - iv. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
 - v. Cut-off of electrical control when it tends to operate the tap beyond its extreme position.
 - h) Remote Control Equipment: The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following:
 - i. Control switches; Raise/ Off/ Lower (spring return to normal type) or independent push buttons.
 - ii. If automatic operation is specified, auto / manual selector switch (maintained contact type) and other items as listed.
 - iii. If parallel operation is specified, master / independent / follower selector switch (maintained contact type) with 'out of step' annunciation.
 - iv. Tap position indicator.
 - v. Facia type alarm annunciators with "accept", "lamp test" facilities and hooter / buzzer for alarms as listed.
 - vi. Necessary auxiliary relays.
 - vii. Lamp indications for:
 - ☐ Tap change in progress
 - ☐ Lower limit reached
 - ☐ Upper limit reached
 - ☐ Transformer cooler control apparatus (if applicable)
 - i. Cable glands for power and control cables.
 - ii. 240 V rated panel space heater with thermostat.
 - iii. CFL type interior lighting fixture with lamp and door switch.
 - iv. MCBs.
 - v. Terminal blocks.
 - vi. Internal wiring.
 - vii. Earthing terminal.
 - viii. Hook up for the remote operation of tap lower and raise operation and contact/ signal for tap position indication to Purchaser's DCS shall be incorporated in the panel.
 - i) Automatic Control of OLTC: Automatic voltage regulator (AVR) for auto control of OLTC shall include:
 - i. Voltage setting device
 - ii. Voltage sensing and voltage regulating devices
 - iii. Line drop compensator with adjustable R and X elements.

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- iv. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
 - v. Adjustable dead band for voltage variation.
 - vi. Additional features as required when parallel operation with other transformers is specified.
- j) Alarms: The following alarms shall be provided:
- i. A.C. supply failure
 - ii. Drive motor auto tripped
 - iii. Other protective purpose considered essential by the Contractor.
 - iv. Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps.
 - v. Tap change delayed
 - vi. AVR failure (if AVR is specified)
 - vii. For the all specified above a "OLTC trouble" group alarm to be provided in DCS which is located in control room.
- k) TESTS:
- i. Routine Tests: Routine tests as per IS: 8468 shall be performed on all OLTC's & Motor drive mechanisms. Over and above, Pressure and Vacuum tests shall be conducted as per IEC: 60214.
 - ii. Type Tests : Type tests as per IS: 8468 shall be carried out on OLTC & Motor drive mechanism when called for. The Contractor shall indicate in his price schedule extra price, if any, for carrying out these tests. If type tests are not called for, type test reports for tests conducted (not older than 5 years) on a similar or higher rating OLTC & Motor drive mechanism shall be submitted for Purchaser's approval.
- l) Additional Requirements, if any: Tap position indicators and OLTC control switch shall be supplied loose if purchaser decides to mount the same in the power transformer control panel.
- m) The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

4.3. 415V LOW VOLTAGE METAL ENCLOSED SWITCH BOARDS:

- 4.3.1. Applicable Standards: The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear- General IS: 3427 requirements

Factory Built Assemblies of SWGR and control gear for Voltages up to and including 1000V AC & 1200VAC	IS: 8623 / BS: 5486 / IEC: 439
Air Break Switches	IS: 13947-P3 / BSEN6049 / IEC: 947-3
Miniature Circuit Breakers	IS: 8828 / BSEN: 60898
Low Voltage Fuses	IS: 13703 / BS: 1362 / IEC: 269-1
Contactors	IS: 13947/ BSEN: 60947 4 / IEC: 947-1
Starters	IS: 13947/ BSEN60947-4/ IEC: 292-1 to 4
Control Switches & Push buttons	IS: 6857 / BSEN: 60947
Current Transformer	IS: 2705 / BS: 7626
Voltage Transformer	IS: 3156 / BS: 7625 / IEC: 44, 186
Indicating instruments	IS: 1248 / BS: 89 / IEC: 51
Marking and Identification of Conductors and Apparatus Terminals	IS: 11353 / BS: 159
A.C. Electricity Meters	IS: 722, 8530 / BS: 5685 / IEC 145,211
Degree of Protection	IS: 13947 / IEC: 947-P1
Selection installation and maintenance of switchgear and control gear	IS: 10118
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

4.3.2. Constructional Features: The switchgear shall be metal enclosed, modular type suitable for indoor/ outdoor installation, dust & Vermin proof, self standing floor mounting with a height not exceeding 2300 mm and shall have following features:

- a) Panels shall be complying to Form 4A as per IS 8623: 1993, Part I / IEC 439-1
- b) Breaker up to 1250A shall be installed in two tiers and above 1250A, it shall be mounted in single tier.
- c) Minimum clearance between live part shall be phase to phase 25.4 mm & phase to neutral 20 mm at any location & shall be complying with the BIL for the panel.
- d) Switchgear shall be divided into distinct vertical sections each comprising :
 - i. A completely enclosed bus bar compartment running horizontally.
 - ii. Enclosed vertical bus bars serving all modules in vertical section.
 - iii. A separate horizontal enclosure for all auxiliary power and control buses.
 - iv. Vertical cable alley of minimum 250 mm wide covering entire height

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- e) Operating devices shall be incorporated only in the front of switchgear.
 - f) Each shipping section shall have metal sheets at both ends
 - g) Cable alley shall be provided with suitable hinged doors
 - h) All doors shall be with concealed type hinges and captive screws
 - i) Each vertical section shall be equipped with a space heater controlled by thermostat
 - j) Each switchgear cubicle shall be provided with interior lighting with 11W CFL luminaries inclusive of lamp with door limit - on/ off switch.
 - k) A 240 V AC, 5/ 15 A socket shall be provided in the interior of each cubicle with On-Off switch.
 - l) All identical equipment and corresponding parts be fully interchangeable without any modifications
 - m) Main and Auxiliary Buses:
 - i. Switchgear bus bars shall be of uniform cross section throughout the length and made of Electric grade Aluminium (91 E – 63401)
 - ii. All bus bars shall be covered with heat shrinkable black PVC sleeves. Coloured polyester tapes for phase identification shall be provided at suitable locations.
 - iii. Bus bar shall be adequately supported to withstand stresses developed due to short circuits.
 - iv. Bus bar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts, washers and nuts
 - v. The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.
 - vi. Vertical bus bars shall have Short Circuit rating same as main bus bar and shall be suitable for all connected load of vertical section.
 - vii. Neutral bus bar size shall be 50% of phase bus bar.
 - viii. Termination on bus bars at ACB, MCCBs shall be as per IEC60947-2. For terminations on MCCBs, where phase- phase and phase to earth clearance are not possible, Cu spreaders of suitable size shall be used along with the use of separators.
 - ix. Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be adequate. Joint positions and insulators shall be properly adjusted so that they don't interfere.
 - x. For the Main PMCC, Contractor shall ensure that incoming feeders from transformer shall be suitably designed for terminating bus duct if required. Contractor shall consider the necessary arrangement (dummy panel, adapter panel, rear extension etc.) if required, for terminating the bus-duct. Phase transposition, if required, will be done in the Main PMCC.
 - xi. Wherever Cu bus bars are provided, it shall be tinned copper & not bare Cu.

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- n) All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor.
 - o) All the indoor switchgear panels shall be suitable for IP-54 degree of ingress protection for the enclosure. Outdoor panels shall be with minimum IP-55, degree of protection
 - p) All panels shall be made up of CRCA sheet steel of following thickness -
 - i. Load bearing members - 2.5 mm.
 - ii. Doors and partitions - Doors – 2.0 mm, Partition - 1.5 mm.
 - iii. Mounting plate – 2.0 mm.
 - iv. Gland plate – 3.0 mm for both incomer and outgoing. For single core cable these plates shall be non magnetic.
 - q) All the panel wiring shall be done with PVC FRLS, multi-stranded copper wires
 - r) Feeder shall have hinged open-able (more than 105°) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.
 - s) Suitable barriers of FRP material shall be provided between two terminals connected to different voltage supplies.
 - t) All doors and detachable components shall be earthed with flexible green coloured (with Yellow coloured band) PVC sheathed 2.5/ 4.0 sqmm. multi-stranded Copper cable.
 - u) The equipment shall be given tropical and fungicidal treatment.
 - v) Each compartment & component shall be provided with name plates (with white letters on Black background) at front, inside & rear side.
 - w) Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.
 - x) Metallic Shrouding shall be provided for the isolation of main and vertical bus; as well as to avoid accidental contacts with live parts.
 - y) Drawing pocket shall be provided on the inside of incomer feeder door.
 - z) Provision for Top/ Bottom cable entry shall be made to suit the site condition.
 - aa) Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type.
 - bb) All the panels shall be provided with 20% extra power & control terminals.
 - cc) All unused contacts of the circuit breaker, protection, auxiliary, control relays shall be wired up to the terminal block.
 - dd) All terminals of different control voltages shall be separate from each other.

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- ee) Stud type terminals and ring type lugs shall be used for control cables.
 - ff) All the control/ power wiring shall be dressed neatly & the wire running through troughs shall be provided with covers
 - gg) Switchgear shall be easily extensible on both sides by the addition of vertical sections after removing the end covers. It shall be provided with a metal sill frame made of structural steel channel section properly drilled for mounting the switchgear along with necessary mounting hardware. Hardware shall be zinc plated or passivated. It shall be provided with labels on the front and rear indicating the switchgear designation.
 - hh) Any operating handle of switchgear shall not be more than 1800 mm and not lower than 300 mm from base of the panel.
 - ii) For individual feeder modules arranged in multi tier formation, it is essential that the modules are integral multiples of the unit size to provide for flexibility in changes if any at site. For safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power slab contacts to engage with vertical Bus bars. A vertical cable alley shall be sufficiently wide for motor control modules and for circuit breaker control modules.
 - jj) A horizontal separate enclosure for all auxiliary power and control buses, as 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.
 - kk) All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section.
 - ll) For draw out type modules, only the handles of control and selector switches, push buttons, knobs & cut outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door.
 - mm) On circuit breaker controlled circuits, protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawal chassis. All cut outs shall be provided with gaskets for the purpose of dust proofing.
 - nn) Current transformers shall not be directly mounted on the buses. Current transformer on circuit breaker controlled circuits shall be mounted on the fixed portion of the compartment.
 - oo) In breaker compartments, external cable connections shall be carried out in separate cable compartments for power and control cables.
 - pp) After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the Bus bars and adjacent circuit live.
 - qq) The withdrawals chassis shall move on suitable guides and on suitably plated steel or stainless steel rollers or balls to facilitate easy withdrawal.

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- rr) Cable alleys shall be provided with suitable hinged doors. It shall be possible to safely carryout maintenance work on cable connections to any one circuit with the Bus bars and adjustment circuits live. Adequate number of slotted cable support arms shall be provided for clearing the cables.
 - ss) Rear of single front switchgear shall be provided with removable panels. It shall be possible for one person to remove and fix the removable panel.
 - tt) All doors shall be provided with concealed type hinges and captive screws.
 - uu) The draw out contacts shall be only between copper/copper alloy/ aluminum fuses, which are silver or tinplated. The contact design shall be such that there should be no arcing/ deformation under the associated peak short circuit current.
 - vv) Switchgear shall be designed in such a way that all components equipment and Bus bars operate satisfactorily without exceeding their respective maximum permissible rise in temperature under ambient temperature conditions prevailing within the switchgear cubical, with reference to ambient temperature outside the switchgear cubical.
 - ww) Provision of ventilating louvers shall be provided with fine-screened brass or GI meshes to prevent entry of vermin and dust.
 - xx) The various types of modules indicating the control requirements of each type together with the list of component equipment required for each type shall be as follows: -
 - i. Incoming circuit - Draw Out type air circuit breaker for above 630A/ Fixed type MCCB for 630A & below with microprocessor based tripping mechanism.
 - ii. Outgoing feeder - ACB/ MCCB/ MPCB
 - iii. Auxiliary services - Starters, capacitors, Distribution Boards and other auxiliary load
 - yy) Physical size of compartment for each type of control and current rating shall be so chosen that all the basic and additional equipment can be housed in the compartment. No equipment associated with any particular circuit shall be permitted to be mounted in any other circuit module.
- 4.3.3. PCC configuration shall be as per SLD with four pole (FP) incomer breaker and TPN outgoing breakers except Lighting panel outgoing which shall be FP.
- 4.3.4. Separate instrument's compartment for indicators of flow meter (s), energy meter, level & pressure controller (if any) shall be provided as per actual requirement of suitable size.
- 4.3.5. Control Voltages : Following control voltages shall be used in LV panels
- a) All ACBs tripping / Closing shall be suitable for 110/ 240V AC (24/ 110VDC) as applicable. The trip coil and closing coils of ACBs shall operate satisfactorily under the following conditions of supply voltage:
 - i. Closing coils - 85 % to 110 % of rated voltage

ii. Trip coils - 70 % to 110 % of rated voltage.

- b) Indications/ Annunciator for LV Main PCC/ MCC – 110/ 240V AC (24/ 110VDC)
- c) Indications for auxiliary DBs - 240V AC
- d) Space heater, 5/15A socket, panel illumination lamp etc. - 240V AC derived from AC bus
- e) 240V AC, 110V AC and other voltages shall be segregated to avoid mix-up of voltages.
- f) Control transformers suitably rated of voltage ratio 415/ 240/ 110 V on the Incomer/ Bus shall be provided. For the control transformers, MCCB or MPCB shall be provided on the 415 V side and MCBs on the 240/ 110V side. The control transformer shall be cast resin type only.

4.3.6. Painting:

- a) All sheet steel work shall be paint through 7 tank electrostatic powder coating process in accordance with the required procedure and with the applicable standards. The switchgear enclosure shall be powder coated with shade as per RAL-7032.
- b) The final finished thickness of paint film on sheet steel enclosure shall not be less than 80 microns. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

4.3.7. Interchangeability:

All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable without having to carryout modifications. For trouble free interchangeability, the draw out arrangements shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.

4.3.8. Drawings & Documents Required:

Prior to fabrication of the switchgear, the contractor shall submit following for Purchaser Representative's approval - the dimensional drawing and design calculations indicating bus bar size, short circuit rating of all the electrical component used, internal wiring, components mounting details etc. The contractor shall submit manufacturers catalogues of the electrical components installed in the switchgear.

4.3.9. Inspection:

At all reasonable times during production and prior to dispatch of the switchgear to site, the Contractor shall arrange and provide all the facilities at their plant for inspection & testing of switchgear.

4.3.10. Earthing:

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- a) Al/ GI earth bus bars of adequate size shall be provided for the entire length of the panel. The framework of the enclosure shall be connected to this earth bus. Provisions shall be made for connection from this earth bus to the main earthing bus bar coming from the earth pit on both side of the switchgear.
 - b) The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bus bar. The armour of cables shall be properly connected with earthing clamp and the clamp shall be ultimately bonded with the earth bus bar.

4.3.11. Labels & Name Plate:

- a) Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.
- b) A nameplate with the switchgear designation in bold letters shall be fixed at top of the central panel. A separate nameplate giving feeder details shall be provided for each feeder module door.
- c) Inside the feeder compartments the electrical components, equipment, accessories like switchgear shall be provided with stickers shall suitably identify control gear, lamps, relays etc.
- d) Engraved nameplates shall preferably be of 3-ply (Red-White-Red or Black-White-Black) lamicoid sheet however black engraved perplex sheet nameplates shall also be acceptable. Engraving shall be done with square groove cutters.
- e) Nameplate shall be fastened by counter sunk screws and not by adhesives.

4.3.12. Danger Notice Plates:

- a) The danger notice plate shall be affixed in a permanent manner on operating side of the switchgear.
- b) The danger notice plate shall indicate danger notice in Gujarati, Hindi and English.
- c) The danger notice plate, in general shall meet to requirements of local inspecting authorities.
- d) Caution name plate, "Caution Live Terminal" shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.
- e) The danger notice plate shall be made from minimum 1.6 mm thick steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.

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- f) The letters, figures, the conventional skull and bones shall be positioned on the plate as per recommendations of latest edition of IS 2551-1982.
 - g) The said letters, the figures and the sign skull and bones shall be painted in signal Red color as per latest edition of IS 5 - 1978.
 - h) The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit the design of the switchgear enclosure.

4.3.13. Cable Entry:

- a) The panel shall have provisions of cable entry from top/ bottom as per site condition. The removable cable gland plate shall be provided to make entry dust and vermin proof.
- b) The panel shall have provisions for fixing the multi-core cable glands.
- c) The cable glands support plates shall be 3 mm thick.
- d) Cable gland shall be double compression screwed type and made of brass.

4.3.14. Mountings:

- a) All equipment in front of panel shall be of flush mounting type.
- b) All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services of others.
- c) All equipment inside the panel shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.
- d) The centerline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.

4.3.15. It is important to note that when pumping station is idle and transformer is required to be kept energized under no load/ part (miniscule) load condition, the necessary LT fixed capacitor bank (approx. 5% of transformer rating) shall be provided in PMCC (transformer LV incomer) panel and shall be manually/ automatically switched on to maintain power factor more than 0.95 but less than 0.99 (near unity). All the components for fixed type Capacitor bank (to be mounted in Main LV PMCC) panel shall be as indicated in typical electrical Single Line Diagram attached with the specifications. This is a complete responsibility of the Contractor to maintain the power factor under idle condition of pumping station. Any power factor adjustment charges levied by power utility shall be recovered from the Contractor along with 5 % lump sum administrative charge by Purchaser.

4.3.16. Moulded Case Circuit Breakers (MCCB):

- a) The MCCBs shall conform to IEC 947 & the latest applicable standards.

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- b) All MCCBs shall be of fixed type unless otherwise specified in the specifications elsewhere.
 - c) MCCBs shall be of four pole/ triple pole with neutral construction arranged for simultaneous four/ three-pole manual closing and opening and for automatic instantaneous tripping on short circuit.
 - d) All the incomer & bus coupler MCCBs for Main LT PMCC panels shall be FP type with microprocessor based O/L +S/C + inbuilt E/F release & all outgoings MCCBs shall be TPN with thermal magnetic based O/L +S/C + E/F releases.
 - e) All MCCB's shall be Schneider make Compact NSX/ Siemens -Sentron 3VL OR equivalent from the approved make list.
 - f) For achieving the Earth Fault protection in thermal magnetic (TM) based MCCBs, external CBCT, Earth Fault relay & shunt trip provision shall be considered as part of complete TM based MCCB.
 - g) The ON, OFF and TRIP positions of the MCCB shall be clearly indicated by using LED indications.
 - h) MCCBs shall be with ICS = ICU = 100%
 - i) MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stresses caused by the peak short circuit current of value associated with the switch gear rating.
 - j) All the MCCBs shall be of current limiting type and shall provide a cut off in 4-8 milli seconds for prospective currents during faults.
 - k) All the MCCBs shall be provided with rotary operating handle with door interlock.
 - l) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
 - m) All MCCBs shall be provided with additional 2 NO + 2 NC contacts, exclusively for Purchaser's use.
 - n) All the switchgear selection for motor feeders shall be Type-2 coordinated.

4.3.17. Entire LV system shall be fuse less type & fuses shall be used only for PT/ Control Transformer primary side. MCBs shall be provided on secondary of PT/ Control transformer

4.3.18. Miniature Circuit Breaker (MCB):

- a) MCB shall be hand operated, air break, quick make, quick break type.

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- b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.
 - c) 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 characteristics of the connected load. Where this is not specified, it shall be Type C.
 - d) The short circuit rating shall be not less than that of the system to which they are connected.

4.3.19. Direct-On-Line Starters: Direct on line motor starter shall have following components/ features:

- a) Direct-on-line starters shall be suitable for Class AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.
- b) DOL starter shall have MCCB/ MPCB, Overload Relay with SPP, Contactor etc.
- c) Type 2 Co-ordination shall be ensured.

4.3.20. Automatic Star-Delta Starters: Automatic star-delta motor starters shall have following components/ features:

- a) Three sets of contactors one for the line, one for the star point and one for the delta, and a timer to automatically change the connections from star to delta.
- b) Star Delta Starters shall consist of MCCB/ MPCB, Overload Relay with SPP, Contactors, electronic timer etc.
- c) 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 after time delay, timer contact de-energizing the star contactor, and delta contactor closing.
- d) Star-delta starters shall be suitable for AC-3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.
- e) Type 2 Co-ordination shall be ensured.

4.3.21. Reversing Starters: Motor Reversing starter shall have following components/ features:

- a) Forward and reverse contactors electrically interlocked with each other.
- b) Reversing starters shall be suitable for Class AC-4 duty as specified in applicable standards, unless otherwise mentioned in tender.

4.3.22. Auto Transformer Starter(ATS): Auto Transformer starter shall have following components/ features:

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- a) Auto transformer shall be air cooled type having 3 tappings of 50%, 65% and 80%. The same should be wound with Copper wire. The size of the wire should be determined to suit the associated motor rating. The tapping requirement indicated is minimum required & Contractor to ensure proper tapping selection based on motor starting requirement.
 - b) Stamping of reputed make and winding wire with 'B' class insulation should be used. This should also be suitable for minimum 6 starts per hour. Core shall be of CRGO material.
 - c) Maximum temperature rise should not be more than 115°C. Kordnoffer circuit (Closed Transition type) should be adopted in ATS panel. There shall be an acrylic/ Hylam sheet over & below the transformer. Also to absorb humming rubber sheet shall be provided below auto transformer.
 - d) Auto transformer shall be vacuum impregnated.
 - e) Testing of transformers should withstand full load starting current for six starts per hour, as per relevant IS.
 - f) ATS shall be provided with thermal overload protector in each coil of transformer from to give protection overheating. Thermal overload protector rating shall be 900°C with 10% tolerance.
 - g) ATS shall consist of MCCB/ MPCB, Overload Relay, and Contactors etc.

4.3.23. Soft Starters: Fully automatic microprocessor based soft starters with built-in bypass terminals for pump control application shall be considered for the motors above 75 kW. The features/ requirements of the starters shall be as per following but not limited to:

- a) The soft starter shall be designed, built and tested according to the latest editions of applicable IEC standards/ IEC 947-4-UL, CE.
- b) Input Voltage – 3Ph, 415V, $\pm 10\%$
- c) Input Frequency – 50 Hz, $\pm 3\%$
- d) Control Voltage – 100 - 240 V AC
- e) Ambient Conditions:
 - i. Temperature – 50 Deg C. (Operating range -5 to 70°C)
 - ii. Relative Humidity of 5 to 95%
- f) Control Method – Torque Control/ Reduced Voltage/ Ramp
- g) Motor Protection – Thermal overload protection
- h) Starter Protection – S/C, Phase imbalance, Phase failure, Phase reversal, O/ V, U/ V, Locked rotor, excessive starts per hour for application, Phase loss input/ output, Motor output loss.
- i) EMC standard – IEC 61000-4-2 level-3, IEC 61000-4-3 level-3

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- j) Built-in communication port for RS 485.
 - k) Type 2 Co-ordination shall be ensured.
 - l) The soft starter shall be complete with the following acceleration and deceleration settings & display requirements as a minimum-
 - i. Starting Torque: Initial torque shall be adjustable from 0-100% of maximum locked rotor torque.
 - ii. Ramp Time: The time between starting torque and maximum torque shall be adjustable between 1 to 60 seconds. The time between maximum torque & stop shall be adjustable between 2 to 120 seconds
 - iii. The current limit feature shall have the following characteristics:
 - ☐ The maximum allowed current during start shall be adjustable from 150% to 500% of soft-starter maximum current rating.
 - ☐ Starting torque shall be fixed at 40% when utilizing the current limit function.
 - iv. Voltage Ramp start & Full voltage DOL start shall be possible.
 - v. For stop function – Linear torque control, Quadratic Torque Control, Voltage ramp control, soft break etc. functions shall be provided.
 - vi. The soft-starter shall be provided with a functional ground to remove and/ or minimize electrical noise injected on the soft starter control board.
 - vii. Normally open output relays shall be provided for faults and status indications.
 - viii. Normally closed contacts for fault relays shall be provided as an option.
 - ix. The soft-starter shall be provided with a 2-position dip switch to select between the normal in-line connection (3-lead motor) and inside the delta (6-lead or 12-lead delta wound motors).
 - x. The soft-starter shall be controlled completely through solid state design algorithms. No moving electromechanical contacts shall be allowed.
 - xi. All adjustments shall be made from the front of the soft starter through keyboard (soft keys)
 - xii. The Soft starter shall have in-built/ remote display with following display parameters.
 - ☐ Three Phase Currents
 - ☐ Three Phase Voltages
 - ☐ Shaft Power in kW / HP (selectable)
 - ☐ Motor thermal capacity
 - ☐ Motor Energy consumption (kWh)
 - ☐ Power factor
 - ☐ Run time in hours
 - xiii. The Soft starter shall have following fault indications
 - ☐ Line failure
 - ☐ Phase imbalance
 - ☐ Over temperature – Motor
 - ☐ Over temperature – Soft Starter
 - ☐ Shorted Thyristor
 - ☐ Open Thyristor

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- ☐ Locked Rotor
 - ☐ Motor output loss
 - ☐ Overload - Shaft Torque
 - ☐ Underload – Shaft Torque
 - ☐ Over voltage
 - ☐ Under voltage
 - ☐ Excessive Starts
 - ☐ Phase reversal
 - xiv. Shaft Power measurement without the use of external electro mechanical sensors.
 - xv. Shaft overload and under load protection shall be available through the controller, even in a by-pass configuration.
 - xvi. When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.
 - xvii. The standard feature pump control shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping. This shall aid in eliminating the phenomenon commonly referred to as “water hammer”.
 - xviii. The soft-starter shall be designed for three-phase control with two anti parallel SCRs in each phase. SCR-Diode combination shall not be acceptable.
 - ☐ The PCB shall provide digital microprocessor control and supervision of all controller operation, including SCR pulse firing control.
 - ☐ The PCB power supply shall be self-tuning to accept control power input from 100 to 240 or 380 to 500 V AC, 50/ 60 Hz.
 - ☐ The SCR firing circuitry shall incorporate an RC snubber network to prevent false SCR firing.
 - ☐ When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.
 - xix. SCRs shall have the following minimum repetitive peak inverse voltage ratings:
 - ☐ 200 to 525V: 1600 V
 - ☐ 200 to 690V: 1800V
- m) Soft Starter shall be ABB make PSTB 840-600-70/ Schneider make Alistart-48 or better from the approved make list.

4.3.24. Contactors: The power contactors used in switchboard shall have following features:

- a) The Contactors shall confirm to IS 13947 & the latest applicable standards
- b) The power contactors shall be of, air break, single throw, triple pole, electromagnetic type.
- c) The insulation class of contactor’s coil should be B or higher.
- d) Operating coils of all contactors shall be suitable for operation on 110/240 V, single phase, 50 Hz supply.

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- e) Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.
 - f) Contactors shall not drop out at voltages down to 70 % of coil rated voltage.
 - g) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.
 - h) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

4.3.25. Relays:

- a) Main protective relays shall be Numerical type. They shall be suitable for semi-flush mounting with only flanges projecting on the front with connections from the rear.
- b) All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.
- c) All protective relays shall be in draw out cases with built in test facilities.
- d) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage
- e) Test block and switches shall be located just below each relay for testing unless otherwise specified. All auxiliary relay and timers shall be supplied in non-draw out cases.
- f) All protective relays shall be provided with at least two pair of potential free output contacts, exclusively for Purchaser's use.
- g) Relay cases shall have adequate number of terminals for making potential free connections, to the relay coils and spare contacts. Paralleling of contacts if any shall be done at the terminals on the casing of the relay.
- h) Each relay shall have provision for easy isolation of trip circuit for the purpose of testing and maintenance.
- i) All relays shall withstand a test voltage of 2 KV, 50 Hz RMS voltages for one minute.
- j) Auxiliary seal in units provided on the protective relay shall be shunt reinforcement type.
- k) 132 kW & above rated motors shall be breaker controlled with motor protection relay Siemens '7SK 80' OR equivalent from approved make list.

4.3.26. Thermal Overload Relays:

- a) Starters shall be complete with a three element, 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.

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- b) Thermal overload relays shall be hand reset type
 - c) 'Stop' push button of the starter and hand-reset device shall be separate from each other.
 - d) Overload relay hand reset push button shall be brought out on the front of the compartment door. Overload relay shall be provided with at least 1 'NO' and 1 'NC' or one changeover contact.

4.3.27. Timers:

Thermal/ Electronics timer for change over in star-delta and ATS panel should be provided.

4.3.28. Switch And Contactor Ratings:

Switch and contactor rating for various motor starter modules shall be selected by the Contractor, based on the specifications. Contractor shall also select appropriate ratings & ranges for thermal overload relays. These details shall be subject to the Purchaser's approval.

4.3.29. Single Phasing Preventers:

- a) Single phasing preventer relay shall be provided to protect motors against single phasing.
- b) It should operate satisfactory from 320/ 480V. Timing range of delay start 0 - 45 seconds.
- c) Toggle switch for Auto SPP by pass should be provided on front of unit.
- d) The relay shall not operate for supply voltage unbalance of $\pm 5\%$. After sensing single phasing, the relay shall operate with a time delay of 2 to 3 secs.
- e) The relay shall not operate for a 3- phase power supply failure. The relay shall be of the hand-reset type with a hand-reset push button. Resetting shall be instantaneous and independent of the adjusted time delay in the tripping of the unit. Visual indication for the operation of the relay shall be provided.
- f) The relay shall be suitable for application to protect reversible and non reversible motors.
- g) 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.
- h) 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.

4.3.30. Power & Control Wiring Connections:

- a) Terminals for both incoming and outgoing cable connections shall be suitable for 1.1kV grade Al/ Cu conductor XLPE armoured cable and shall be suitable for connections of solder less sockets for the cable size.

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- b) Main PMCC incomer feeder shall be suitable for bus duct connections using Aluminum Bus bars for transformer ratings greater than 1000kVA.
 - c) Both control and power wiring shall be suitable for Bus Duct/ Cable termination as per guidelines mentioned in transformer specifications.
 - d) Both control and power terminals shall be properly shrouded. Power terminals shall be of stud type.
 - e) 20 % spare terminals shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one outgoing wire is connected to per terminal.
 - f) Suitable barriers of enclosures shall preferably separate terminals strips for power and control from each other.
 - g) Wiring inside the modules for power, control, protection and instruments etc shall be done with use of 1.1 kV grade, multistranded Cu, PVC FRLS wiring.
 - h) Power wiring inside the starter module shall be rated for full current rating of respective contactor but not less than 4.0 Sq. mm. 2.5 Sq. mm copper wire shall be used for current transformer circuits.
 - i) Other control wiring shall be done with 1.5 Sq. mm copper conductor wires.
 - j) Wires for connection to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.
 - k) There shall be control transformer for control power supply (110/ 240V AC) and separate control bus.
 - l) Particular care shall be taken to ensure that the layout of wirings is neat and orderly. Identification ferrules shall be filled to all the wirings terminations for ease of identification and to facilitate checking and testing.
 - m) Washers shall be used for all Copper and Aluminum connections.
 - n) Final wiring diagram of power and control circuit with ferrules nos. shall be submitted along with the panel as one of the documents against the contract.

4.3.31. Terminals:

- a) The outgoing terminals and neutral shall be brought to a cable alley suitably located and accessible from the panel front.
- b) The current transformer for instruments metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming or outgoing cables to internal components of the distribution board is permitted; only one conductor may be connected in one terminal.

4.3.32. Wire Ways:

- a) The horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

4.3.33. Indicating Instruments:

- a) All analogue indicating meters shall be 144 x 144 mm size taut band with 240° Scale. All indicating meters shall be provided as per enclosed electrical Single Line Diagram.
- b) Ammeters for motor feeders shall have suppressed scale up to 6 times beyond full load.
- c) Dials shall be parallax free and white with black numbers and letterings & pointer shall be of knife-edge type. Such instruments shall be provided with zero adjustor accessible from the front.
- d) Instruments shall have an accuracy class 1.0 or better.
- e) Instrument dials shall be white with black numbers and lettering.
- f) Ammeter and current coils of wattmeter's and ammeters shall continuously withstand 120 % of rated current and 10 times the rated current for 0.5 second without loss of accuracy.
- g) Voltmeters and potential coils of voltmeters shall withstand 120% rated voltage continuously and twice the rated voltage for 0.5 seconds without loss of accuracy.

4.3.34. Metering Instruments:

- a) Multifunction meters shall be provided for all the feeders of 250A & above. For balance all feeders, kWh meters shall be provided. Size of the MFM shall be 96 x 96 sq. mm. MFM shall be provided with following metering features:
 - i. Current, Voltage, Energy (kWh), MD (kW, kVA), PF & Hz etc.
 - ii. MFM shall be L&T make 'Quasar' / Siemens OR equivalent.
 - iii. MFM shall be with accuracy class 1.0 or better & having RS 485 communication port.
- b) Watt-hour meters shall be of 3-phase two- element type suitable for measurement of unbalanced loads in three phases, three wire circuits. They shall be suitable for semi flush mounting on vertical panels.
- c) Watt hour meters shall be of the induction type and shall be provided with reverse running stops.
- d) Watt-hour meters shall be suitable for operation from the secondary of CTs and PTs. They shall be provided with a separate 3 phases, 4 wires type test terminal blocks for testing of meters without disturbing CT and PT secondary connections.
- e) Meters shall be provided with potential indicating lamps and shall have reverse running stops.

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- f) Meters shall have pointer as well as cyclometer type of register. They shall read KWH, KVARH, and PF as the case may be without the use of multiplication factor which, if unavoidable, shall be 10. The number of digits provided shall be adequate to cover 1000 hours of operation.
 - g) Current coils of meters shall have a continuous overload capacity of 120 % for both accuracy as well as thermal limits. Also the coil shall withstand at least 10 times rated current for 0.5 second without loss of accuracy.

4.3.35. Current Transformers:

- a) Current transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.
- b) Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second for breaker feeders.
- c) Unless otherwise specified, the minimum performance requirement of current transformers is as follows:
 - i. Measuring CTs - 15VA, accuracy class 1.0 and.
 - ii. Protective CTs - 15 VA, accuracy class 5P20.
- d) The above mentioned burdens are minimum required & it will be Contractor's responsibility to coordinate the current transformer burden with the requirements of relays, instruments and leads associated with that particular current transformer. Contractor has to provide sufficiency calculations for the same.
- e) Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block
- f) CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current
- g) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests.
- h) Identification labels giving type, ratio, output and serial numbers shall be provided.

4.3.36. Voltage Transformers:

- a) Voltage transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.
- b) Unless otherwise specified, the minimum performance requirements of Voltage transformers are as follows:
 - i. Measuring VTs - 50 VA per phase and accuracy class 1.0
 - ii. Protective VTs - 50 VA per phase and accuracy class 3.0.
 - iii. Dual purpose VTs - 100 VA and dual accuracy class 1.0/ 3P for metering and protection respectively. VA is per phase.

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- iv. The above mentioned burdens are minimum required & Contractor has to provide sufficiency calculations for the same.
 - c) All secondary windings of voltage transformers including open delta windings shall be rated for $110\text{ V} / \sqrt{3}$, $110\text{V} / 3$ per phase.
 - d) Voltage transformer shall have a continuous over voltage factor of 1.2 and short time over voltage factor as follows:
 - i. 1.5 for 30 seconds in case of effectively earthed system.
 - ii. 1.9 for 8 hours in case of non-effectively earthed system.
 - e) Voltage transformers shall be complete with suitable rated primary, fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. All the secondary circuits of the PT shall be protected by MCBs.
 - f) It shall be possible to replace voltage transformers without having to de-energize the main bus bars.
 - g) The terminals of PT secondary and tertiary windings, which are required to be connected to earth, shall be earthed by an isolating link without a fuse.
 - h) Identification labels giving type, ratio, output and serial numbers shall be provided.

4.3.37. Push Buttons:

- a) Push buttons shall have two normally open and two normally closed contacts unless otherwise specified. The contacts shall be able to make and carry 5A at 110V DC and shall be capable of breaking 1A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.
- b) Emergency stop' push buttons shall be of Mushroom type, lockable in the pushed position and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.
- c) The Internal wiring and terminal blocks shall meet the relevant requirements.

4.3.38. Auxiliary Transformers:

Any auxiliary voltage required for any of the component inside the switchgear shall be derived from the main supply by providing adequately rated auxiliary transformer mounted inside.

4.3.39. Indicating Lamps: Indicating lamps shall be:

- a) Clustered LED type and of low watt consumption.
- b) Provided with series resistors.
- c) Provided with translucent lamp covers of colors 'Red', 'Green' and Amber' etc. as required.

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- d) Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 110 V AC or at the specified AC/ DC system voltage as applicable.

4.3.40. Control & Selector Switches: Control and selector switches shall be:

- a) Rotary type with enclosed contacts.
- b) Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 230V AC and 1A (inductive break) 220V D.C.
- c) Provided with escutcheon plates clearly marked to show the positions.
- d) Control switches shall be spring return to normal type & provided with pistol grip type handles.
- e) Selector switches shall be maintained contact stay put type. Switches in ammeter circuits shall be of break type contact. Selector switches shall be provided with oval handles.

4.3.41. Space Heaters:

- a) Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.
- b) Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.
- c) 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.
- d) Space heater indicated in the breaker modules represents the space heater for each vertical section of the switchboard. Where breakers are mounted in two-tier formation, then only one space heater with associated MCB and thermostat is adequate for the vertical section

4.3.42. Cubicle Lighting/ Receptacle:

- a) Each control cabinet, marshalling box, etc. shall be provided with interior lighting by means of 11 W CFL luminaries with door operated On/ Off switch.
- b) A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB.

4.3.43. Routine and Acceptance Tests to be conducted by the manufacturer at their own risk and cost in presence of Purchaser/ Purchaser's representative during inspection & testing at manufacturer's works:

- a) Following Routine tests as per IS: 13947 and IEC: 60947 standards & other specified relevant IS standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's representative on LV Switchgear panel complete with the accessories.
 - i. Dielectric test on main circuit.

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- ii. Test on auxiliary and control circuit.
 - iii. Measurement of insulation resistance of the main circuit.
 - iv. Design and visual check.
 - v. Dimensional check and BOM verification.
 - vi. High Voltage test on power & control circuit.
 - vii. Functional & mechanical operation test of all components.
 - viii. Measurement of thickness of sheet steel & paint.
 - ix. Verification of wiring as per approved schematic.
- b) Following Type Tests reports as per IS: 13947 and IEC: 60947 to be submitted for the same rating & type of LV Switchgear panel conducted in past for review of Purchaser at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
- i. Dielectric test on main and auxiliary circuit.
 - ii. Temperature rise test.
 - iii. Making and Breaking test of switching elements.
 - iv. Degree of protection test.
 - v. Short circuit withstand test.
 - vi. Electromagnetic compatibility test.
- c) Certified copies of all type and routine test certificates and Calibration Certificates of measurement instruments which are used during inspection shall be submitted for the Purchaser's review/ approval before dispatch of the switchgear.

4.3.44. Test Certificates:

- a) Testing of switchgear shall be carried out at factory or at site as per standard in presence of Purchaser/ Purchaser's representative.
- b) The test results shall be recorded on prescribed forms. The certificates for the test carried out at factory or at site shall be submitted in duplicate to the Purchaser/ Purchaser's Representative for approval. Components and equipment that are not fully interchangeable are liable for rejection. Contractor shall replace all such non interchangeable equipment at his cost.

4.3.45. Drawings/ Documents required: After award of contract Contractor has to submit drawings/ documents for Purchaser's approval as mentioned below but not limited to:

- a) General arrangement diagram showing dimensions of enclosure, length, widths and depth of enclosure and bill of quantity indicating the rating, make of each components and quantity.
- b) Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.

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- c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
 - d) Schematic power and control wiring diagrams with bus bar rating with material, instrument & control transformers, switchgear rating, control interlocks, relays, instruments, space heaters details etc.

4.4. LOCAL PUSH BUTTON STATIONS:

4.4.1. Constructional Features: The constructional features of the local push button stations shall be as follows:

- a) Metal enclosed, weatherproof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminum or sheet metal of 2 mm thickness.
- b) Dust and vermin proof.
- c) Provide a degree of protection of not less than IP55.
- d) Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light gray epoxy paint.
- e) Provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.
- f) Provided with two earthing terminals suitable for earthing wire /strip.
- g) Provided with removable undrilled gland plate and cable glands for two nos. 5C x 1.5 mm² Copper conductor, XLPE insulated, armoured cable. The cable entry shall be from the bottom.
- h) Earthing shall be provided by 8 SWG GI wire and connected to earthing system.

4.5. APFC PANEL WITH CAPACITOR BANKS:

4.5.1. Capacitor Banks:

- a) The type of capacitors shall be All Polypropylene type double layer conforming to IS 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V
Rated frequency	50 Hz.
Permissible over voltage	1.1 V _n
Permissible over current:	1.5 I _n
Temperature category:	50° C
- b) The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.
- c) The capacitors shall have Low Dielectric Loss of $\leq 0.5 \text{ W / kVAr}$.

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- d) Each capacitor bank shall be provided with the 7% detuned filter.
 - e) * kVAR is net reactive compensation required to maintain 0.99 PF at 415 V Bus, i.e. excluding compensation required for detuned filters.
 - f) Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.
 - g) Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.
 - h) Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of capacitor inrush current.
 - i) Contactor for switching of capacitor banks shall have AC -6b utilization category according to IEC 60947-4-1 & sized accordingly.
 - j) All the components shall be suitable for capacitor duty application.
 - k) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. Capacitor shall be designed to improve the power factor to 0.99 lagging
 - l) It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/ Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
 - m) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The assembly of the banks shall be such that it provides sufficient ventilation for each unit.
 - n) Each capacitor case and the cubicle shall be earthed to a separate earth bus.
 - o) Capacitor shall conform to IS 2834 -1986.
 - p) The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.
 - q) 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 upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

4.5.2. Control Cubicles:

- a) Capacitor and capacitor control shall be housed in a metal enclosed cubicle. Capacitor shall be housed in the lower compartment and capacitor control unit at the top compartment, the two compartments being segregated. Control cabinets shall be free standing floor mounted type and shall meet the requirements of Metering, Protection & related provisions for APFC panel as tabulated below:

Panel Name	Breaker Type	Protection	Metering	Indications	Other
APFC Panel					
Incomer	ACB (TPN, MDO) OR MCCB (TPN, Fixed Type)	TM based O/L, S/C release , APFC Relay, E/F Relay with CBCT & Shunt Trip	Analogu e A, V	R Y B, On, Off, Trip	ETPB, A/M SS, Annunciator
Outgoing	MCCB (TP, Fixed Type)	TM based O/L, S/C release	A, AS	On, Off, Trip	Start, Stop Push Buttons

- b) APFC panel shall have AI bus bars sized for appropriate SC rating for 1 sec & to carry continuous rated current.
- c) All CTs/ PTs shall be cast resin type.
- d) All the MCCB's shall be current limiting type. Necessary auxiliary contact block required is included in Contractor's scope.
- e) One contact of power factor correction relay shall be provided for annunciation "POWER FACTOR LOW". The relay shall switch-on/ off capacitor banks for loads from 5% to 100%. The annunciation window shall be with test, accept and reset push button & hooter.
- f) Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.98 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.
- g) The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/removal of capacitor or other components and maintenance considerations. Contractor shall submit GA drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.

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- h) For control circuit 415/ 240/ 110V control transformer shall be considered. VA burden to be decided by the Contractor.
 - i) Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.
 - j) Bus bars shall be sleeved with coloured heat shrinkable sleeves. All the Bus bar supports shall be SMC type only.
 - k) Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL-7032 for exterior & interior with minimum thickness 80 micron.
 - l) All necessary auxiliary contactors are included in scope.
 - m) Contractor shall note that verification of double layer construction shall be done on any one of the capacitor bank during inspection by opening the capacitor bank at no extra cost.
 - n) The cubicle shall be fabricated out of 2.0 mm thick cold rolled sheet steel & shall comprise of
 - i. Isolating ACB / MCCB
 - ii. Contactors
 - iii. Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.
 - iv. Auto-manual selector switch
 - v. Microprocessor based Automatic Power Factor Correction (APFC) Relay – minimum 8 stage relays.
 - vi. Push button for opening and closing the power circuit
 - vii. Red and Green lamps for capacitors ON/ OFF indication
 - viii. Protective relays
 - ix. Space heater and cubicle lighting & receptacles.

4.5.3. Principle of Operation: On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.

4.5.4. APFC Relay: APFC relay shall have following standard features:

- a) The Automatic Power Factor Correction relay shall be of microprocessor based type and shall automatically switch ON/OFF the capacitor banks to attain the value of “pf” close to the set value.
- b) Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.
- c) To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.

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- d) Following adjustment shall be available in APFC Relay.
 - i. Power factor
 - ii. Dead band capacitive region with respect to set power factor (PF).
 - iii. Inductive region with respect to set PF
 - iv. Operating time for programmable switching steps.
 - v. Auto/ manual selector switch.
 - vi. Manual step control.
 - e) All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.
 - f) It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3.....13, 14.
 - g) Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out will only be reconnected by the pulse counter, after 60 sec. has elapsed so that it has safely discharged. This is a requirement for 415 V capacitors
 - h) Loss of voltage element. This would prevent abnormal switching surges on loss of supply. Also it would control the switching on/off surges.
 - i) Dead band features – Relay response sensitivity adjustable using dead band so that hunting is prevented.
 - j) Auto/Manual control – This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

4.5.5. Performance Tests:

- a) Contractor shall carry out all routine tests as specified in relevant IS/ IEC standards on all major components and furnish copies of test reports for Purchaser's approval. Wherever required, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.
- b) Contractor shall also carry out all routine and functional tests as specified in the relevant IS on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.
- c) During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.
- d) Primary Injection Test for various currents & time settings shall be provided in routine test.

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- e) All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

4.5.6. Maintenance Requirements

- a) As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with the equipment.
- b) Contractor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

4.5.7. Drawings / Documents Required:

- a) Dimensioned general arrangement drawings of capacitor and capacitor control panel.
- b) Justification for number of steps for switching.
- c) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.
- d) Complete schematic and wiring diagrams for capacitor control panel.

4.6. CABLING SYSTEM:

- 4.6.1. The scope shall be inclusive of supply, installation, testing & commissioning of power & control cables, cable terminations, cable accessories, stripping of cable insulation, supplying and fixing of Aluminium lugs for aluminium cables & tinned plated copper lugs for copper cables and crimping the same to the conductor, supply and fixing of double compression cable glands including all labour supply and consumable material required for jointing/ termination. The rate shall also include the laying of cable in ground/ in cable trays / cleating to structure etc.

4.6.2. Applicable Standards:

The cables shall confirm to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

PVC insulated cables (for voltage up to 1100 V)	:	IS: 694
HRPVC & PVC insulated cables heavy duty	:	IS: 1554
Cross linked polyethylene insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 189-1 & IEC-189-2
PVC insulation and sheath of electric cables	:	IS: 5831
Polyethylene insulation and sheath for	:	IS: 6474

electric cables

Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and sheath of electric cables	:	BS: 6746

4.6.3. Constructional Features:

- a) The 11kV power cables shall conform to 11kV Earthed grade (E), three core, stranded, Aluminium conductor, screened by extruded semi-conducting compound, cross-linked poly ethylene (XLPE) insulated, cores screened with non-magnetic metallic tape laid up with inner and outer extruded PVC sheath compound Type-ST2 and galvanized steel strip armouring. The cables shall generally conform to IS 7098-1985 with relevant parts thereof.
- b) Armouring shall conform to latest version of IS: 3975.
- c) The LV Power cables shall be 1.1kV grade, 4/ 3.5/ 3 Core, multi-stranded, Al/ Cu conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanized wire (up to 6 sq mm) / steel strip(>6 sq mm) armoured cables. All single phase, Lighting cables, UPS cables shall have 100% Neutral.
- d) All the control cables shall be 1.1kV grade, no. of cores (as per requirement/ application with minimum 2 spare cores for 7C & above) multi-stranded, Copper conductor, XLPE insulated, extruded inner PVC & outer PVC FRLS sheath compound type ST2 and galvanized steel round wire armoured.
- e) All control cables shall be with following specific requirements:
 - i. Copper conductor stranded class 2.
 - ii. XLPE Insulated
 - iii. Provided with inner extruded PVC and outer PVC FRLS sheath of extruded black PVC compound.
 - iv. Galvanized steel armouring in the form of GI round wire.
 - v. Core identification shall be by printed numerals.
 - vi. The insulation over the individual conductor core will be colour coded.
 - vii. Minimum 2 spare cores for above 7C.
- f) The DC power supply cable shall be two core, multistranded copper conductor, armoured cables with inner extruded PVC & outer PVC FRLS sheath. All control wiring shall be PVC FRLS insulated.
- g) All the power & control cables used in the Hazardous area shall be flame proof type suitable for the intended application.

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- h) Earthing Cable shall be Single core multi-stranded Cu, 1.1 kV grade, XLPE insulated, un-armoured green coloured outer sheath with yellow strips/ band cable to be laid in trays, underground, trenches etc. as applicable.
 - i) Submersible Cables: Multi core flexible Cu conductor XLPE insulated & PVC sheathed heavy duty cable suitable for submersible application (in case of submerged pumps) shall be manufactured as per governing standards. High purity electrolytic grade, annealed Cu conductor shall be used. Cables shall be extruded inner & outer PVC sheathed. PVC compound shall be dielectric grade & shall be impervious to water, oils & grease etc. Similarly double PVC sheathing shall also be done as per IS: 5831/ 1984. Flexible inner sheath & high abrasion resistant flexible outer sheath is required for these cables. Double PVC sheathing shall be done so as to withstand abrasion & prevent ingress of water along the interstices of the cable. Core identification shall be by printed numerals. Conductors shall be as per IS 8130. Cable shall be constructed as per relevant IS/ IEC standards.

4.6.4. Cable Colours:

- a) All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.
- b) The colour coding should be as follows:
 - i. 3 phase Red, Yellow and Blue
 - ii. single phase or dc supply Red and Black
 - iii. earth Green/Green with Yellow coloured band
 - iv. control Gray (DC)

4.6.5. Cable Conductors;

- a) Cables up to 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.
- b) Single core cable shall have non magnetic material armouring.
- c) Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm².
- d) Small control cables shall be of a minimum cross-section of 1.5 mm².
- e) Internal wiring of control panels shall be of a minimum cross-section of 1.5 mm² flexible and multistranded.

f) Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm² for external use and 1.0 mm² for internal use.

g) Cable Sizing shall be done as per design criteria specified in specifications.

4.6.6. 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. Necessary loop at both ends shall be provided for future use and 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_ _ _

4.6.7. Cable Terminations:

a) Cable Lugs

- i. Cable lugs shall be of tinned copper, solder less crimping type for Cu cables & AL lugs for the AL cables.
- ii. The current rating of the lugs shall be same as that of the respective cable conductors.
- iii. Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
- iv. Double holes extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
- v. Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs. This shall especially be ensured for Al cable terminations & bimetallic terminations shall be used wherever required.
- vi. If termination is done with crimping tool employing crimping die then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned and special jelly applied over it to prevent further oxidation.

b) Cable Glands

- i. Glands shall generally be of the double compression hexagonal type brass glands. Earth continuity of brass glands shall be assured.

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- ii. Double compression type cable glands shall be used. Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.
 - iii. For single core cables, gland shall be with brass ring.
 - iv. Glands for single core cables shall be constructed from non-magnetic materials.
 - v. Cable glands shall be with metric threads.
 - vi. Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.
 - vii. For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.
 - viii. For dry indoor situations, standard industrial glands with shrouds are acceptable.
 - ix. For hazardous areas, glands conforming to EEE standard shall be used with double seal and shroud.
- c) Trefoil Clamps for Single Core Cables.:
- i. All the single core cables shall be laid in trefoil formation only.
 - ii. The grouping & sequencing of three single core cables arranged in trefoil formation shall be done in such a way to ensure balanced current distribution.
 - iii. Trefoil clamp of suitable size & having non magnetic material shall be used.
 - iv. The Trefoil groups shall be held in trefoil clamps at an interval not exceeding 3.0 meters.
 - v. In addition to trefoil clamps as mentioned above, the tre-foil groups of cables shall be additionally tied by means of 3.0 mm dia. nylon cord clamp at an interval not exceeding 750 mm.
- d) Where ever applicable, supply & installation provision of bimetallic strip for connection between Al to Cu strip & GI to Cu strip shall be provided.

4.6.8. Cable Drums:

- a) 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.

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- b) Before winding the cables on drums, Contractor shall obtain Purchaser's approval for the drum lengths. Cable ends shall be sealed by non-hygroscopic sealing caps.
 - c) Contractor has to ensure reference of an arrow and suitable accompanying wording which shall be stenciled on the sides of the drums indicating which way it should be rolled. The number on each drum shall be either branded at the end of the drum or stamped on the metal attached to an end of the drum. The cable shall be placed on the drum in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. The drum shall be securely blocked in position so that the cable will not be displaced during transit. Cable ends shall be sealed by non-hygroscopic sealing caps.
 - d) It shall be the Contractor's responsibility to prepare the drum cutting schedule so that cable wastage is minimum while cutting.
 - e) Contractor shall obtain Purchaser's approval for the drum lengths.

4.6.9. Tests Before and After Laying of Cables at Site: Following Routine & acceptance tests on each drums as per IS 10810, IS 7098 standard & other specified relevant standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's Representative.

- a) For 1.1 kV Power & Control cables:
 - i. Dimensional & visual check
 - ii. Conductor resistance test
 - iii. Insulation Resistance Test
 - iv. High voltage test
- b) For 11 kV power cables:
 - i. Design and visual check
 - ii. Conductor resistance test
 - iii. Very low frequency AC HV test (instead of DC test)
 - iv. Insulation resistance including P.I. at rated voltage
 - v. Capacitance and tan delta
 - vi. AC leakage current
 - vii. Partial discharge measurement

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- c) All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 6.0 in IS: 1255 (Code of practice for Installation & Maintenance of Power Cables up to and including 33kV).
 - d) Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the Megger for cables of different voltage grades shall be as indicated below.

Voltage Grade	Megger rating
1.1kV	500V
11kV	1000V

- e) Following tests in the presence of Purchaser/ Purchaser's representative shall be carried out at site before commissioning of cables.
 - i. Insulation Resistance test between phases and phase to Neutral and phase to earth.
 - ii. Continuity test of all the phases, neutral and earth continuity conductor.
 - iii. Sheathing continuity test.
 - iv. Earth resistance test of all the phases and neutral.

4.6.10. Drawings/ Documents Required:

- a) As a part of the Bid, Contractor shall furnish the following :
 - i. General information
 - ii. Principal technical data
- b) After award of contract it shall be the responsibility of Contractor to work out a detailed layout for the complete plant cabling system. The layout drawing shall be furnished for the approval of Purchase/ Purchaser's representative before commencement of installation including cable trays, cable racks/ trenches, accessories, tray supports, conduits etc.
- c) Contractor to submit following Drawings/ Details after award of contract
 - i. Cable Sizing calculations
 - ii. Details of Installation of cables in trenches, on cable trays, directly buried etc at all locations inside the plant.
 - iii. Cable routing layout inside and outside the plant with route marker provided at 15 meter interval.
 - iv. Bill of quantities of cables, lugs and glands.
 - v. HV Cable termination and mounting Kit Layout drawing.

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- d) Following Type Tests reports as per relevant standard to be submitted for the same rating & type of Cables conducted in past for review of Purchaser/ Purchaser's Representative by the Contractor at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.
- i. Annealing test
 - ii. Tensile test
 - iii. Wrapping test
 - iv. Test for thickness of insulation & sheath
 - v. Physical test for insulation & sheath
 - vi. Tensile strength and elongation at break of insulation and sheath
 - vii. Loss of mass test
 - viii. Ageing in air oven
 - ix. Shrinkage test
 - x. Heat shock test
 - xi. Insulation resistance test
 - xii. High voltage test
 - xiii. Flammability test

4.6.11. Cable tray and accessories:

- a) Cable trays shall be of Galvanised Steel/ Fibre Reinforced Plastic and of ladder/ perforated/ solid type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings. All hardware (i.e. bolts, nuts, screws, washers, etc) shall be hot dip galvanized.
- b) Cable trays of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows etc., shall be fabricated from 14 gauge (2.0 mm thick) mild steel sheets. Cable tray covers shall be fabricated from 16 gauge perforated (1.60 mm thick) M.S. sheets.
- c) The cable trays shall be supplied in standard lengths of 2500 mm and clear inside widths of trays shall be as follows:
 - i. Perforated type trays : 150, 300, 450 and 600 mm.
 - ii. Ladder type trays: 300, 450, 600 and 750 mm

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- d) Cable trays, accessories and covers shall be painted with one shop coat of red oxide zinc chromate primer and two site coats of aluminium alkyd paint for indoor use.
 - e) For outdoor use, cable trays, accessories and covers shall be either galvanized or made of aluminium as specifically mentioned in the layout drawings.
 - f) For use in corrosive atmospheres both indoors and outdoors, the cable trays, accessories and covers shall be as per serial no.(e) above.
 - g) The spacing of rungs for ladder type of trays shall be 250 mm unless otherwise noted.
 - h) All finished cable trays and accessories shall be free from sharp edges, corners, burrs and unevenness.

4.7. EARTHING & LIGHTNING PROTECTION SYSTEM:

4.7.1. Scope:

- a) The scope includes collection of data, design of the system as per relevant National/International Standards preparation of layout drawing supply of earthing conductors, earth electrode, earthing strips installation and approval to the satisfaction of electrical inspector under this tender specification.
- b) Earthing system shall be provided to ensure equipment safety, personnel safety and facilitate designed operation of protective switching during earth fault conditions in the associated system.

4.7.2. Applicable Standards: The earthing and lightning protection system shall conform to the CEA guidelines and the latest applicable standards indicated below:

- | | | |
|---|---|----------------------|
| a) Code of Practice for Earthing | : | IS: 3043 |
| b) Code of Practice for the Protection of | : | IS/IEC 62305 |
| c) Building and allied structure against Lightning. | | |
| d) Hot dip galvanizing | : | IS: 2629, 2633, 4759 |
| e) Structural steel | : | IS: 2062 & 808 |
| f) Welding | : | IS: 816 |

4.7.3. Earthing & Lightning system:

- a) The design basis for designing earthing conductor is indicated under design criteria for electrical system. Earthing system shall be provided for complete plant i.e. pumping stations, switchyard and all electrical equipment as per the latest edition including all official amendments and revisions of IS-3043 and CEA guidelines.
- b) All materials and fittings used in the earthing installation shall conform to the relevant Indian Standards or shall be approved by the Engineer's representative & CEIG.

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- c) Contractor has to carry out soil resistivity test at, at least 4 locations for which locations shall be provided by Purchaser's representative. Testing to be done at each site.
 - d) Soil resistivity shall be carried out by Wenner four electrode method as described in IS 3043. Contractor has to carry out the test in presence of Purchaser's representative & test shall be carried out keeping electrode spacing as 1, 2, 4, 6, 8, 10, 15, 25 M (each, along all 8 directions) as per normal practice and report has to be submitted. Polar curves shall be used for measurement of mean soil resistivity, which shall be used in finding earthing resistance at a particular location. Mean soil resistivity values shall be approved by Purchaser's representative.
 - e) The Contractor shall base his earthing calculations on actual measurement carried out by him in the presence of Purchaser/ Purchaser's Representative.
 - f) Galvanized Iron flat / wire shall be used as earthing conductor.
 - g) The underground joints in the system shall be properly welded or brazed and the bolted type connection shall be made with structures/ equipment. Petroleum jelly shall be applied to contact surface of the bolted joints, which will be covered with bituminous compound and tapes.
 - h) Earthing conductor shall be protected against mechanical damages considering the installation conditions.
 - i) The earthing system shall comprise one or more earth electrodes, earthing grid or a combination of these in order to obtain the required earth electrode resistance of less than 1 Ohms.
 - j) For equipment earthing, two earthing leads will be used if rated voltage of the equipment is 250 volts & above and one earthing lead will be provided for equipment rated below 250 volts.
 - k) The earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm below FGL.
 - l) For each 11 KV DP Structure, minimum 2 nos. of CI plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit- 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block and CI Cover complete as per IS 3043 with necessary length of double GI earth flat 25x6 mm bolted with lug to the plate complete connected to the required point of DP with end socket as per direction and duly tested by earth tester conforming to IS as per drawing and specifications complete with 600 x 600 x 3.5 mm CI earth plate.

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- m) For each transformer neutral, minimum 2 nos. of Cu plate type earthing electrodes shall be provided. The earth plate shall be buried in specifically prepared earth pit 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering and bricks masonry block CI Cover complete as per IS 3043 with necessary length of double Copper earth flat 25x6 mm bolted with lug to the plate complete connected to the transformer neutral with end socket as per direction and duly tested by earth tester conforming to IS as per drawing and specifications complete with 600 x 600 x 3.15 mm Copper earth plate.
- n) For other equipment & area, Earth electrodes shall be of heavy duty galvanized mild steel of not less than 40 mm NB and minimum 3000 mm long. Where multiple rods are used they shall be separated by a distance of not less than 2000mm.
- o) Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing strips shall be connected. These connections shall each be housed in individual inspection chamber set which shall project 100 mm above the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.
- p) All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Purchaser's Representative.
- q) All civil works, such as excavation, boring, provision of charcoal & salt in adequate quantity, backfilling for the installation of the earth electrodes and the earth pit/ inspection pit shall be in the scope of Contractor.
- r) After the earth installation has been completed the Contractor shall demonstrate to the Purchaser/ Purchaser's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.
- s) Main Equipotential Bonding Conductor: Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.
- t) Circuit Protective Conductors: An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:
- i. a separate core within a multicore cable
 - ii. A separate conductor installed within a conduit or trunking. Steel conduit or trunking shall not be used as a circuit protective conductor.
 - iii. The metal sheath of an armoured cable. The sheath shall be bonded to the metal work of the apparatus and to the apparatus earth bar, if any.
 - iv. the copper sheath of a mineral insulated copper sheathed cable
 - v. An independent earthing conductor MS or GS run adjacent to the circuit it protects.
 - vi. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

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- vii. The armoring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

u) Instrumentation Earth:

- i. An instrumentation earth bus shall be provided in each control panel. This shall comprise a GI 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 control panel electrical power earth.
- ii. 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 on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radially from the same earth point.
- iii. All signal cable screens (analogue and digital) shall be terminated on to 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.
- iv. Surge Protector Devices (SPDs) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

4.7.4. Important Instructions for Earthing:

- a) Each pole of lightning arrestors shall be earthed with separate earth pit.
- b) Two-earth conductor shall connect outdoor CT secondary winding to earth grid.
- c) The switchyard fencing shall be earthed at every alternate block and the switchyard gate shall be earthed with flexible GI wire.
- d) All the earthing material with laying etc. shall be included in the scope.
- e) The entire plant will have an earth grid laid in trenches/ trays/ buried in the ground outside. The main earthing grid shall be embedded at a minimum depth of 600 mm below FGL which shall be connected to earth electrodes.
- f) All interconnections of the earthing grid conductors will have welded type joints except at electrodes with disconnecting facility and at equipment with bolted connections. All indoor earthing grids will be suitably interconnected to the external earthing grid.
- g) Each steel/ RCC column of the building will be interconnected to the floor-earthing grid. Steel columns, steel strips / conduits, cable trays etc. will not be used as earth continuity conductors.
- h) Disconnecting type facility shall be provided between Earthing grid & each earth electrode.

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- i) All connection between the conductors shall be welded/ brazed type. Metallic pipe, conduit, structures shall be bonded to lightning protection conductors to prevent the side flashover. But no metallic pipe, conduit, structure shall be used as air termination conductor or down conductor.
 - j) The down conductors shall be fixed with embedded brass posts (on concrete columns) with nuts & bolts used for fixing the saddle/ clamp (direct drilling of down comer and fixing with screw shall not be acceptable).
 - k) Cleats for 'earthing and lightning protection systems' shall be of GI.
 - l) The lightning protective conductor shall not be connected with the earthing above ground however both the systems shall be interconnected below ground.
 - m) The earth pits may require boring & drilling in the soil & the same shall be considered in Contractor's scope.
 - n) Earth electrode with disconnecting facility shall be provided so that the resistance of the independent earth electrode may be measured.
 - o) Internal earth Bus of each panel shall be connected to both ends to the earthing system by means of earthing conductor.
 - p) Metallic frames of all current carrying equipment, structures supporting and adjacent to current carrying conductors, lightning protection system conductors, metallic structures, metallic stairs, hand rails, fences shall be connected to a single earthing system. Neutral points of various systems shall be connected to the dedicated treated earth pits and these earth pits shall be interconnected to each other below ground.
 - q) All connections in the equipment earth conductors buried in ground (or otherwise) shall be cad welded/ brazed, whereas connection at equipment end shall be of bolted type. All connections shall be of low resistance. All bimetallic connection shall be treated with suitable compound to prevent moisture ingress. For Bimetallic bolted connection, bimetallic washers shall be used. All bolted joints shall have minimum two bolts to ensure proper surface contact. Termination of stranded conductors at earth inserts shall be with ring type/ lugs.
 - r) Galvanized conductors shall be touched up with zinc-rich paint where holes are drilled at site for bolting to equipment/structure.
 - s) Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductor. The minimum length of such risers inside the building shall be 200 mm and outdoor shall be 500 mm above ground level.
 - t) Metallic conduits and pipes shall be connected to the earthing system unless specified otherwise.

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- u) All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval of not more than 10 meters by 25 x 3 mm GS flat.
 - v) Earthing Pits
 - i. Adequate number of earthing pits shall be provided in conjunction with earthing grid for the earthing system. The minimum spacing between two adjacent earthing pits shall not be less than 2000mm and shall be kept 1500 mm away from footings of the structure.
 - ii. Earthing pits shall be located in ground, which has a reasonable chance of remaining moist. Arrangement comprising of GI pipe with top funnel with wire mesh shall be made to facilitate pouring of water to keep earthing pit wet.
 - iii. A galvanized iron strip of adequate size (as per calculations) shall be provided from plate electrode to about ground level to facilitate jointing with earth conductors. Each earth electrode ending at the pit shall be connected to suitable linking strips to connect and disconnect the earthing suitably.
 - iv. Earthing chamber shall be of RCC/ brick chamber of 600 mm x 600 mm, with Hinged cast Iron chequered cover plates. The covers shall have holes for handling. Earthing pits (chambers) shall be painted Green and the earth-pit number shall be marked on it.
 - v. Earthing cables crossing other metallic structures such as conduits pipelines etc shall be minimum 300 mm away from such structures.
 - vi. Earthing conductors shall be protected against mechanical damage.
 - vii. All earth lead connections shall be as short and direct as possible and shall be without kink.
 - viii. The main earth loop in plant area shall be generally routed along cables. When equipment are located away from main earth loops, suitable sub-loops shall be run up to them for deriving connections for individual equipment. The entire earthing system shall fully comply with the CEA guidelines and requirements.
 - ix. The contractor shall have to carry out any changes as desired by the Electrical inspector or the Engineer in charge, in order to make installation conforming to the CEA guidelines 2010 and IS 3043.

4.7.5. Lightning Protection:

- a) The lightning protection system need will be established by calculating the risk factor value of each building, structure etc. as per procedure given in IS/IEC 62305-2010 and if found necessary the same shall be provided by the Contractor.
- b) For Lightning protection of Civil Structures including RCC Buildings, fixing of 25x6 mm GI earth strip to roof as per IS/ IEC std, saddle clamp, down comer connector etc. as required with all hardware shall be in Contractor's scope.

4.7.6. Galvanizing:

- a) 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

<u>Fabricated Steel</u>	
i. Thickness less than 2 mm, but not less than 1.2 mm	340 gms/ sq.m
ii. Thickness less than 5 mm, but not less than 2 mm	460 gms/ sq.m
iii. Thickness 5 mm and over	610 gm/ sq.m
<u>Fasteners</u>	
i. Up to nominal size M10	270 gms/ sq.m
ii. Over M10	300 gms/ sq.m

- b) Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.
- c) Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

4.7.7. Drawings/ Documents Required:

The Contractor should prepare Layout drawings, after award of contract and before commencement of work for Purchaser's approval, showing the location of earthing grid, electrodes, interconnection grids and earthing leads to various equipment, down comers, isolating links etc. should be accompanied by design calculations.

4.8. LIGHTING & RECEPTACLE SYSTEM:

4.8.1. Scope

- a) The scope of the Contractor shall include design, supply and installation of all equipment necessary for a complete lighting and receptacle system. The lighting system includes Lighting fixtures (indoor/ outdoor), lamps, lighting panels (LP), switchboards, Receptacles, JB's, cables/ wires for lighting/ receptacles, conduits etc. The supply of street light/ flood light poles as per IS 2713 or IS 3713 is also included in the Contractor's scope.
- b) All light fixtures for indoor and outdoor shall be LED type only.
- c) The various types of lighting fixtures with lamps shall be installed based on the mounting arrangement shown in the typical drawings enclosed with the specification. Installation scope shall include all material to mount the fixtures in proposed manner.
- d) The various types of lighting fixtures as per specified in this specifications shall be assembled, installed, tested & commissioned by the Contractor.
- e) The type of lighting fixtures and receptacles, illumination level and approximate quantity required shall be generally as per design criteria.
- f) Lighting system installation shall be as per the tender specifications

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- g) It shall be the responsibility of the Contractor to work out complete detailed requirement of lighting and receptacle system for the whole plant and staff quarters including area lighting as per specification and accordingly procure and install them.

4.8.2. General Requirements: The Lighting system includes following items.

- a) Lighting fixtures complete with Lamps and accessories. Only LED fixtures shall be used for both indoor & outdoor applications (Except for High mast lighting).
- b) Lighting system equipment
- c) Light control switches, receptacle units with control switch units, lighting wires, conduits, earth wires and other similar items necessary to complete lighting system.
- d) Lighting fixture supports, street lighting poles and flood light towers/ poles.
- e) Lighting main distribution board, lighting panels
- f) Multi core cables for street, boundary and flood lighting

4.8.3. INTERNAL AND EXTERNAL ILLUMINATION:

- a) It shall be the responsibility of the Contractor to work out a detailed layout for the complete plant in order to provide the levels of illumination as indicated in the relevant standards
- b) The types of fixtures to be used in various areas are also indicated in the above mentioned drawing. The Contractor shall be responsible for measuring the levels of illumination and uniformity after installation and establish compliance with the specification.
- c) The lighting system will comprise the following:
 - i. Normal A.C Lighting: Normal lighting in all indoor and outdoor areas will be operated on 230V, 1Phase, 50 HZ A.C supply
 - ii. Emergency Lighting: Emergency Lighting shall be designed such that at all junctions, exit passages & strategic locations, Lux level shall be maintained above 10 Lux. Emergency light fitting shall be 240 V self contained 2 x 10 W LED fixture with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house/ area. Emergency fixtures shall come in service when AC supply fails. Pump room and Electrical room shall be considered for Emergency lighting.

4.8.4. Applicable Standards: The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

- a) Lighting Fixtures & Accessories for General & High mast

Electrical lighting fittings general and safety requirements	:	IS: 1913/ BS: 4533
Code of practice for industrial lighting	:	IS: 6665
Code of Practice for Interior Illumination	:	IS 3646

Code of Practice for Lighting of Public Thoroughfares	:	IS 1944
Calculation of co-efficient of utilization	:	IS: 3646 (Part - III)
Testing procedure of photometric testing for LED luminaires		LM 79
Testing procedure on the lifespan of LEDs		LM 80
National Lighting Code		SP72
Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources		IS:16105
Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products		IS:16106
Limits of Harmonic Current Emissions		IS 14700-3-2
DC or AC supplied electronic control gear for LED modules performance requirements		IEC 62384
Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules		IEC 61347-2-13
Environmental Testing: Test Z- AD: composite temperature/ humidity cyclic test		IEC 60068-2-38
Electro Magnetic compatibility (EMC)- Limits for Harmonic current emission-- (equipment input current ≤ 16 A per phase)		IEC 61000-3-2
EMC Immunity requirement		IEC 61547
LED modules for general Lighting-Safety requirements		IEC 62031
Classification of degree of protections provided by enclosures (IP Codes)		IEC 60529
Fixed general purpose luminaires		IEC 60598-2-1
General Lighting - LEDs and LED modules – Terms and Definitions		IS:16101 / IEC TS 62504
LED Modules for General Lighting Part 1 Safety Requirements		IS:16103(Part1)
LED Modules for General Lighting Part 2 Performance Requirements		IS:16103(Part2)
Safety of Lamp Control Gear, Part 2 Particular Requirements Section 13 D.C. or A.C. Supplied Electronic Control gear for Led Modules		IS:15885(Part2/Sec13)
Industrial lighting fittings with metal Reflectors	:	IS: 1777
Decorative lighting fittings	:	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)
High pressure mercury vapour lamps	:	IS: 9900/BS: 3677/ IEC: 188
Screw less terminal and electrical connections for lighting fittings	:	IS: 10322
High pressure sodium vapour lamps	:	IS: 9974
Emergency lighting units	:	IS: 9583
Ignition proof enclosures, dust-tight for elect. equipment	:	IS: 11005
Luminaries	:	IS: 10322(Part I to V)

b) Lighting System Equipment:

Arrangement for busbars, 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: 439
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: 269
'D' Type fuses	:	IS: 8187
Current transformers	:	IS: 2705/BS: 7626/ IEC: 185
Voltage transformers	:	IS: 3156/BS: 7625/ IEC: 186
Direct acting electrical indicating Instruments	:	IS: 1248/BS: 89/IEC: 51
A.C. electricity meters	:	IS: 722/BS 5685
Electrical relays for power system protection	:	IS: 3231/BS: 142/ IEC: 255
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 phosphate iron and steel	:	IS: 6005/ BS: 3189
Fittings for rigid steel conduits for electrical wiring	:	IS: 2667
National Building Code of India (NBC)	:	NBC 2016

4.8.5. Other Design considerations for Lighting:

- a) Lighting panels shall be provided in various areas and circuit wiring to the lighting fixtures shall be made from lighting panels. Lighting panel shall comprise of Four pole MCB + RCCB (100 mA) for incomer and SP MCB's for each outgoing single phase circuits.
- b) The wiring for lighting circuits in indoor areas will be done by wires run in GI conduits. For outdoor lighting, wiring will be done by using armoured cables.
- c) Lighting cable from Main lighting DB (MLDB) to Lighting panels shall be Al conductor, XLPE insulated, 1.1KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam.
- d) For lighting fixtures (Pump room) 1100V grade, 4C x 2.5 sq. mm. PVC insulated, multi stranded copper conductor armoured/ unarmoured cables shall be used.
- e) For lighting fixtures (For Office, electrical room, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded Copper conductor wires of area not less than 1.5 sq mm laid in min. 20 mm dia GI conduit (above false ceiling) shall be used.
- f) For 5/15A decorative sockets (For Office, toilets etc. areas) 1100V grade, FRLS PVC, multi-stranded copper conductor wires of area not less than 2.5/ 4.0 sq. mm. Cu laid in minimum 20 mm dia. GI conduit shall be used.
- g) Wiring shall be concealed in wall below false ceiling with concealed switch board. Minor civil work like chasing wall, cut outs for conduit, switch board, Lighting Panel in wall, entries for tray, conduits etc. is in scope.
- h) Lighting cable from MLDB to Lighting Panels and Lighting Panels to street light fixtures, shall be Al conductor, XLPE insulated, armoured, 1.1 KV grade, laid in cable trays otherwise cleated along the wall/ column/ beam and buried in the ground.

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- i) The point wiring for lighting/ receptacle/ exhaust fan/ wall mounted fan/ ceiling fan shall include conduits, conduit accessories, FRLS PVC insulated multistranded Copper conductor wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, accessories, anchor fasteners etc. It shall include wiring from lighting panel to switchboard and receptacles & switchboard to lighting fixtures. Sheet metal switchboard embedded in wall shall be considered for receptacles and lighting switchboards on wall shall be considered for lighting.
 - j) For power sockets in wall/ furniture, PVC switch box of approved make with switch plate & accessories and 16 Amp piano modular switches and 5/15A sockets etc. as applicable shall be considered. For all types of point wiring the receptacles with switches shall be included in the point wiring rate.
 - k) Lighting switchboard consisting of (*) no. of 6A piano switch without indicator, 1 no. 6A piano switch with indicator, 1 no. white coloured cover plate for (*) module (4/ 6/ 8/ 12 module), 1no. 2/ 3 pin shuttered socket of 5/ 15A and metal flush box.
 - l) Decorative socket switchboard consisting of (*) no. of 16A piano switch with indicator, (*) no. 2/ 3 pin shuttered socket of 5/ 15A and metal flush box, 1 no. white coloured cover plate for (*) module (4/ 6/ 8/ 12 module).
 - m) Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring.
 - n) Lighting Control Philosophy as per mentioned below shall be observed. From each switch
 - i. Max. 2 (3 in case unavoidable) normal LED light fixture.
 - ii. Max. 4 (5 in case unavoidable) for LED down lighters
 - o) All indoor, outdoor & street light fixtures shall be controlled directly from respective Lighting Panels, through MCB.
 - p) Each lighting panel/ Receptacle DB shall have minimum 2 spare circuits of 10/ 16A SPN outgoing feeders. A circuit consists of R, Y, and B Phase each.
 - q) Lighting for staircase shall be controlled with flushed modular switch. The conduit for main staircase shall be concealed. Lighting for all staircases shall be with 2 way switch
 - r) Contractor shall note that any chasing in walls or cutouts or openings such as fixing of LPs, DBs, switchboards, concealing conduit in wall etc. in walls required shall be made before plastering of brickwork wherever applicable and installation rates quoted shall be inclusive of chasing, cutting & making the plaster as per standard practice.

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- s) Lighting for street light fixtures/ flood light fixtures shall be carried out with cables. The supply of cables, junction boxes, street light poles & structural steel required for mounting fixtures/ LPs etc. are in the scope of Contractor. The cable wiring shall include supply & installation of cable required from LP to the junction box mounted on street lighting pole / near indoor fixture and also between junction box mounted inside pole/near indoor fixture to control gear box and same for flood lighting, supply and installation of all termination accessories such as lugs, cable glands etc. DBO Contractor's scope shall also include excavation, preparation of soil bedding, supply and installation of protection cover, back-filling, supply and installation of cable route markers etc.
- t) Point Wiring for lighting/ raw power receptacle/ emergency lighting:
- i. Point wiring covers the wiring between a circuit of the lighting panel to switchboard and then from switchboard to lighting fixtures connected to that circuit of the lighting panel.
 - ii. For receptacle circuits point wiring shall cover wiring between circuit of the lighting panel to receptacles connected to that circuit of the lighting panel.
 - iii. The scope of the Contractor shall include the supply, erection, testing and commissioning of the above LPs/ DB boards for supply of power to the various sockets required for computers, raw power points etc. The point wiring rate from these DBs shall include supply of wires, conduits, cleats/ clamps etc. as may be required and shall be in the scope of electrical Contractor.
 - iv. The conduit point wiring rate for exhaust fan shall include conduits/ casing capping, conduit/ casing capping accessories, Switch boards, PVC insulated wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, sheet metal switchboards fabricated out of 16 SWG. sheet steel housing 5 Amp piano switches. It shall include wiring from EXHAUST FAN DB/ RDB to switchboard & switchboard to exhaust fan as applicable. Neutral for individual circuit shall be run separate from DB to individual receptacles.
 - v. All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor under the scope of this contract.
 - vi. Required no. of 1-Ph & 3-Ph, industrial receptacles with respective 2P/ 4P ELCB (30mA) & 3/ 5 pin plug shall be provided for maintenance purpose.
 - vii. Receptacle & its ELCB shall be mounted in prefabricated CRCA box of 16 SWG, epoxy painted with shade 631 of IS-5. Earthing studs shall be provided for connecting external earthing with receptacle box.
 - viii. The Configuration of Industrial receptacle units shall be as per following – Combination
 - ☐ 240V, 1-Ph, 50Hz, 3 pin, 15A Industrial receptacles with RCBO (30 mA).
 - ☐ 415V, 3-Ph, 50Hz, 32/63A Industrial receptacles with respective RCBO (30 mA).
- u) Lighting Fixtures and Accessories:
- i. General

Normal supply voltage, phase and frequency		240 V, 1 ph, 2 wire, 50 Hz,
Variation in supply		
Voltage (AC & DC)		±10 %
Frequency		±5 %
Combined voltage & frequency		±10 %
Design ambient air temperature		50°C

- ii. The Luminaires 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 Luminaires 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 Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.
- vi. The Luminaires and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- vii. The Luminaires shall have a sturdy and corrosion resistant high pressure Die cast Aluminium housing with weatherproof gasket for lamp and control gear accessories. The Housing shall be Epoxy coated, without any cracks or thorough holes, made in a single piece of die-cast LM6 aluminium alloy. The luminaires shall be totally enclosed, dust tight and water proof.
- viii. Heat sink used should be aluminium extrusion having high conductivity. The dimensions of luminaires shall be optimum and adequate to permit sufficient heat dissipation, through the body itself, so as to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.
- ix. The Luminaire Housing shall be suitable for termination of Cable with Double Compression Cable Glands
- x. The optical system shall consists of individual PC lenses on high power LEDs designed & tested to achieve typical street lighting distribution from the LED lantern. These lenses provided for individual LEDs are to be fixed on lens plate in order to have consistent light distribution from luminaires. Luminaires should conform to the photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in IS 1944.

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- xi. Suitable number of LED lamps shall be used in the luminaires. The manufacturer shall submit the proof of procurement of LEDs from OEMs at the time of testing
 - xii. The Luminaires shall be provided with high tensile heat resistant toughened glass of minimum 0.8mm thickness or UV resistant polycarbonate cover fixed with stainless Steel screws.
 - xiii. An extruded silicon loop gasket shall be provided in the lantern body to ensure a weather proof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc. Luminaire should conform to degree of protection of IP 65 or above. Felt gasket will not be accepted.
 - xiv. Year of Manufacture, Batch No., Serial Number or Identification No. Luminaire Manufacturer's Name / Logo, Wattage and Frequency should be embossed on the housing.
 - xv. LED luminaires, should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. Lumen maintenance report as per LM 80 guidelines shall be submitted for the LEDs used along with the BID.
 - xvi. Luminaires should conform to the IS standards for Safety & Performance and test certificates as per IS 16107 should be provided by the manufacturer. In case of luminaires are imported, the CONTRACTOR shall conform to test parameters as per UL or equivalent standards.
 - xvii. The electrical component of the LED and LED driver must be suitably enclosed in sealed unit to function in environment conditions mentioned earlier.
 - xviii. All the connecting wires inside the Luminaire shall be low smoke halogen free, fire retardant cable.
 - xix. Adequate protection against Overloading, Short Circuit, Over Voltage, over temperature, Under Voltage, String Open shall be provided within the Luminaires.
 - xx. Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.
 - xxi. The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/ PAS 62612 depending on the type of luminaire.
 - xxii. All the material used in the luminaires shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.
 - xxiii. The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the Employer for verification of the required parameters and tests. CONTRACTOR shall confirm the same in the BID.
 - xxiv. The control gear shall comply with the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384 as appropriate.
 - xxv. The LED lighting fixtures offered shall comply with the following requirements;

Sr. No.	Parameter	Design Requirement / Value
1.	Type	Dimmable LED Luminaires complete with all accessories for Street Lighting
2.	Rated Voltage	230 V
3.	Expected Frequency	50 Hz +/- 3%
4.	Operating Voltage Range	150 V to 270 V
5.	Power Factor	> 0.90
6.	Operating Temperature Range	0 Deg C to 50 Deg C
7.	Working Humidity	10% - 90% RH
8.	Driver Type	Constant Current based Electronic Driver
9.	Driver Efficiency	> 92%
10.	Driver Life	>20000 hrs.
11.	Protection required in Driver module	
a.	Short Circuit	To be provided by the contractor
b.	Over Voltage	To be provided by the contractor
c.	Over Temperature	To be provided by the contractor
d.	Under Voltage	To be provided by the contractor
e.	String Open Protection	To be provided by the contractor
12.	Luminaires IP Protection	Minimum IP 65 for Outdoor Fixtures
13.	Minimum Surge Protection	>4 KV
14.	THD	≤ 15%
15.	Power Factor	≥ 0.9
16.	Rated Minimum LED Life (L70)	50000 Burning Hours
17.	Rated Minimum Driver Life	20000 Burning Hours
18.	CRI	>70
19.	Junction temperature rise	< 85 Deg C
20.	Solder point temperature	< 70 Deg C
21.	Maximum temperature rise for Driver	<30 Deg C at 45 Deg C ambient
22.	Make of LED	Cree / Nichia/ Philips / Osram

23.	Make of Driver	Cree / Nichia/ Philips / Osram
24.	Operating Hours	Dusk to Dawn (max 12 Hrs.)
25.	Efficacy of Luminaires	>92lm/W
26.	Colour Temperature	5000K – 6000K
27.	Illumination Regulation	<5%
28.	Material used for following	
a.	Housing	Die cast aluminium/ extruded Aluminium body with powder coated finish
b.	Heat Sink	Die cast aluminium/ extruded Aluminium body with powder coated finish
c.	Clip / Fasteners	Stainless steel.
d.	Diffuser	Toughened glass (0.8mm thick)/ UV stabilized Poly carbonate material
29.	Maximum temperature of Heat sink	<70 Deg C
30.	IK protection of Optic Cover	>IK05
31.	Wires used Inside Luminaires	Cu conductor, low smoke halogen free, fire retardant e-beam cable
32.	Cable gland IP protection	IP 65

xxvi. Each luminaires shall have a terminal block suitable for loop-in, loop-out and T-off connection by 230/ 415 V, 1 core, FRLS PVC insulated Copper conductor wires up to 4 sq. mm in size. In outdoor areas the termination at the luminaires shall be suitable for 1100 V, PVC insulated, Cu/ Al conductor, armoured cables of sizes up to 6/ 16 sq. mm conductor. Terminals shall be of stud or clamp type. The internal wiring should be completed by means of stranded Copper wire of minimum 1 sq. mm size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

xxvii. Mounting facility and conduit knock-outs for the luminaires shall be provided.

v) Earthing

- i. Each luminary shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
- ii. 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.

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- iii. 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.
 - iv. Earthing of each pole shall be carried out with one dedicated earth electrode. The earth electrode can either be a GI coil type or GI pipe/ rod type electrode. The GI rod/ Pipe electrode shall be 2.5 m deep and can be hammered directly into the ground where ordinary soil is present. For Hard strata, preparation similar to that mentioned in latest version of IS 3043 or the latest version of Rural Electrification Corporation (REC) manual can be carried out. For GI Coil earthing, preparation as per REC manual shall be followed. The earth electrode shall be connected with two 25X6 sq.mm GI strips to the two distinct earth boss on the pole.
- w) Painting/ Finish:
- i. 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.
 - ii. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
 - iii. The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodised as indicated under various types of fittings.
 - iv. 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.
 - v. The finish of the luminaries shall be such that no brigHV spots are produced either by direct light source or by reflection.
 - vi. External control gear box provided for housing accessories shall be painted or galvanised.

4.8.6. Outdoor/ Street Lighting Luminaries:

- a) LED luminaires:
- i. Street light LED luminaires shall be outdoor weather proof type for illumination of main roads, traffic islands etc. The luminaires shall have dimmable drivers.
 - ii. The luminaires shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.
 - iii. The luminaires shall be suitable up to 70/150/ 250 watts LED lamps and for mounting heights from 4 metres to 12 metres.
- b) Post Top Lantern:
- i. Post top lantern luminaries shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc.

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- ii. The luminaries shall have cast aluminium spigot 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.

4.8.7. External Light Poles-Street Light/ High Mast Flood Light (where applicable):

- a) All the Poles shall be designed to withstand the maximum wind speed as per IS 875. The top loading i.e., area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BSEN 40-3:2000, pr EN-40-3-3.
- b) 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 aluminium paint shall be applied. One steel ladder shall be provided separately. 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.
- c) 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.
- b) The pole shaft may have Octagonal or Conical cross section and shall be continuously tapered with single longitudinal welding as applicable. There shall not be any circumferential welding.
- c) All Octagonal or Conical pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside.
- d) The welding of Octagonal or Conical pole shaft shall be done by Submerged Arc Welding (SAW) or using high end MIG/ TIG Welding process. The welding shall be carried out conforming to approved procedures. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.
- e) The Octagonal or Conical poles shall have integrated Junction box with open able door of adequate size (approximate 600mm length) at the elevation of 750 mm from the base plate.
- f) The door shall be hinged type with mechanical interlock, dust proof, weather proof and vandal resistance and shall ensure safety of inside connections and components. The door shall be flushed with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.
- g) The door of the integral Junction Box shall permit clear access to the components inside viz., termination strips, connectors, MCBs, cables etc.
- h) The Octagonal or Conical pole shall be adequately strengthened at the location of the door to compensate for the loss in section.
- i) Material for Octagonal or Conical Poles shall be HT Steel Conforming to grade S355JO; Base plate shall be FE 410 conforming to IS 226/ IS 2062; and Foundation Bolts shall be of EN.8 grade.

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- j) Aesthetic appearance - All the grooves and carvings of the pole unit shall be free from any kind of distortion for a pleasing aesthetic appearance.
 - k) The Octagonal or Conical poles shall be hot dip galvanized as per IS 2629/ IS 2633/ IS 4759 standard with average coating thickness of 70 micron. The galvanizing shall be done in single dipping.
 - l) The Octagonal Poles shall be bolted on a pre-cast foundation with a set of foundation bolts for greater rigidity.
 - m) Top Mountings -The galvanized mounting bracket shall be supplied along with the Poles for Installation of the luminaires.
 - n) The Octagonal or Conical pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.
 - o) Electrical connections - Four way connectors shall be provided along with Slide lock suitable for connecting 1.1 kV grade, 4 C x 16 sq.mm Al cable. It shall also in-house 1 no. 6 amps DP MCB, 2.5 sq.mm connectors for looping with 2.5 Sq.mm Copper wires for connecting to the luminaire through 1.1 kV grade, 3 core X 2.5 mm² PVC insulated copper conductor flexible un-armoured Cable from the terminal block to the fixture within the pole. All the cables laid through the pipe shall be without any joint.
 - p) Two nos. Earth Boss shall be provided at the bottom of the pole (diagonally opposite) suitable for connecting 25X6 mm GI/ CU earth strip for earthing of the poles. Similar Earth Boss suitable for connecting 4 sq.mm copper wires shall be provided on the control plate inside the Junction Box for earthing of the electrical components.
 - q) Two nos. 50 mm NB HDPE sleeves of suitable length shall be provided through the foundation up to the Junction Box for entry of power cable.
 - r) The Contractor shall carry out all the relevant tests and inspection in the presence of the Employer or Third Party Agency, as may be selected by the Employer, before the dispatch of the poles at no extra cost to the Employer.
 - s) The CONTRACTOR shall inform the EMPLOYER at least Fifteen (15) days in advance, about the manufacturing schedule so that arrangement can be made for inspection. EMPLOYER reserves the right to waive the inspection at any stage.
 - t) All the material/ equipment/ accessories shall be supplied with manufacturer's test certificates.
 - u) CONTRACTOR shall submit the Proposed Product Catalogue, Detail Data sheet, spare parts list and drawing of Pole & Bracket along with the BID for each product quoted.
 - a) High mast shall be outdoor weather proof type for illumination of main roads and area lighting, wherever found necessary.

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- b) The high mast shall be continually tapered, polygon cross section, telescopically jointed steel fabricated construction. The mast shall be hot dip galvanised internally and externally. Weather proof door shall be provided near the base to permit access to winch, cables, plug, socket etc. The mast shall be designed for wind speeds depending upon wind pressure and direction as per relevant Indian Standards. Foundation bolts shall be included in the scope of supply.
 - c) The moving platform shall be of steel construction hot dip galvanised and designed to hold the number of flood light luminaires specified. The control gear boxes shall be cast aluminium weather proof type mounted on the moving platform. The moving platform shall be raised or lowered with the help of winch, pulley system and stainless steel wire ropes. The winch shall be suitable for hand operation or alternate by electric power.
 - d) The mast shall be suitable for mounting numbers of luminaires as required. The standard mast heights are generally from 16 to 30 meters.
 - e) CONTRACTOR shall arrange for all the tools and equipment including M20 concrete foundations shall be provided for all the poles. Approx dimension of the foundation for evaluation purpose is 600X600X1700 mm. However, CONTRACTORs shall design as per the stability requirement and Soil bearing Capacity of each location. The Poles shall be bolted on a pre-cast foundation with minimum four foundation bolts for greater rigidity.

4.8.8. Emergency Light Luminaries:

- a) Emergency light fitting shall be 240 V self contained 2 x 11 W fixture with built in Ni-Cd battery having charging facility and six hours back-up time. The emergency light fittings shall be provided at strategic locations of each house / area.
- b) Emergency fixtures shall come in service when AC supply fails.
- c) Pump room and Electrical room shall be considered for Emergency lighting.
- d) In addition to above emergency fixtures, every pump station shall be provided with two nos. of portable emergency luminary, which shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two metre length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaries.
- e) The luminaries shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal AC supply the luminary shall start automatically and on restoration of AC supply the luminary shall switch off automatically.

4.8.9. Testing:

- a) The Routine test on each of the offered Luminaire shall be carried out by the CONTRACTOR before dispatch. Following tests shall be carried out as Routine tests by the CONTRACTOR for the offered Luminaires;
 - (i) Visual and Dimensional check
 - (ii) Checking of documents of purchase of LED

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- (iii) Insulation resistance test
 - (iv) HV test
 - (v) Reverse polarity
 - b) The Acceptance test shall be carried out by EMPLOYER or EMPLOYER's Representative on a sample of the lot offered for Acceptance. The Lot shall be different from the lot from which the Type test samples have been drawn. The cost of the testing shall be borne by the CONTRACTOR. Following tests shall be carried out as Acceptance tests by the CONTRACTOR for the offered Luminaires;
 - (i) Visual and Dimensional check
 - (ii) Checking of documents of purchase of LED
 - (iii) Insulation resistance test
 - (iv) HV test
 - (v) Over voltage protection
 - (vi) Surge protection
 - (vii) Reverse polarity
 - (viii) Lux measurement
 - (ix) Test for IP 65 protection
 - c) Following Type tests reports shall be provided by the CONTRACTOR for the offered Luminaires along with the BID;
 - (i) Resistance to humidity
 - (ii) Insulation resistance test
 - (iii) HV test
 - (iv) Over voltage protection
 - (v) Surge protection
 - (vi) Reverse polarity
 - (vii) Temperature rise Test
 - (viii) Ra (Colour Rendering Index) measurement test
 - (ix) Lux measurement
 - (x) Fire retardant Test
 - (xi) Test for IP 65 protection
 - (xii) Endurance Test,
 - (xiii) Life Test
 - (xiv) Photometric Measurements Test Report (IES LM 79)
 - (xv) LED Lumen Maintenance Test Report (IES LM 80)
 - (xvi) Vibration test as per ANSI

4.8.10. Lighting System Equipment:

a) Main Distribution Boards and Lighting Panels:

- i. Main Lighting distribution board (MLDB) shall have MCCB as incomer & outgoing feeder with thermal magnetic release for O/L+S/C+E/F protections.
- ii. This MLDB shall feed to different Lighting Panels/ Lighting DBs for further distribution.
- iii. Where ever MLDB is not applicable, lighting feeder of appropriate rating shall be derived from the local distribution board. This feeder will feed to local LP catering to lighting requirements of that particular area.

b) 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-54 for indoor. 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 2.0 mm thick.
- ii. The lighting panel for outdoor lighting shall have a programmable timer for automatic control of lighting along-with contactor, MCB, auto/ manual selector switch.
- iii. All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets.
- iv. A slotted metallic sheet shall be provided inside. Only the MCBs operating knobs shall project out of the metallic sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with Four pole MCB + RCCB
- v. All accessible live connections/metals shall be shrouded and it shall be possible to change individual MCBs from the front of the boards/ panels without danger of contact with live metal.
- vi. 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.
- vii. 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.
- viii. Two earthing terminals shall be provided to suit the earthing conductor.
- ix. All sheet steel parts shall undergo rust-proofing process which should include 7 tank processing. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final epoxy based finish paint of colour 63I as per IS 5.

c) Busbars:

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- i. Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.
 - ii. Busbars shall be provided with at least the minimum clearances in air as per applicable standards.
 - iii. Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the bus bars, bus bar risers/droppers and contacts does not exceed 85° C under site reference temperature.
 - iv. The bus bars, bus bar connections and bus bar supports shall have sufficient strength to withstand thermal and electro-mechanical stresses of the MCB's let through/cut-off current associated with the specified short-circuit level of the system.
 - v. Busbar supports shall be SMC type. Separate supports shall be provided for each phase of the bus bars.
 - vi. The neutral bus of the main 3 phase, 4 wire distribution board shall be 100% of the phase busbars.
- d) Panels/ Boards' Component & Lighting Accessories:
- i. MCB/ ELCB :
 - ☐ MCBs shall be C curve type for lighting panels.
 - ☐ For all the lighting panels RCCBs shall be with 100 mA sensitivity & for all receptacles RCBO sensitivity shall be 30 mA.
 - ii. MCCB :
 - ☐ MCCB requirements shall be as per specified in the LV switchgear requirements & as specified above.
 - iii. Indicating Instruments and Meters:
 - ☐ 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.
 - ☐ Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
 - ☐ Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.
 - ☐ Potential fuses shall be provided at the tap-off point from the bus bars for the voltmeters.
 - iv. Instrument Transformers:

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- ☐ Current and voltage transformers shall be of cast resin type, with insulation class B, & accuracy class 1.0 unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
 - ☐ Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.
 - ☐ Voltage transformers shall be provided with suitably rated primary and secondary fuses.
- v. Indicating Lamps:
- ☐ Indicating lamps shall be of the clustered LED type, low watt consumption.
- vi. Internal Wiring
- ☐ Panels/ boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 1.1 kV grade, FRLS PVC insulated, multistranded Copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
 - ☐ Cross Ferruling i.e., engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.
 - ☐ All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make of approved list, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current, the minimum rating shall be 20 A.
 - ☐ Terminals for circuits with voltage exceeding 125 V shall be shrouded.
 - ☐ Terminals shall be numbered and provided with identification strip for identification of the circuit.
 - ☐ Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.
- vii. Labels & Diagram Plate:
- ☐ All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/ panel.
 - ☐ Labels shall be made of non-rusting metal, 3-ply lamincoid or engraved acrylic
 - ☐ Inside the door of the 1 phase ways lighting panels a circuit diagram/ description shall be fixed for reference and identification.

viii. Conduits:

- ☐ 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.
- ☐ Steel conduits shall be seamed by welding and hot dip galvanised. They shall be supplied in standard lengths of 5 metre.
- ☐ Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work.

ix. Junction Boxes:

- ☐ Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, three (3) phase receptacles etc.
- ☐ The junction boxes shall be dust and vermin proof and shall be fabricated from 14 SWG 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.
- ☐ 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.
- ☐ 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, galvanised 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.
- ☐ The boxes shall be painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.

x. Lighting Poles and Flood Light Pole Mounting:

- ☐ 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 aluminium paint shall be applied.
- ☐ Poles for mounting flood lights shall be supplied whenever required and as per typical attached drawing. Unless otherwise specified, poles shall be painted with red lead oxide primer and two coats of aluminium paint. One steel ladder shall be provided separately. 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.

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- ☐ 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.
 - ☐ Outdoor JBs shall be minimum IP 55 protected.
 - ☐ Cable entry for street lighting junction boxes shall be from bottom.
 - ☐ Rain water canopy shall be provided at the top for the outdoor JBs. Terminal strip shall be provided for looping loop out of cables.
 - ☐ Street lighting JB shall consist of terminal strip (3 ways) for looping in & loop out of cables. The JB shall be provided with 6A MCB (C- Curve type) for isolation of lighting fixture, as well as sufficient arrangement (earthing studs) for termination of 2 nos. earthing connections.

xi. Ceiling Fans/ Wall Mounted Fans:

- ☐ Ceiling/ Wall mounted fans shall be suitable for operation on 240 V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc for ceiling fans and easy accessibility for wall mounted fans. The fans shall be supplied with appropriate speed regulators.
- ☐ Exhaust fans, where ever required shall also be provided. The exhaust fan with all parts shall be according to IS: 2312- 1967 & its latest amendment with IP-55 specification. The exhaust fan shall have epoxy powder coating with specially pretreated components for better resistance to corrosion and acid alkali flumes. The exhaust fan shall have totally enclosed highly efficient heavy duty motor with pressure die cast aluminum rotor mounted on two ball bearings.
- ☐ The fans shall generally conform to the applicable standards indicated in Tender. Details regarding blade sweep and suspension requirements shall be as per Project layout drawing/price schedule.

4.8.11. STREETLIGHT FEEDER PILLAR/ SWITCHING POINT:

- a. All Feeder Pillars (FP) shall be Outdoor type, Wall/ Column/ Steel Support mounting, Weatherproof, double door, single front, non-compartmentalized enclosure with locking facilities.
- b. The OFP (Outdoor Feeder Pillar) shall be made of Galvanised sheet steel enclosure. All the feeder pillars shall be Outdoor type with permanent rain canopy and shall be dust, damp and vermin proof. All feeder pillars shall conform impact resistance of IK10 and shall be minimum IP54 certified.
- c. The GI feeder Pillar shall be fabricated from 3 mm CRCA sheet and shall be Hot Dipped Galvanized as per relevant latest standards after entire fabrication. The enclosure shall be

powder coated with Epoxy paint as per desired colour of DSCDL. The gland plate shall be 3mm thick.

- d. The fabricated enclosure shall not have any welds or bolt heads apparent from outside. All fabrication work like cutting, drilling, punching, shearing & welding etc. related to the enclosure shall be complete before proceeding to 7 tank process. The fabricated body shall be thoroughly cleaned and treated by chemical agents as required to produce a smooth surface free of scales, grease and rust.
- e. Sheet metal components shall be pre-treated using the seven tank phosphating process consisting of de-greasing, acid pickling, de-rusting, phosphating and passivation including repeated rinsing in between each process. On completion of passivation of the components they shall be preheated and then epoxy powder coated with selected shade for exterior as well as interior and Glossy White shade for the gland plates (Inside the panel) and component mounting plate.
- f. All interiors and exteriors of the enclosure shall be finished and painted to prevent rusting and corrosion. The paint should be carefully selected to withstand tropical heat, rain and environmental effects. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. Thickness of all painting shall be minimum 80 - 100 microns DFT. The final colour of Feeder pillar shall be as per DSCDL requirements.
- g. The gasket shall be of neoprene rubber suitable to withstand all weathers for long tenure of service. All hardware shall be made of non corrosive material either HD Galvanized or stainless steel. Door shall be with concealed type hinges & captive screws.
- h. Both the doors shall have an Inspection/ View Window for monitoring the energy meter reading without opening the door. The window on the external door shall be provided with a metal flip cover with small canopy which can be moved up and down for viewing the meter.
- i. Both the doors shall have panel type lock with keys in duplicate.
- j. All the feeder pillars shall be of uniform height and shall be mounted with the bottom of the panel at minimum 500mm above the Finished Ground or Floor level as the case may be.
- k. A danger notice board written in English, Hindi and Assamese shall be made of 2mm thick GI plate and shall be provided on the front door of the feeder pillar.
- l. The details of max load in KW, Rating of Incomer, no of phase, voltage, frequency, controller no., Meter No., road name, Pillar no. name of the agency and year of erection shall be labelled using radium sticker/radium paint.
- m. The feeder pillar shall consist of Incoming Four Pole (FP) RCBO or MCB with ELCB, 3 Phase smart Energy Digital Meter, FP Contactor for each outgoing circuit, Astronomical Timer, Outgoing FP MCB apart from all the smart control components like Gateway controller, Power Supply Unit for the Gateway unit, Battery for Back up etc. It shall also consist of FP Isolator for isolating the smart lighting control equipment without discontinuing supply to the light pole during the outage of the smart control system.
- n. The feeder pillar shall have cable entry at the bottom suitable for terminating double compression glands for 2 Runs of 3.5 C 50sqmm Aluminium conductor, XLPE insulated

armoured cable at the incoming terminal and minimum 4 Runs of 4 core 16 sqmm Aluminium conductor, XLPE insulated armoured cable at the outgoing terminal.

- o. All MCBs/ RCBOs/RCCBs shall be comply with the relevant IS and IEC standards. It shall be current limiting type and shall provide a cut off in, < 10 ms for prospective currents during faults. It shall be provided with fixed thermal overload, short circuit and earth fault release as appropriate. The breaking capacity of the MCB shall be 16A for 1 sec.
- p. The Outgoing and Incoming breakers shall be discriminated based on Current.
- q. The other power and control components are as listed below;
 - i. The minimum rating of the incomer shall be 32A, 100mA sensitivity, Current limiting type, Characteristic Curve C, Breaking capacity 10 kA for 1 sec.
 - ii. All the contactors shall have high rupturing capacity rated for 3 phase 440 V, 50 Hz, Four Pole, AC 3 duty.
 - iii. Astronomical timer having Single channel and capable of Auto resetting when power resumes, provision of manual over ride, switching ON / OFF the circuit as per the Sun set and Sun rise timings along the year.
 - iv. Min 25X3 mm tinned Copper bus bar with SMC support insulators shall be provided for power distribution within the feeder pillar. The size of phase and neutral shall be equal.
 - v. Outgoing FP RCBOs – 30mA sensitivity, Current limiting type, Characteristic Curve C, Breaking capacity 10 kA for 1 sec.
 - vi. Terminal connectors suitable for terminating the above mentioned cables. Min 12 nos. 25 sqmm terminals for incoming cable and Separate 5 nos. terminals shall be provided for tapping power for the luminaire with 2.5 sqmm Copper conductor PVC insulated Un-armoured cable. Twenty percent spare terminals shall be provided.
 - vii. Under voltage and Over voltage Monitoring Relay for connection and disconnection of the power during off band abnormal voltage within a time band.
 - viii. All connecting power & control wiring shall be carried out with stranded copper conductor PVC insulated LSHF wires. Minimum size of control wiring shall be 1.5 sqmm and power wiring shall be 4 sqmm.
 - ix. Space Heater with MCB and Thermostat and 7W LED Luminaries with lamp shall be provided inside with a door limit switch. The lamp and the heater shall be tapped from the outgoing of the meter with separate DP MCB circuits.
 - x. An Aluminium / GI Earth bus shall be run at the bottom of the Feeder Pillar which shall be connected to the earth leads at the two extreme ends for connecting the GI earthing strip from the electrode.
 - xi. Cast Resin CT of appropriate rating (---/5A) shall be provided at the incomer of each phase for measurement of the current.
 - xii. Multifunction meter with RS 485 and RJ 45 connectivity for measuring, Line and Phase Voltage/ Current; kW, KVAR, KVA; kWh kVAh, kVARh (L & C); Frequency, Phase wise Voltage and Current Harmonics upto min 7th order; Maximum demand.
 - xiii. CONTRACTOR shall provide provision for connection through SIM, Ethernet, RS 485 and OFC to connect with server through whatever mode is available at site.
- r. Two nos. Pipe Earthing electrode shall be provided for each Feeder pillar and connected with 25X6 mm GI earth strip. The pipe electrode shall be as per the latest version of IS 3043.

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- s. HDPE/ DWC pipe of suitable size (minimum 40 mm ID) for conveniently accommodating the above incoming and outgoing cables shall be laid upto the feeder pillar for carrying the buried cables upto the feeder pillar for termination. The GI strip for earthing shall be laid with proper dressing.
 - t. The feeder pillar shall be mounted on prefabricated Galvanised Steel Support structure duly fastened with a concrete foundation with M20 concrete suitable to sustain the local geological conditions, seismic conditions and max wind speed requirements.
 - u. All the material/equipment/accessories must confirm to the relevant IS with its latest amendments. All the material/equipment/accessories shall be supplied with manufacturer's test certificates.
 - v. Insulation resistance between live parts and earth terminal shall be 5 MΩ minimum. All power equipment shall be able to withstand high voltage (HV) test at 1.5 kV for 1 minute between live parts (current carrying parts) and earth terminal without breakdown of insulation.
 - w. Following documents needs to be submit for approval
 - i. General Arrangements drawing.
 - ii. Support and foundation drawings
 - iii. Wiring diagram.
 - iv. QAP (Quality assurance Plan).
 - v. Datasheet for each component.
 - x. Routine test shall be conducted as per relevant IS/IEC and shall be carried out at manufacturer place and same shall be witnessed by DSCDL/DSCDL's representative. Following shall be minimum check
 - i. Visual inspection Check
 - ii. Bill of material.
 - iii. Electrical Continuity check.
 - iv. Functional Check.
 - v. HV insulation check.
 - y. Type Test certificate shall be submitted for review.

4.9. L.V. MOTORS

- 4.9.1. Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85% of the rated motor voltage.
- 4.9.2. The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard).
- 4.9.3. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.
- 4.9.4. Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

4.9.5. INDUCTION MOTOR (SUBMERGED) (AS APPLICABLE)

- 4.9.5.1. The motor shall be of Squirrel Cage, Induction type, Air Filled yet capable of Water immersion up to 20mwc for S1 duty – Motors with Oil or Water filled windings shall not be allowed.
- 4.9.5.2. It is rated for 415 (+/-) 10 % V, 3 phase 50 (+/-)5% c/s A.C. Its winding should be of Class “H” insulation * (withstanding winding hot spot temperature of up to 185°C respectively) while the nominal temp rise of winding hotspot should not exceed that of class “B”.
- 4.9.5.3. It should be wound using Dual Coated, Super Enamelled; Copper wire with high temperature index as per I.S. 4800 Part-13. PVC / Poly propylene – poly ethylene insulation for winding wires shall not be allowed. Motor’s Insulation should be Vacuum Varnish Impregnated & Oven Baked to ensure Moisture Impervious & Mechanically Robust insulation. Dip or Pour type Air Dry Varnishing shall not be allowed.
- 4.9.5.4. The Motor Rating should be higher of the two criteria: Maximum power consumption throughout the range of performance at 50 Hz OR 15 % more power consumed at duty point at 50 Hz.
- 4.9.5.5. Selected Min Motor Rating (Round off to next available size contractor is to offer this as Minimum rating irrespective of the Pmax or BkW of his selected pumpset)Standard commercially available motor ratings are :
- 3.7, 5.5, 7.5, 9.3, 11, 15, 18.5, 22, 30, 37, 45, 55, 75, 90, 110, 132, 160, 200, 250, 315, 400, 450 kW
 - Do not select less than 3.7kW under any circumstances

The motor Rotor shall be of Dual cage Copper Bar Brazed type* to assure:

Long Corrosion free Service life.

Easy of On site Repairing.

Beneficial Fly Wheel type Inertial effect which reduces detrimental effects of water hammer.

Better Motor Efficiency & Cooler Operating Temperature

4.9.5.6. Motor Cooling :

To restrict the Dead Water Level (in case of Vertical Installation) in the Sump to 1m, Medium & Large sized pumps ($\geq 55\text{kW}$) should have a Cooling Jacket – i.e. motor cooling is accomplished by circulation of pumped water between the motor casing & the jacket shell. This jacket shell is fed by cold water from the pump casing & discharges its heated water back into the sump (in case of Wet Installation) or Pump casing (in case of Dry Installation) by integrally cast ducts. There should not be any pipes, hoses, etc for this circulation.

In case the pumps are to be installed horizontally OR the dead water level in the sump or well exceeds 1.5 mts. From the pump center line, the motor can be cooled just by water immersion i.e. no jacketing is required. The mode of cooling (either direct immersion or via. Jacket cooling)

4.9.5.7. Motor Protection

Thermal Overload Protectors (Bi Metallic Over Load Relays) should be embedded in each phase of the stator winding to detect overheating & trip the motor from the control panel in the event of the temperature exceeding the safe operating limit (above 130 °C).

To detect primary Mechanical Seal's Leakage a Moisture Sensor shall be provided in intermediately Oil Chamber (& not in the Motor casing or else where) – this shall detect water mixing in oil by mode of increased leakage current from the moisture sensor.

4.9.5.8. Cables

A watertight Cable Junction Box sealed from the motor shall be provided for the motor power and signaling cables.

The cable shall be brought directly out of the submerged motor without joints, and shall be of sufficient length as per price bid to be terminated in an IP 67 junction box outside adjacent to the wet well & above the HFL. They shall be sized in accordance with the electricity utility regulations and BS 7671.

It should have Power as well as Control Cables of Dual Sheathed EPRS / PVC Armored type with Copper Core of required size as per detail engineering. However the Cross Section of the cable shall be ample enough to ensure a Voltage Drop of not more than 2% at actual site conditions.

4.9.5.9. Shaft & Bearings

The Solid Shaft shall be supported by heavy duty Ball or Roller bearings with a minimum L10 life of 75,000 hours in accordance with BS 5512. The bearings should be Permanently Greased with Premium Quality, High Temperature, Long Life Grease thereby obviating the need of re-lubrication for upto L10 life of the bearings. The Bearing should be of metric series & not imperial only.

Oil Lubricated bearings shall not be allowed.

In case the motor is to be driven via a VFD, atleast one of the bearings (DE or NDE) should be Current Insulated to prevent “electric fluting damage” caused by Harmonics.

4.9.5.10. Stuffing Box / Oil Chamber

The pressurized entry of water into the motor (from the pump's volute casing) should be prevented by Two separate mechanical seals in mounted in a Tandem mode within an oil chamber.

The Primary (Inboard) seal should be of Silicon Carbide or Tungsten Carbide faces to withstand erosive wear due to any silt particles.

The Secondary (Outboard) seal should be of Carbon v/s Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide – i.e. Thermally Unstable materials like Alumina/ Aluminum Oxide shall not be allowed.

4.9.5.11. Materials of Construction

Unless otherwise specified in Data Sheet, the Material of Construction for the pumps shall be as follows:

Motor casing, oil chamber & other parts	CI IS: 210 Grade FG 260 or GG25 or EN JL1040
Rotor of submersed motor	Aluminium Die Cast or Dual Cage Copper Bar (for motors \leq 300 HP)
	Dual Cage Copper Bar (for motors > 300 HP)
Motor cooling jacket (if applicable)	SS 202 or Epoxy Coated MS

4.9.5.12. TESTS:

INSPECTION AND TESTING AT MANUFACTURER'S WORKS

The motor shall be tested in accordance with relevant IS with or without VFD.

In case of manufacturer not having adequate testing facility within reasonable distance; the motors should be tested at the Alternative Test Bed or at Field within 30 days of installation which the contractor/ manufacturer is bound to offer at no extra cost. The Field Testing shall include the following:

- Motor Routine Tests:
- IR
- HV
- No load amperes, Vibration etc.

Pump Performance Testing (in accordance with IS 5120 / IS ISO 9906, Grade 2 -5% / ISO 2548-5%) :

- (1) Measurement of Head, Discharge, Motor Input at at least 6 different points to plot the Actual Performance Curves

All the Extra Charges for such Field Testing shall be borne by the Contractor. It is clarified that, in case of Field Testing Failure; client reserves the right to detain the pumps in their custody until the contractor replaces the failed pumps with New pumps which shall again be subjected to Retesting. No extra charges shall be allowed by Client to the contractor.

Pump testing should be carried out preferably with VFD. In case the pump sets are to be used with VFD then the testing has to be conducted compulsorily with VFD.

4.10. DC SYSTEM

- 4.10.1. Scope: DC system (as applicable) shall include the following:

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- a) One set of 24/ 30V or 110 V DC, maintenance free rechargeable sealed lead acid batteries of adequate AH capacity shall be provided for control of electrical switchgears in the Plant.
 - b) Batteries shall be provided with battery charger cum DC distribution board. Battery charger shall include a float & float cum boost charger, indicating lamps and annunciations.

4.10.2. Sealed Maintenance Free Lead Acid Battery.

- a) Applicable Standards: The sealed maintenance free lead acid battery shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification this specification shall govern.

Sealed lead acid: IS: 1651, 1652 BS: 6290

- b) The sealed batteries shall be a starved electrolyte type with electrolyte immobilized in a micro-porous material to allow recombining of generated oxygen internally. The battery shall be completely explosion resistant, shall tolerate freezing and shall not allow gases to escape during normal charging conditions. The battery shall not require any watering and be maintenance free.
- c) Positive Plates: Positive plates shall be either of cast solid in pure lead in one piece with plate formation and shall have adequate mechanical strength or of tubular plate which shall consist of a suitable bar with spines cast of suitably alloyed lead to give adequate mechanical strength or of pasted positive plates consisting of either pure lead, low anti-monial lead alloy or lead calcium positive grids; having double separation with a glass wool retainer mat or any other suitable material placed against the surface of the positive plates for good service life.
- d) Negative Plates: The negative plates shall normally be of the box type. End negative plates, if of box type may be of the half pasted type. Pasted plates shall have adequate mechanical strength and shall be so designed that the active material is maintained in intimate contact with the grid under normal working conditions.
- e) Containers: The containers shall be made of plastics, or fiber reinforced plastics (FRP). The container shall be spill proof, leak proof, explosion resistant and increased safety type enclosure.
- f) Vent Plug: The vent plug shall be for safety pressure vent and of self resealing type.
- g) Separators: The plate separator shall consist of a micro-porous matrix which shall serve as the mobiliser for the electrolyte. The battery separator shall maintain the electrical insulation between the plates and shall allow the electrolyte to permeate freely.
- h) Connectors and Terminal Posts: Inter-cell and inter-tier connectors and terminal posts shall be of Copper. 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 terminal connections. All the metal parts of the terminals shall be lead coated. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

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- i) Electrolyte: The electrolyte shall be battery grade sulphuric acid conforming to latest editions of relevant standards. The sealed battery shall be transported with the electrolyte immobilized, sealed and fully charged.
 - j) Accessories: The battery shall be complete with accessories and devices, including but not limited to the following:
 - i. Battery racks
 - ii. Set of inter cell, inter-tier and interbank connectors as required for the complete installation.
 - iii. One Voltmeter with suitable range and leads for measuring cell voltage
 - iv. Insulated wrencher.
 - k) One set of terminals and cable boxes with glands for connecting cable as required.
 - l) Battery Racks: Battery racks shall be constructed from good quality teak wood and painted with two coats of approved alkali resisting paint. The construction of the racks shall be suitable for fixing to a flat concrete floor. The racks shall be rigid, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form a continuous row. Insulators shall be provided below the legs of the stands.
 - m) Capacity: The standard ampere-hour capacity at ten hour rate of discharge of the battery has been based on the requirements of loads as applicable and the minimum ambient temperature specified. Contractor shall guarantee that the capacity of the battery offered by him is adequate for the duty specified (all loads being coincident from the instant of supply failure even at the minimum ambient temperature as specified) assuming that the battery is fully charged to
 - i. 2.15 V at the start of the cycle
 - ii. 1.75 V/ cell at the end of the cycle.
 - n) The Battery sizing basis shall be IEEE 485 & the Contractor to note that the Battery sizing shall be done considering design ambient temperature of 50° C & following factors.
 - i. Design Factor- Min. 1.1
 - ii. Aging Factor- Min. 1.25
 - iii. Temperature Correction Factor- Min. 1.1
 - o) Cell Identification: Each cell shall be marked in a permanent manner to indicate the following information:
 - i. Cell number
 - ii. Type of positive plate
 - iii. Ah capacity at 10 hour rate

iv. Type of container

v. Manufacturer's name

vi. Month and year of manufacture.

- p) Drawings/ Document: The complete battery layout drawing shall be furnished as part of the tender and also after award of contract for Employer's approval

4.10.3. Battery Chargers:

- a) 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.

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
Transformers and inductors (power, audio, pulse and switching) 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:4007
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:439
Air break switches	IS : 13947 (Part –3)BSEN 60947-3
Miniature circuit breakers	IS 8828/BSEN:60898
HRC cartridge fuses	IS:9224/BS:88
Contactors	IS:13947 (Part – 3) /BS:775/ IEC:158-1
Control switches/push buttons	IS:6875
Degree of Protection	IS:13947- (Part 1) /IEC:947-1
Climate-proofing of electrical equipment	BSCP:1014
Code of practice for phosphating iron and Steel	IS:6005/BS:3189
Semi-conductor converters	IEC:146
Semi-conductor rectifier equipment safety code	IS:6619
Specification for copper rods and bars for electrical purposes	IS: 613

- b) Requirements: The Battery Charger shall be microprocessor based & shall have two chargers mainly- i) Float Charger ii) Float cum Boost Charger.

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- c) The float & float-cum-boost type battery charger shall comprise silicon controlled rectifiers (SCRs) connected in a full wave bridge circuit. Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic. Microprocessor shall be MU 1000C or Equivalent makes from the approved makes.
- d) The rectifier transformer shall be dry type and double wound with required number of taps. The DC output voltage during float charging shall be stabilized within $\pm 1\%$ of the set DC bus voltage for AC input voltage variation of $\pm 10\%$, frequency variation of $\pm 5\%$ and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content shall be within $\pm 1\%$ of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of $\pm 1\%$. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%. The setting of the output DC bus voltage shall be adjustable between $\pm 10\%$ of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.
- e) If the spare float charger supplying DC load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes. Two blocking diodes in series shall be provided to take care of short circuit of any one diode
- f) 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. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilized within $\pm 2\%$ for AC input voltage and frequency variation of $\pm 10\%$ and $\pm 5\%$ respectively. There shall be provision for manual control if auto-mode fails. The boost charge voltage and current settings shall be adjustable between 70 to 100% of maximum boost charge voltage and between 30 to 100% of maximum boost charging current.
- g) Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.
- h) In the float charging mode, the charger shall be designed for supplying:
- i. The DC loads of control, indication and annunciation circuits that remain energized during normal operation and the momentary closing and trip coil loads of circuit breakers, vacuum contactors; and
 - ii. The float charging current of the battery.
 - iii. 25% margin over the above load.
- i) Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 42. Sheet steel used for construction shall be 2 mm thick. The units shall be wired using 1100 V grade, FRLS PVC insulated, multi-stranded Copper conductor cables.
- j) During boost charging the DC bus load shall be connected via two diodes in series connected to the tap cell of the battery. This is to take care in case of failure of standby charger supplying DC load.

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- k) 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 marked test pins.
 - l) 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.
 - m) All components and modules shall be clearly and unambiguously marked and all wiring colour coded and tagged
 - n) Each battery charger shall be provided with accessories that include, but not limited to the following:
 - i. 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 $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance. The controller shall also be suitable for boost charging the battery in case of float-cum-boost charger.
 - ii. Boost charge current limiter with potentiometer to adjust the setting
 - iii. Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.
 - iv. 240 V AC compact fluorescent lamp fixture for internal lighting with MCB
 - v. Automatic voltage regulator unit with Manual/ Auto control switch
 - vi. Double wound, dry type, three phase suitably rated mains transformer with fuse protection and with one set of power factor correction capacitors to maintain a power factor of 0.85 (lag).
 - vii. 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 $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, earth fault, set output voltage and phase failure or voltage unbalance.
 - viii. 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.
 - ix. Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit
 - x. Coarse and fine control potentiometers for manual control

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- xi. Selector switch for mode of charging i.e. float charging / boost charging
 - xii. Off-load tap changing switch for changing the taps of the transformer
 - xiii. DC voltmeter with fuses and a three position selector switch
 - xiv. DC ammeter with shunt
 - xv. AC ammeter with selector switch for incoming AC power
 - xvi. AC voltmeter with selector switch for incoming AC power
 - xvii. MCB for incoming AC supply along with surge suppressers
 - xviii. MCB on DC output side with kick fuses and alarm contacts
 - xix. Voltage dropping diodes in load circuit during boost charging mode
 - xx. DC under voltage relay and earth fault relay
 - xxi. AC/ DC switching relays for alarm and indication circuits including buzzer
 - xxii. Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat
 - xxiii. Each battery charger shall be provided with the following alarms / indications:
 - ☐ AC and DC supply 'ON'
 - ☐ AC and DC supply fail
 - ☐ Modes of charging
 - ☐ Over voltage
 - ☐ Under voltage on DC side
 - ☐ Earth fault on DC side
 - ☐ AC/ DC MCB trip

o) The DC circuit switching shall be through DC MCBs only.

p) Power Electronic Components:

- i. Diode and thyristors shall be of mono-crystalline type silicon, capable of providing 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.

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- 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 thyristors shall be protected against overvoltage due to chopping surges with the aid of snubbers (i.e resistor-capacitor combination and Metal oxide variator

4.10.4. DC Distribution Board:

- a) The distribution board shall be of floor mounting design. Entry for incoming and outgoing cables shall be from the bottom. Bus bars shall be of Copper. Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs suitable for DC application.
- b) Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.
- c) An earth busbar of 25x3 mm copper flat shall be provided along the length of the DB at the bottom. Two nos. earthing terminals shall be provided on the external face of the board for connection to the earthing grid.

4.10.5. Tests:

- a) The batteries, chargers and distribution boards and their components shall be subjected to routine/ acceptance tests as per the applicable standards. For battery & battery charger, following tests are also to be carried out:
 - i. Visual checks for dimensions and general arrangement.
 - ii. Wiring checks.
 - iii. Functional checks.
 - iv. IR Test.
 - v. Capacity test.
 - vi. Test for voltage charging and discharging.
 - vii. Ampere-hour and watt-hour efficiency test.
 - viii. Hipot test, excluding electronic controller, at 2 kV AC for one minute.
- b) Certificates of type tests carried out on similar equipment not older than 5 years shall be furnished by Contractor.

4.10.6. Drawings/ Documents Required:

After award of contract Contractor has to submit the below mentioned drawings/ documents for Employer's approval :

- c) Dimensioned general arrangement drawings
- d) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details
- e) Complete schematic and wiring diagrams.
- f) Detailed BOM for the complete panel, with details of switchgear, controller, components etc.

4.11. DIESEL STANDBY GENERATOR:

4.11.1. **Applicable Standards :** The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 4722
Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V AC or 1200 V DC	:	IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	:	IS-2705/BS-7626, IEC-60185
Voltage transformer	:	IS-3156/BS-7625/IEC 60186
Electrical Relays	:	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	:	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	:	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse	:	IS-9385/BS-2692/ IEC-60282

Low Voltage Fuse	:	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating instruments	:	IS-1248/BS-89/IEC-6005
A.C. electricity metres of induction type voltage greater than 1000 volts	:	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452/BS-3676
Control switches/push buttons	:	IS-6875/BSEN 60947
Noise and Emission Limit	:	As per latest notification of ministry of Environment and Forests

4.11.2. General Requirements:

The diesel engine and generator shall be skid mounted and shall be located in a room near Treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weatherproof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for DG capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. In case more than one D.G set is required for achieving the required capacity they shall be operated in parallel with necessary synchronizing arrangement. At no point DG sets will be operating parallel with grid.

The diesel engine fuel shall be stored in an above ground bulk storage steel tank to be located adjacent to the generator room at a site accessible for filling to local road tankers. The storage tank shall be sized to store fuel for one (1) day running of the engine at full load. The tank shall be provided with fittings to permit the visual observation of fuel level and filling by local tanker operators. A level meter shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

The fuel storage tank shall be located in a bund capable of holding not less than 125 % of the maximum storage tank contents. Fuel transfer pumps shall be provided to automatically transfer fuel from the bulk storage tank to a high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally) and if a high level day tank is used, to automatically dump the day fuel back to the bulk storage tank.

The system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm.

The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

All alarms shall be conveyed to the central HMI through the PLC.

4.11.3. Diesel Generating Set Automatic Control

AMF Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure. Diesel generating set for use in auto mains failure mode shall have a three position automatic / off / manual selection and shall operate as follows:

(i) Automatic mode :

On occurrence of mains failure the following sequence shall be followed.

Mains to Generator changeover

- mains failure detected
- delay of 10 seconds
- generator is started and run up to speed
- time delay of 50 seconds
- mains supply is switched off
- generator supply is switched on

Generator to Mains changeover

- mains healthy detected
- manual changeover signal received,
- generator supply is switched off
- mains supply is switched on
- generator runs for 2 minutes and stops

All timer settings shall be adjustable.

If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

4.11.4. Alternator for Diesel Generating Set:

The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be 11kV for capacity more than 2MVA.

Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field, brushless type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000 : Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23. The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for regreasing whilst in service.

The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in IS 12075.

The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation heater. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, its neutral and control panel shall be earthed as per relevant standards.

The alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within $\pm 2.5\%$ for a power factor of 0.8 to unity, including hot to cold variations. The steady state frequency droop between no load and full load shall not exceed 5%. Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second. The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within $\pm 5\%$ of rated.

4.11.5. Diesel Engine for Generating Set:

Engine shall be four strokes, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than $\pm 5\%$ of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2. Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated. Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer. The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energised battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfill the starting requirements. Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the hand turning equipment is connected. Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbocharger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion.

Machined surfaces shall be incorporated for mountings and for leveling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for leveling purposes and shall be designed to resist horizontal movement of the diesel set.

The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe etc.

4.11.6. Diesel Generator Control Panel:

The control panel shall be separately mounted on anti vibration mountings and shall Comprise the following:

- ☐ Breaker incorporating short circuit and overload trip
- ☐ Earth fault protection for the Alternator

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- ☐ Alternator Over & Under Voltage Protection
 - ☐ Voltage Controlled Over Current Relay
 - ☐ voltmeter and seven position selector switch
 - ☐ ammeter and 4 Position selector switch
 - ☐ frequency meter
 - ☐ Power Factor Meter
 - ☐ kWh Meter
 - ☐ engine temperature and oil pressure gauge
 - ☐ service hours run indicator
 - ☐ key switch start and stop control
 - ☐ operational status indicator
 - ☐ anti-condensation heater and thermostat
 - ☐ alternator anti-condensation heater controls
 - ☐ mains fed battery charger
 - ☐ Auto start on mains power supply failure facility
 - ☐ Fails to Start (Alarm)
 - ☐ Over / Under Voltage Alarm
 - ☐ Battery Charger Fault (Alarm)
 - ☐ Low fuel Oil Level (Alarm)
 - ☐ Over Load (Alarm)
 - ☐ Low Lube Oil Pressure (Trip)
 - ☐ High Water Temperature(Trip)
 - ☐ High Lube Oil Temperature (Trip)
 - ☐ Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting. Simple operating instructions shall be detailed on the fascia of the control panel.

4.11.7. Synchronizing Panel

Whenever two sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchroscope, relays, meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

4.11.8. Acoustic Enclosure

- a) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
- b) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam /glass wool as acoustic material.
- c) The sound level shall be restricted to 75 dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
- d) The acoustic enclosure shall be certified to meet the emission norms.

4.11.9. Bulk Fuel Storage Tanks

Tanks and fittings, etc shall conform to IS 803 or BS 799: Part 5. The tank shall be constructed in mild steel and the fittings in materials other than:

- Yellow brass, including low grade alloys of copper and zinc.
- Lead and zinc.

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- Galvanized metals.
 - Natural rubber.

An ullage volume above maximum contents level of the tank shall not be less than 5% of the maximum volume of the fuel. The maximum fuel surface level below the point of entry of the vent shall not be less than 100 mm. The internal surface shall be cleaned and treated with temporary preservative, soluble in fuel oil, before shipment. The following fittings shall be included:

- (a) 600 mm diameter manhole complete with portable cover situated in the top of the tank complete with ladder to the interior.
- (b) Dipstick, calibrated in litres with guide tube and striker plate.
- (c) Local indication of fuel level to be given at a position where it can be easily read during fuel delivery.
- (d) Filling pipe work and fittings complete with isolation valve and captive end cap. The filling point to be at the top of tank to prevent siphoning.
- (e) Outlet pipe situated at the raised end of the tank not less than 150 mm above tank bottom, complete with check valve, isolating valve and end cap.
- (f) Drain pipe situated at lowest point in tank complete with isolating valve and captive end cap.
- (g) Inlet fittings for overflow pipe from daily service tank or tanks (where specified).
- (h) Vent pipe situated at high level in the tank. The pipe shall rise continuously from the tank and terminate with an inverted 'U' bend and vermin screen.
- (i) External ladder for horizontal tanks more than 2 m diameter.

Drawings / Documents Required:

All Drawings, data, technical particulars, calculations, detailed literature, catalogues Test certificates etc shall be submitted along with the bid/ after award of contract.

5.0 SAFETY EQUIPMENT / REQUIREMENTS AND MISCELLANEOUS ITEMS:

- 5.1. Following safety procedure and practice should be provided by Contractor in switchgear room/ sub-station as per latest edition of I.S. 5216.
- 5.2. 900 mm wide antiskid insulating mat as per IS 15652 and of reputed make to be spread in front of the 11kV, 415V switch gear panels & power DBs, DCDB etc.
- 5.3. First aid box with all the standard contents.
- 5.4. First aid chart made of cloth for electrical shock treatment printed in English, Hindi and Gujarati duly framed with front glasses.
- 5.5. Charts / drawings duly framed with front glass.
- 5.6. 11kV and 415V Single line diagrams in adequate sizes approved by Purchaser's representative & in line with the local electrical inspector
- 5.7. Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system etc.
- 5.8. Provision of portable type Class A, B, C, and D type fire extinguishers at various locations in line with the statutory requirements.
- 5.9. FIRE SAFETY:
 - a. The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Tariff Committee, 10th edition 1988.
 - b. Water Sealing & Fire Barriers at appropriate locations as specified in this specifications & good engineering practices.
- 5.10. DEGREE OF PROTECTION:
- 5.11. The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels etc. to be installed shall provide minimum degree of protection as detailed here under
 - i. Installed outdoor – IP 55
 - ii. Installed indoor – IP 42, 52, 54.
- 5.12. The degree of protection shall be in accordance with IS 13947 (Part I)/ IEC 947 (Part I)/ IS 2063/ IEC 529.

6.0 INSTALLATION, TESTING & COMMISSIONING – ELECTRICAL EQUIPMENT:

6.1. GENERAL:

- 6.2. In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer In Charge the Contractor shall unload, erect, install, wire, test and place into commercial use of all electrical & instrumentation equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, and properly aligned and oriented.
- 6.3. The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.
- 6.4. Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.
- 6.5. The Contractor shall erect and commission the equipment as per the instructions of the Purchaser/ Engineer In Charge and shall extend all co-operations to him. All the guidelines of original equipment manufacturer shall also be followed for erection, testing and commissioning
- 6.6. In case of any doubt/ misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.
- 6.7. The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.
- 6.8. Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between bus bars/ wires. The Contractor shall also carry out the adjustments/ alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.
- 6.9. The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/ mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer In charge.
- 6.10. Equipment furnished with finished coats of paint shall be touched up by the Contractor if their surface is spoiled or marred while handling.
- 6.11. Foundation work and grouting of fixing bolts or channels for all transformers, switchgear, motors, and control panels shall be carried out by the Contractor.

6.12. POWER/ DISTRIBUTION TRANSFORMERS:

Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standards Code of Practice IS: 10028. All commissioning tests as applicable, vide Appendix B of IS: 10028 (Part II) shall be carried out. Fire Wall of 4 Hr fire rating shall be provided between two transformers.

6.13. HV/ LV SWITCHGEAR CONTROL PANELS:

- a. Switchgear control panels shall be installed in accordance with the latest Indian Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.
- b. Following minimum clearances shall be observed while finalizing the HV/ LV panel layouts-
 - i. Minimum clearance of 1.0 meter shall be maintained from the rear of the panel to the nearest wall /structure.
 - ii. Minimum clearance of 2.0 meter between panels facing opposite to each other.
 - iii. Side clearance for LV panels shall be either $\leq 200\text{mm}$ or $\geq 800\text{ mm}$.
 - iv. For HT metal enclosed, indoor panels, Minimum 1 meter clearance from all sides & 2.0 meter in the front.

6.14. Emergency Exit doors shall be provided for electrical room, complying with the requirements of NBC 2005 latest edition.

6.15. After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/ panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary arrangements for proper functioning of the equipment.

6.16. EARTHING AND LIGHTNING PROTECTION SYSTEM:

6.17. The Contractor shall install copper/ steel conductors, braids, etc., required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/ coating, drilling, brazing/ soldering/ welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Contractor's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

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- 6.18. The quantities, sizes, material of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be shown in the earthing layout drawings, which are to be prepared by Contractor & approved by Purchaser's representative.
- 6.19. 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 when the floors are cast or during construction of walls. Contractor's scope of installation shall also include, laying the conductors in position with 60 mm concrete cover, making welded connections to inserts/pads/risers above the floor near the equipment. The embedded conductors shall be connected to reinforcing rods wherever necessary.
- 6.20. If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Contractor where required, together with associated civil work such as excavation/chasing, concreting and surfacing. The concrete cover over the conductor shall not be less than 60 mm.
- 6.21. Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth up to 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing/ welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch, and tampered utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.
- 6.22. Installation of earth connection leads to equipment and risers on steel structures/ walls shall include laying the conductors, welding/ cleating at specified intervals, welding/ brazing to the main earth grids risers, bolting at equipment terminals and coating welded/ brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/ structure.
- 6.23. Electrodes shall be installed in constructed earth pits, and connected to main buried earth grid, The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe/ rod/ plate electrodes in test pits and connecting to main earth conductors.
- 6.24. Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening/ cleating/ welding of the down comers on the walls/ columns of the building and connection to the test links to be provided above ground level.
- 6.25. Installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.
- 6.26. Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- 6.27. Suitable earth risers shall be provided above finished floor/ ground level. If the equipment is not available at time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.

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- 6.28. Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.
- 6.29. An earthing mat shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.
- 6.30. A separate earth electrode bed shall be provided adjacent to structure supporting lightning arrestors. Each connection shall be as short and as straight as practicable. For arrestors mounted near transformers, earth conductors shall be located clear off the tank and coolers.
- 6.31. Wherever earthing conductors passes through walls, galvanized iron/PVC sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound.
- 6.32. Earthing Connections:
- a) All connections in the main earth conductors buried in earth/ concrete and connection between main earthing conductor and earth leads shall be of welded type.
 - b) Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
 - c) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
 - d) Metallic conduits and pipes shall be connected to the earthing system.
 - e) Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also no intermediate earthing connection shall be made to lightning arrester and transformer earthing leads which shall be directly connected to pipe electrode.
- 6.33. Earth Electrodes:
- a) Electrodes shall as far as practicable, be embedded below permanent moisture level.
 - b) Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of pipe 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 work such as excavation and connection to main earth grid.
 - c) Earth pits shall be treated with salt and charcoal. In case found necessary, then with the approval of Purchaser's representative, Back fill compound of suitable composition may be used. Back fill material shall not be water soluble & shall retain moisture & enhance conduction around electrode. Back fill compound shall be low resistance & non corrosive earth enhancement compound which shall provide safe discharge path to fault current & lightening current.
 - d) Ohmic value shall be within safe limits & it shall be stable & not fluctuating.

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- e) Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

6.34. INSTALLATION OF CABLE RACKS AND CABLE TRAYS:

6.35. General

- a) Lines and grade for trays may be measured from building steel and finished floor elevations. Change in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.
- b) Where embedded steel inserts in concrete floors/ walls for welding the supports for cable racks/ trays are not available, Contractor shall provide suitable anchor fasteners at no extra cost.
- c) Cable shall be clamped to the cable trays at every 750 mm distance.
- d) Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

6.36. Cable Trays: All the cable tray shall be hot dipped galvanized with minimum galvanization thickness as per mentioned in this specifications.

- a) Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.25 mm for trays up to 100 mm width, not less than 1.5 mm for trays from 100 mm to 150 mm width and not less than 2.0 mm for trays from 150 mm to 300 mm width.
- b) All the cable trays above 300 mm width shall be of ladder type with minimum thickness of 2.5 mm.
- c) Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.
- d) All cable trays tees, intersection units, bends, turns and sets shall be prefabricated (made by the manufacturer) and shall be of a matching design to the main section of cable tray.
- e) Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.
- f) Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.

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- g) Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.
 - h) All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kgs.
 - i) Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray
 - j) The sizing of the cable tray shall provide a minimum of 20% spare capacity.
 - k) The tray shall be run at least 300 mm clear of plumbing and mechanical services.
 - l) Bends in the installation shall take account of the minimum bending radii of cables to be installed.
 - m) All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2 meter interval.
 - n) Other cable tray details & cabling system shall be as per typical drawings attached with the specifications.

6.37. Cable Trunking – Metal:

- a) Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.
- b) Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- c) The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self retaining 'quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.
- d) Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

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- e) Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.
 - f) Trunking shall be supported at intervals not greater than 2 meter horizontally or 2.5 meter vertically.
 - g) Crossings over expansion joints shall be made in flexible conduit.
 - h) Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.
 - i) Cable and conduit/ trunking runs shall be determined by the Contractor and agreed by the Purchaser's Representative before any work is started. The run shall be at least 300 mm clear of plumbing and mechanical services.
 - j) Conduit/ trunking systems erected outside a building shall be weatherproof.

6.38. CABLE INSTALLATION:

6.39. General:

- a) Cable installation shall be in accordance with IS 1255: 2001- latest edition.
- b) Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
- c) Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
- d) Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/ Protection	Tele- communication
HV Power	N/A	300	500	500
LV Power	300	N/A	300	300
C&I/ Protection	500	300	N/A	100
Tele- communication	500	300	100	N/A

- e) These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

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- f) A distance of minimum 300mm shall be maintained between the cables to be laid on trays/ conduits carrying low voltage AC and DC signals and a distance of minimum 600 mm shall be maintained between cables carrying HT and LT signals.
 - g) In order to make economic use of the cable support system, cables shall be arranged in groups having diameters in the close proximity. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
 - h) 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 suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled junction boxes shall be constructed of die cast Aluminium and provide degree of protection IP 65.
 - i) Instrumentation cables shall be continuous without any joints. Separate cables shall be used for digital and analogue signals at all times. Digital and analogue signals shall be segregated within junction boxes.
 - j) Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.
 - k) Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation as per indicated in above table shall be maintained between power and non-power cables when run on the same support system.
 - l) Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

6.40. Laying of Cables:

- a) Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box.
- b) Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
- c) Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.
- d) 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.

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- e) Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables.
 - f) A loop of 1.0 meter shall be left near each field instrument before terminating the cable.
 - g) Cables shall be complete uncut lengths from one termination to the other.
 - h) Separate cables shall be used for digital and analog signals.
 - i) All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules.
 - j) Identification tags shall be securely fastened to the cables at both the ends.
 - k) Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.
 - l) 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.

6.41. Cables Laid Direct in Ground:

- a) Buried cable up to 1.1 kV shall have a laid at a minimum depth of 750 mm measured from FGL to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.
- b) Cables of greater than 1.1kV shall be buried at a minimum depth of 1 meter.
- c) The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. For HT cables sand bedding shall be of 150 mm & cables shall be covered with half round Hume pipes of twice the diameter of cable.
- d) Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked 'Danger-Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.
- e) Warning tape shall be laid a minimum of 200 mm above the protective covers.
- f) Cables are to be installed without tees or through joints unless otherwise approved by the Purchaser's Representative. Single core cables shall be run in trefoil formation.

6.42. Cables Laid in Underground Ducts:

- a) Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 750 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 meter deep and encased on all sides by 150 mm of concrete.
- b) The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.
- c) Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Purchaser's Representative. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated. However, for two different trefoil formations, they shall be laid in separate ducts.

6.43. Cables installed in Conduit:

- a) Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537, Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.
- b) A space factor of 40% shall not be exceeded, but in any case conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.
- c) Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.
- d) Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/ or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.
- e) Heavy hexagonal lock nuts shall be used at all positions where running joints are required and care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

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- f) Generally not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Purchaser/ Purchaser's Representative.
 - g) Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.
 - h) Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

6.44. Surface Installation:

- a) Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips at every 500mm, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Purchaser's Representative before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Purchaser's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Purchaser/ Engineer in Charge before carrying out the work.
- b) Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

6.45. Concealed Installation:

- a) Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

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- b) At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish. The conduit junction boxes shall be provided after every 30M straight line of conduit and at each bend.
 - c) Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.
 - d) The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

6.46. Cable Installed in Flexible Conduit:

- a) Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.
- b) Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

6.47. Cable Clipped Direct:

- a) All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

6.48. Cable Installed in Internal Floor Trench:

- a) In shallow trenches (maximum depth 500 mm)
- b) In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.

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- c) Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum separation distance of 300mm shall be maintained.
 - d) All other trenches including walk through service ducts
 - e) Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.
 - f) Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above 'cold' wet services. Cables should not be run if at all possible above or in close proximity to 'hot' services.
 - g) The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

6.49. Cable Terminations and Joints:

- a) Power Cable Terminations
 - i. Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.
 - ii. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.
 - iii. Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.
 - iv. Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.
 - v. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.
 - vi. Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

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- vii. Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

b) Power Cable Joints:

- i. Through joints shall only be allowed with the approval of the Purchaser's Representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

c) Multi-core or Control Cable Terminations:

- i. A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.
- ii. Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.
- iii. Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.
- iv. Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

6.50. Cable Fixings:

- a) Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.
- b) Large single cables shall be secured with cable clamps or cable cleats.

6.51. Cable Identification:

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

6.52. Marking Locations of Underground Cables:

- a) The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.
- b) Cable route markers as per the attached drawing shall be installed at an interval not more than 15 meter & at bending/ road crossings the interval shall be at every 10 meter.
- c) The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

6.53. Additional Requirements for Cable Installations:

- a) The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.
- b) All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.
- c) Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.
- d) After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at 10 meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.
- e) Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:

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- i. 11 kV, XLPE insulated, multicore : 15 times the overall dia of the cable
 - ii. armoured cables
 - iii. 1.1 kV, XLPE insulated, multicore : 12 times the overall dia of the cable
 - iv. armoured cables
 - v. (If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)
- f) Power, control and instrumentation cables shall be laid in separate cable racks/ trays.
- g) Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.
- h) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.
- 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 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm 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 than 75 mm in the centre and tapering towards the sides of the trench.
- j) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.
- k) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directory into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.

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- l) Cable splices will not be permitted except where permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturer's and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.
 - m) Jointing of cables shall be in accordance with relevant Indian Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.
 - n) At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.
 - o) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.
 - p) When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.
 - q) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.
 - r) After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.
 - s) Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

6.54. LIGHTING SYSTEM INSTALLATION:

6.55. This covers the requirements of installation of the following:

- a) Lighting fixtures complete with lamps and accessories
- b) Main Lighting distribution board
- c) Lighting panels
- d) Receptacles and lighting control switches
- e) Point wiring
- f) Street lighting poles and flood light towers
- g) Multi core cables for street and boundary lighting
- h) Maintaining equipment/ materials during storage and being responsible for the equipment/ material until they are handed over to Purchaser.
- i) Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

6.56. Applicable Standards for lighting system installation

Electrical wiring installations : IS: 732

(System voltage exceeding 650 V)

Code for practice for interior illumination (Part-1) : IS: 3646/ BS: 8206

Code of practice for street lighting installation : IS: 1944

Code of practice for industrial lighting : IS: 6666

Code of practice for fire safety of building : IS: 1646

Boxes for enclosure of electrical accessories : IS: 5133(Part-1)

Guide for safety procedures and practices in : IS: 5216

electrical work

Ceiling roses : IS: 371

6.57. Lighting Fixtures:

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- a) The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings. The rates quoted for installation shall include all materials required to mount the fixtures. Hooks in RC slabs for suspension of high bay fixtures shall be provided wherever not already provided. Cost of supply and installation of such hooks shall be included in the cost of installation of lighting fixtures. Rate for installation of lighting fixtures shall include cost of installation of control gear box wherever applicable.
 - b) Installation of receptacles and switches shall be carried out suitably. Switch shall be mounted in flush with the front cover plate. Cost of supply and installation of necessary hardware shall be included in the lump sum rates quoted for installation of receptacles/ switches.
 - c) Lighting distribution boards shall be installed at the suitable location. Installation shall include supply and installation of base channels, foundation bolts, etc.
 - d) Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 1000 mm (min.) above the grade level. Cost of construction of concrete plinth shall be included in Contractor's scope. No cement and steel will be supplied by Purchaser. Installation cost of lighting distribution board shall include cost of installation of earthing conductor from LDB to the nearest earthing grid.

6.58. Point Wiring:

- a) Contractor has to prepare the detailed conduit layout drawing showing primary & secondary point wiring points. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches of receptacle units.

- i. Primary Point Wiring:

- Primary point wiring covers the wiring between a circuit of the lighting panel to the junction box of the first lighting fixture/receptacle unit and between junction boxes of the subsequent lighting fixture connected to that circuit of the lighting panel. In some cases where there are junction boxes, the primary point covers the wiring between junction box and the first lighting fixture/receptacle unit in that circuit.

- ii. Secondary Point Wiring:

- Secondary point wiring covers the wiring of the remaining lighting fixtures/receptacle unit other than that covered under primary point of that circuit in the lighting panel. Secondary point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and control switches of receptacle units.

- b) Supply and Installation of Conduit Point Wiring:

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- i. The point wiring shall include supply of necessary materials for the conduit wiring such as galvanized rigid steel conduit, galvanized M.S. fixing saddles with spacer plates, nylon/fiber fixing plugs, galvanized M.S. fixing screws, 12 SWG galvanized steel earthing wire, FRLS PVC insulated Copper conductor wires, control switches and pulling, termination of the earthing/ FRLS PVC insulated wires as required, installation of control switches, drilling holes in brick walls/RCC roof slabs for taking the wiring conduits and refinishing and any other works/material necessary for making point wiring complete in all respects.
 - ii. Wires used for conduit point wiring of lighting fixtures/ceiling fans, 5A receptacles and receptacles above 15A shall be 1.1 kV grade, FRLS PVC insulated, single core, multistranded Copper conductor wires of sizes not less than 1.5 sq. mm and 2.5 sq. mm respectively. Wires shall conform to IS: 694 and shall bear the ISI mark.
 - iii. Contractor shall take into consideration necessary galvanized MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.
- c) Supply & Installation of cabling for Street and Flood Lighting
- i. Work includes supply and installation of cables required between LDB and junction box mounted on street lighting pole/flood lighting tower and also between junction box mounted on flood light tower to metal enclosed control gear box located near flood light fixture, supply and installation of all the termination accessories such as crimping type cable lugs and double compression cable glands at each junction box and fixture, termination, testing and commissioning of cables. Contractor's scope of work also includes excavation, preparation of riddled soil bedding, supply and installation of protective covers over the cable, backfilling, ramming, supply and installation of route markers, supply and installation of HDPE / Hume pipes for road crossing, etc, supply and installation of necessary cleating arrangement for cabling on flood light tower, supply of labour, supervision, welding equipment, all tools and tackles and testing equipment as required.
 - ii. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary the same shall be provided by the Contractor and a joint marker shall also be provided at no extra cost. Earthing of street light pole/flood light tower, lighting fixtures, etc. are included under Contractor scope.
- d) Point wiring shall also include/ hold good for the following :
- i. Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
 - ii. Drilling holes in brick/ RCC wall and roof for taking cable or conduit, sealing and refinishing with cement plaster.

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- iii. Testing, commissioning and handing over the lighting system in commercial working condition.
 - iv. Marginal shifting of any fixture/accessory from the location indicated in the lighting layout drawings.

6.59. Outdoor Lighting (Street and Flood Lighting): The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

- a) Installation of multicore/ single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.
- b) Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination, testing and commissioning of cables.
- c) Contractor's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of HDPE/ Hume pipes for road crossing shall also be included in the scope of installation of point wiring.
- d) Supply and installation of necessary cleating arrangement for cabling on flood light poles.
- e) Contractor shall provide necessary foundation for erecting street light pole/ flood light tower and install the same. Contractor shall prepare foundation drawings with necessary details & Purchaser Representative's approval shall be obtained.
- f) Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Contractor and joint marker shall also be provided at no extra cost.
- g) Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation of point wiring. Contractor shall earth street light pole/flood light poles and junction box with 25x3 mm G.S. flat tap off from the 25x3 mm M.S. flat earthing grid along the street lighting included in scope. The Contractor shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate poles.
- h) Installation of lighting Poles and Towers for Outdoor Lighting (Street and Flood Lighting)-
 - i. Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
 - ii. All street light poles and towers shall be painted with one shop coat of red oxide oil primer followed by two coats of aluminium alkyd paint.

6.60. Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 230 V, AC 1- Ph Distribution Boards.

Installation of above items shall include necessary foundation channels, bolts/ nuts, etc. for grouting lighting distribution boards, iron brackets/ grouting brackets, bolts/nuts for wall/ column mounted panels and associated civil works.

6.61. Details of work requirements are covered in lighting installation notes and details and typical drawings which form the part of specification. Any changes, if necessary due to site conditions/requirements shall be carried out after obtaining approval of Purchaser/ Purchaser's Representative. The changes carried out shall be marked clearly in the layout drawings by Contractor and 'AS BUILT DRAWING' shall be prepared by the 'Contractor' and this shall be forwarded to Purchaser's site / design office.

a) Wiring

- i. Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Where cable wiring is specified cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.
- ii. Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.
- iii. Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires the following colour wires shall be used.

R - Phase -	Red
Y - Phase -	Yellow
B - Phase -	Blue
N - Neutral -	Black

- b) There shall be a circuit breaker on each live conductor of supply mains at the point of entry.
- c) Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.
- d) Receptacles and lighting fittings in general shall be fed from different Circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.
- e) Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.
- f) For long conduit wiring runs, inspection/ pull boxes shall be provided at intervals not exceeding 10 meter. Such facilities shall also be provided at conduit bends.

6.62. General Practices for lighting:

- a) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.
- b) Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.
- c) All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

6.63. Earthing for lighting:

Conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints.

- a) Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.
- b) For outdoor lighting poles & mast 8 SWG GI earth wire shall be run buried in ground at a depth of 600 mm along-with lighting cables and shall be terminated up to the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting. In case of lighting poles where the main earth grid is far away from the pole, local pits shall be provided for pole earthing.

7. PRE COMMISSIONING TESTS ON ELECTRICAL EQUIPMENT/ SYSTEMS TO BE CARRIED OUT AFTER INSTALLATION:

7.1. GENERAL:

Pre-commissioning tests in addition to mentioned in the specification requirements for various equipment but not limited to following shall be carried out by Contractor in presence of Purchaser/ Purchaser's representative. Commissioning shall be carried out only after obtaining satisfactory results, acceptable to Purchaser/ Purchaser's representative.

7.2. ELECTRICAL EQUIPMENT:

i. 11 KV Equipment (Lightning Arrestors, AB Switch/ Isolators & Insulators etc):

- a) Visual checks for cracks in insulators.
- b) Earth secured continuity check
- c) IR Test with 5KV Megger

ii. Power/ Distribution Transformer:

- a) Insulation resistance test HV side, LV side and HV - LV.
- b) Magnetizing current test.
- c) Winding resistance test.
- d) Voltage Ratio & Tap continuity test at all tap.
- e) Vector group test.
- f) Magnetic Balance Test.
- g) Buchholz Relay Test (if any)
- h) Neutral CT Test (if any)
- i) Winding Temperature Indicator/ Oil Temperature Indicator Test
- j) Polarization Index Test (For LV windings 3.3 KV and above)
- k) Local/ Remote operations of OLTC (if any)
- l) Operational tests of RTCC panel (if any) as per schematic drawing.
- m) No load test and performance observations

iii. HT Metal Enclosed Switchgear:

-
- a) IR values of power and control circuits
 - b) Local/ Remote operations in test as well as service position including all electrical interlocks
 - c) Control circuit and operational tests as per schematic drawing.
 - d) Tripping through relays and trip circuit health.
 - e) Anti pumping device operation
 - f) Protection system operation stability and sensitivity by primary injection testing method including testing of metering circuits
 - g) HV Test on switchboard
 - h) Panel indication, annunciation, space heater circuits
 - i) Spare contact for customer use
 - j) Termination correctness & proper installation.
- iv. LT Metal Enclosed Switchgears:
- a) IR Values of power & control circuits.
 - b) Mechanical charging - closing - tripping of breaker.
 - c) Electrical charging - closing - tripping of breaker.
 - d) Trip circuit healthiness and tripping through relays.
 - e) Remote closing/ Tripping/ Interlocks circuits
 - f) Indication/ Annunciation/ Panel space heater circuit/ Spare contacts for customer use
 - g) Secondary injection testing of protective relays/ releases.
 - h) CT testing for polarity, ratio, IR values and magnetization for class PS characteristics
 - i) PT testing for ratio, IR values.
 - j) IR Values of breaker.
 - k) Testing of modules for DOL/ Star-Delta/ ATS/ Soft Starter starting or any other starting method as per the schematic drawings applicable.
- v. Power and Control Cables:
- a) IR Values before Hi-pot

-
- b) Hi-pot Test - Measurement of leakage current
 - c) IR Values after Hi-pot
 - vi. Induction Motors:
 - a) IR Values
 - b) Polarization Index Test
 - c) Interlocks and simulation tests local / remote operations
 - d) No load test
 - vii. Control Panels for Miscellaneous Equipment:
 - a) IR Values of all power circuits
 - b) Operational test and scheme - wiring testing as per control schematics
 - viii. Lighting System:
 - a) Visual inspection for operating problems
 - b) System activation -burning in the lamps for 100 Hrs
 - c) Measuring light level & reflectance.
 - ix. Earthing System:
 - a) Earthing resistance of each electrode.
 - b) Earthing resistance of grid.

8. DRAWINGS / DOCUMENTS:

8.1. The following drawings shall be submitted by the Contractor.

- i) Load List.
- ii) Single Line Diagram.
- iii) General arrangement drawing of Electrical Equipment.
- iv) General arrangement, Data Sheet, Sizing Calculation, Bill of Material, Scheme drawing/Wiring diagram, Write up, inter-connection diagram, assignment drawing, as applicable for all the electrical equipment.
- v) Performance curves for pump motors capacity V/s head, efficiency, KW requirement.
- vi) Detailed Single line Diagram (SLD) indicating the Rating of components including switchgear, bus-bar, CT, PT, cables etc.; Configuration of components; Protection details; interlocks; indications & annunciations provided; etc. for each system.
- vii) Supporting calculations with formulae, reference to standards and assumptions shall be submitted for each system.
- viii) Layouts of Switchyard, cable tray routing, earthing including downcomers, lightning arrestors and earth pits, lighting layout etc.
- ix) Type Test certificates of the components from Accredited Laboratories
- x) Apart from the above indicated drawings and documents in the list, all the drawings and documents which are indicated in the relevant section of the equipment shall be furnished.

**TECHNICAL DATASHEETS
FOR
ELECTRICAL WORKS**

TECHNICAL DATA SHEETS (ELECTRICAL WORKS)

TABLE OF CONTENTS

Sr. No.	Description
1.0	11 KV Two Pole Structure
2.0	Distribution transformer 11 kV /0.433 kV
3.0	415V Metal Enclosed Switchgear (Main PMCC/MCC Panel /PDB/DB)
4.0	415 V APFC Panel
5.0	Power, Control, Instrumentation Cables
6.0	Earthing and Lightning Protection Systems
7.0	Lighting & Receptacle System
8.0	Maintenance-free Sealed Lead Acid / Ni-Cd Battery
9.0	Battery, Battery Charger & D.C. Distribution board
10.0	Miscellaneous Equipment Details
11.0	Diesel Standby Generator Set
Note:	
1.0	Technical Schedules cover only salient features of equipment offered by the Contractor. The Contractor shall certify that the specification requirements are fully complied with, except those specifically brought out in Schedule of Deviations from Technical Specification.
2.0	For (*) items, Bidder to provide Quantity/ Ratings based on Design Criteria & Specification requirements. Ratings & Configuration, wherever specified (in Technical specifications/ Data Sheets/ Price Schedule/ SLD) for equipments, shall be minimum requirements. Electrical Switchgears/ Distribution Board Configuration (components/ equipment/ protections/ metering/ instruments) shall be as per indicated in typical reference SLDs & in line with design criteria & specification requirements.
3.0	Bidder to provide filled data sheets for the below mentioned equipments. As applicable, separate data sheets needs to be filled for each equipment/ system covered under SWM Project.

1.0 11 KV TWO / FOUR POLE STRUCTURE:

- a. For installed (1W+1S) transformers cumulative rating ≤ 800 KVA, Four Pole Structure/ 2 Nos. of DP structure complete with all accessories as per requirement.
- b. For installed (1W+1S) transformers cumulative rating > 800 KVA, single Two Pole Structure complete with all accessories. Point of Supply Breaker Panel/RMU as per requirement.

(A) LIGHTNING ARRESTERS:

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
0	General			
	Designation		Lightning Arrester	
	Make		As per approved make list	
1.3	Applicable Standards		As per Tender Specification	
1.4	Type		Station Class type	
1.5	Quantity (Min. 3 nos. per D.P.Structure)	Nos.	As Per Requirement	
1.6	Installation		Outdoor	
1.7	System voltage, No of Phases & Frequency	kV	11kV, 3 Phase & 50 Hz	
0	Ratings			
	Rated arrester voltage	kV	9	
	Rated frequency	Hz	50	
2.3	Nominal discharge current of 8/20 microwave shape (Station class)	KA	10	
2.4	Basic Insulation level of equipments to be protected			
a)	Impulse withstand (1.2*50 micro sec)	KV(P)	75	
b)	1 min. Power frequency withstand voltage	KV	28	
2.5	Terminations - Clamps & Connectors suitable for ACSR conductor provided		Provided.	
0	Arrestor housing			
	Minimum creepage distance	mm	25 mm / kV	
	Minimum cantilever strength of arrester assembly	kN	Bidder to Furnish	
0	GA drawing Indicating Height, Weight, overall dimensions and mounting arrangement details		Bidder to Furnish	

(B) ISOLATOR (G.O.D)

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
0	General			
1	Designation		Isolator (Gang Operated Disconnectors)	
2	Make		As per approved make list	
1.3	Applicable Standards		As per Tender Specification	
1.4	Type		Vertically mounted Double Air Break Central Rotating Type	
1.5	Quantity (1 Set per D.P.Structure)	Sets	As Per Requirement	
1.6	Installation		Outdoor	
1.7	System voltage, No of Phases & Frequency	kV	11 KV, 3 Phase & 50Hz	
	Design Requirements			
1	Ambient temperature	°C	50	
2.2	Rated Current	*A	As per System Requirement	
2.3	Short Time Rating	KA	26.2 KA for 1 sec	
4	Insulation level	Full/ Reduced	Full	
2.5	Phase spacing as per IS/CBIP & to suit BIL & Lightning Impulse Voltage	*mm	Bidder to Furnish	
2.6	Earthing switch required to be provided and interlocked with main switch		Yes	
2.7	Height of mounting above GL	mm	As per IS/CBIP	
2.8	Operating device for Isolator with Earth Switch – Manual with Operating handle with reduction gear and suitable electro-mechanical interlock.		Yes	
2.9	Orientation of operating mechanism box W.R.T isolator		Suitably mounted on DP	
2.10	Auxiliary contacts (6NO+6NC) Make before break		Yes/ No	
	Insulator Data			
	Rated voltage	KV	11	
	1 min. Power frequency wet flash-over voltage	KV	28	

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
3.3	Impulse flash-over : Positive wave(1.2*50 micro sec)	Kv (peak)	Bidder to Furnish	
3.4	Impulse withstand (1.2*50 micro sec)	kV (peak)	75	
3.5	Creepage distance	mm	25 mm per kV	
3.6	Minimum Cantilever strength	kN	Bidder to Furnish	
4.0	GA drawing Indicating Height, Weight, overall dimensions and mounting arrangement details		Bidder to Furnish	

(C) DROP OUT FUSE (DO FUSE)

Sr. No.	Description	Unit	Particulars	To be confirmed by Bidder
0	General			
1	Designation		DO Fuse	
2	Make		As per approved make list	
1.3	Applicable Standards		As per tender specification	
4	Type			
5	Quantity(1 per DP Structure)		As Per Requirement	
1.6	Installation		Outdoor	
1.7	System voltage, No of Phases & Frequency	kV	11 KV, 3 Phase & 50Hz	
0	Rating			
2.1	Rated Current	*A	Bidder to Furnish	
2.2	Insulator Rating Insulator Creepage Distance Insulator Impulse withstanding		12 kV Porcelain 25 mm / kV As per relevant IS	
2.3	Fuse Carrier		Bakelite Tube	
2.4	Contacts		Spring Loaded Phosphor Bronze	
3.0	Operating Mechanism		12 KV 4 element type operating rod	
4.0	Connection Details		ACSR Conductor	

2.0 DISTRIBUTION TRANSFORMER

Sr.No	Description	Unit	Particulars	To be confirmed by Bidder
1.	Manufacturer's Name And Country Of Manufacture		Bidder to Furnish	
2.	Applicable Standards		As Per Specifications	
3.	Quantity	Nos.	As Per BOQ	
4.	Application / Designation		Power Distribution	
5.	System Voltage - Nominal - Highest	Kv Kv	11 12	
6.	Method of Connection HV Winding LV Winding		Delta Star	
7.	Rated Frequency	Hz	50	
8.	Type Of Winding / Material		Two Winding / Copper	
9.	3 Phase / Single Phase Unit		3 Ph Unit	
10.	Rating Of Each Unit	KVA	As Per BOQ	
11.	Voltage Rating	KV/ KV	11 / 0.433	
12.	Cooling		ONAN	
13.	Percentage Impedance at Principal Tap & Without Negative Tolerance	%	As Per IS 1180:2014 & its latest amendment	
14.	Over fluxing Withstand Capability		(110% Continuous)	
15.	Vector Group		Dyn11	
16.	Winding Insulation (HV & LV)		(Uniformly Insulated)	
17.	Short Circuit Current	Ka	26.2	

18.	Maximum Duration Of Fault	Sec.	1 Sec	
19.	Insulation Withstand Voltage			
	1 Min Power Frequency Withstand Voltage (Dry & Wet) - HV (11 Kv)/ LV (0.433 Kv)	Kv	28/ 3	
)	Lightning Impulse Withstand Voltage - HV (11 Kv)/ LV (0.433 Kv)	Kv (Peak)	75/ NA	
20.	TEMPERATURE RISE (H Factor of Max. 1.3 As Per IEC 60354 To Be Considered)			
	Maximum Ambient Air	°C	50	
)	Yearly Average Air (Minimum)	°C	32	
c)	Temperature Rise Of Top Oil By Thermometer(Maximum)	°C	50	
d)	Maximum Temperature Rise Of Windings By Resistance (Maximum)	°C	55	
e)	Hot Spot Temperature (Maximum)	°C	98	
f)	Loading Combination For Which Above Temperature Rises Are Applicable			
21.	<u>Weights</u>		Bidder To Furnish	
a)	Core Winding Assembly	Kg		
b)	Oil	Kg		
c)	Tank, Coolers And Fittings	Kg		
d)	Total	Kg		
e)	Un-tanking Weight	Kg		
f)	Minimum Clearance Height for Lifting Core And Windings From Tank	Mm		

22.	Maximum Flux Density			
a)	At Rated Voltage	Wb/M ²	1.6	
b)	At 110% Rated Voltage	Wb/M ²	1.76	
23.	Current Density		Bidder To Furnish	
a)	HV	A/Cm ²		
b)	LV	A/Cm ²		
24.	<u>GUARANTEED LOAD LOSSES</u> AT RATED CURRENT AT 75°C WINDING TEMPERATURE (WITHOUT IS POSITIVE TOLERANCE) i) 100% LOAD ii) 75% LOAD iii) 50% LOAD	KW	Minimum 3 Star Rated Transformer As Per IS 1180- 2014 & its latest amendment	
25.	<u>Guaranteed No Load Losses</u> (Core Loss And Dielectric Loss) At 100% Rated Voltage And Frequency (Without Is Positive Tolerance)	Kw	Minimum 3 Star Rated Transformer As Per IS 1180- 2014 & its latest amendment	
26.	<u>Guaranteed No-Load Current:</u> A. When Excited From LV Side At 100% Rated Voltage B When Excited From LV Side At 110% Rated Voltage	A A	Bidder To Furnish	
27.	<u>Guaranteed Efficiency</u> i) At 75 °c ii) At Unity P.F iii) At Full Load		Bidder To Furnish	
28.	Regulation: At Full Load, 0.8 P.F At 75°C Winding Temperature	%	Bidder To Furnish	
29.	Core:			
a)	Material of Core Lamination		CRGO/ MOH	

b)	Insulation of Core Lamination		Bidder To Furnish	
30.	Winding			
a)	Class of Insulation		Bidder To Furnish	
b)	Material		Copper	
31.	Tapping			
a)	Tapping On Winding	HV/LV	HV	
b)	Whether On Load / Off-Circuit		OLTC / OCTC	
c)	Tapping Range	%	(-) 15% To (+) 5% for OLTC (-) 10% To (+) 5% for OCTC	
d)	Tapping Step	%	In Steps Of 1.25% for OLTC In Steps Of 2.5% for OCTC	
32.	<u>Parallel Operation</u>		No	
33.	<u>Terminal Bushings</u>		HV / LV	
a)	Rated Voltage Class –	KV	11/ 0.433	
b)	Rated Current Class –	A	Bidder To Specify	
c)	Impulse(1.2/ 50 μ Sec. Wave Withstand) –	Kvp	75	
d)	One Minute Power Frequency Withstand (Dry & Wet)	Kv (Rms)	28	
e)	Minimum Clearance In Air (Ph-Ph/Ph-Gnd)	mm/ Kv	25	
f)	Minimum Creepage Distance (Total)	Mm	Bidder To Furnish	
g)	Protected Creepage Distance	Mm	Bidder To Furnish	
h)	Voltage Tap For Use With Potential Device	Reqd./ Not Reqd.	Bidder To Furnish	

34.	<u>Bushing CT, If Required</u>	Reqd./ Not Reqd.	Not Required	
a)	BCT Core No.			
b)	CT Ratio			
c)	Class			
d)	VA Burden	VA		
e)	Knee Point Voltage (vk)	V		
f)	Magnetizing Current (Ie.) mA at (vk /2)	V		
g)	Secondary Resistance (Rct)	Ohms		
35.	<u>Terminal Connections</u> Rigid Bus/ ACSR Conductor / Air Insulated Cable Box With Disconnecting Chamber/ Bus Duct		As Per System Requirement	
36.	All The Accessories, Protections, Equipments - Compliance With Specification, SLD & Data Sheet Requirements.		Yes/ No	
37.	No Of Units To Be Subjected To Acceptance Tests		Each Unit	

3.0 415V METAL ENCLOSED SWITCHGEARS

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Make		As per approved list	
2	Applicable Standards		As per Tender Specification	
3	Overall dimensions of 415V Metal Enclosed Switchgear panel (Length x Depth x Height)	mm	Bidder to Furnish	

Sr. No	Description	Unit	Particulars	To be filled By Bidder
4	Quantity	Nos	As per Specification Requirement & ref. SLD.	
5	415 V Switchgear and Bus bar Ratings			
a)	Rated voltage phase and frequency		415 V, 3 Ph 50 Hz	
b)	Type of Construction ACB- EDO MCCB – Fixed Type		Metal Enclosed, modular Type Front operated Draw out / Fixed type, construction as per Form 4 of IS 8623/ IEC 60439 & its latest amendment	
c)	Maximum system voltage	V	415 +10%	
d)	One minute power frequency voltage			
	i) Power circuits	V	2500	
	ii) Control circuits	V	1500	
	iii) Aux. Circuits connected to Sec of CTS	V	1500	
e)	i) Continuous current rating of Bus bars under site reference Ambient Temperature and type ii) Bus Bar Material	A	Minimum as per SLD & specification Aluminum(Al)	
f)	Bus bar insulation		Fully insulated encapsulation by heat shrinkable coloured PVC sleeves and tapes.	
g)	Reference Ambient Temperature	° C	50° C	
h)	Maximum Temperature of Bus bars, Droppers and Contacts at Continuous current rating under site ambient temperature	° C	85° C for non silver plated joints 105° C silver plated joints	
i)	Short Circuit current withstand for Busbars and droppers (i) Short time 1 sec	kA (rms)	Bidder to Furnish based on Design requirements	
6	Switchgear Constructional			

Sr. No	Description	Unit	Particulars	To be filled By Bidder
	Requirements			
a)	Type of Construction		Single front type as per Form 4 of IS 8623 / IEC 60439	
b)	Thickness of sheet steel (i) Frame, Frame enclosures, doors, covers and partitions	mm	CRCA Sheet – 2.0 Partition – 1.6 Load bearing Members -2.5 mm Gland Plate – 3 mm	
c)	Degree of protection		IP 54 for Indoor IP 55 for Outdoor	
d)	Color finish shade		Interior : Glossy white	
			Exterior : Light grey semi glossy Shade 631 of IS-5	
e)	Earthing Bus - Material - Size		Al suitable for Max.SC rating for 1 sec)	
f)	Earthing conductor (Main grid) - Material - Size		GI suitable for Max.SC rating for 1 sec)	
g)	Minimum clearances in air of live parts (i) Phase to Phase (ii) Phase to Earth	Mm Mm	As per IS std. & to suite BIL 25 mm 20 mm	
h)	Cable entry to cubicles		Bottom	
7	Instrumentation Transformers			
a)	Current transformer			
i)	Make		As per approved make list	
ii)	Ratio		.../ 5A - As per Requirements	
iii)	Burden	VA	15 Minimum	
iv)	Accuracy Class (Metering)		1.0	
v)	Accuracy Class (Protection)		5P20	
b)	Voltage transformer			
i)	Make		As per approved list	
ii)	Ratio		415/√3 / 110 √3 - As per Requirements	

Sr. No	Description	Unit	Particulars	To be filled By Bidder
iii)	Burden	VA	50 VA Minimum	
iv)	Accuracy Class (Metering)		1.0	
v)	Accuracy Class (Protection)		3P	
8	Switchgear, Starters & Other Components		Minimum requirements as per SLD, Design Criteria & Specification requirements (Yes / No)	

4.0 415V APFC PANEL

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Capacitor Bank Panel Particulars			
a)	Make		As per approved make list	
b)	Applicable Standards		As per Tender Specification	
c)	Quantity		As per BOQ	
d)	Rated Capacity	KVAR	* Bidder to furnish as per design requirement.	
e)	Capacitor losses (i) For complete bank (ii) For individual units	Watts Watts	0.5W/ kVAr 0.2W/ kVAr	
f)	Rated voltage	V	415	
g)	Rated frequency and phases		50 Hz, 3 Phase	
h)	Ambient temperature	° C	50	
i)	Cable gland required		Yes	
j)	Size of cable		As per design Requirements	
k)	Cable entry		Bottom	
2	Unit Capacitors			
a)	Rated voltage	V	415V	
b)	Standard Rated Output per bank at 415V	KVAR	5 / 10 /15 / 25 / 50 / 100 KVAR	
c)	Maximum over voltage the unit capacitor is capable of withstanding continuously	%	As per IS 13585	
d)	Type		Double Layer APP	
3	Constructional Requirement			
a)	Overall dimensions of Capacitor control panel	Mm	Pl. Furnish	

Sr. No	Description		Unit	Particulars	To be filled By Bidder
	(Length x Depth x Height)				
b)	Thickness of sheet steel i) Frame, Frame enclosures, doors covers and partition		mm	CRCA - 2.0 Partition-1.6 Gland plate -3	
c)	Degree of protection			IP 4X	
d)	Color finish shade			Interior : RAL 7032	
				Exterior : RAL 7032	
e)	Earthing bus	Material		GI	
		Size	mm x mm	* Bidder to furnish as per design requirement.	
f)	Earthing conductor	Material		GI	
		Size	mm x mm	* Bidder to furnish as per design requirement.	
4	Design Requirements				
a)	Insulation level		kV (rms)	2.5	
b)	Capacitor bank connection			Delta	
c)	Short circuit withstand for busbars Short time (1 sec)		kA (rms)	*	
d)	Type of switching			Automatic switching responsive to power factor through power factor sensing relay	
e)	Switching steps		Min. 8	As Per Requirements	
f)	Rating of contactor			AC 6b Duty - To suit KVAR unit	
g)	Incomer switch current rating		150% of rated	* As Per Requirements	
h)	Busbars			Al	

5.0 POWER, CONTROL & INSTRUMENTATION CABLES

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
1	11 kV (E), multi strand, Al, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured power cable (as required)	LS	As per IS 7098 Part -II & its latest amendment	
a)	Make		As per approved	
b)	Applicable Standards		As per Tender Specification	
2	1.1 kV, multi strand Cu/ Al, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured power/submersible cable (Cu conductor cable & GI round wire armoring for sizes upto 4 sq mm & below, for balance all, above 4 sq. mm conductor size- Al conductor & GI flat strip armoring) (Cu conductor, double PVC sheathed, water tight, flexible cable for submersible pump application)	LS	As per IS 7098- Part -I & its latest amendment	
a)	Make		As per approved list	
b)	Applicable Standards		As per Tender Specification	
3	1.1 kV, multi-strand Cu, XLPE insulated, inner & outer extruded PVC sheathed, GI armoured control cables	LS	As per IS 7098 & its latest amendment	
a)	Make		As per approved list	
b)	Applicable Standards		As per Tender Specification	
c)	GENERAL			
	Type of Cable Gland (Suitable for Cable Size as per requirement)		Double compression brass type	
	Type of Cable Lugs (Suitable for Cable Size & material or bimetallic - as per requirement)		Crimping type	
	All Cable accessories as per specification requirements to be provided.		Yes/No	

6.0 EARTHING AND LIGHTNING PROTECTION SYSTEM

Sr. No	Description	Unit	Particulars	To be filled By Bidder
1	Main Earthing Grid		To Suite as per Maximum SC Rating & Design	
2	Conductor Leads To Equipment		(Minimum 2 distinct earthing leads for equip. having > 125V & 1 earthing lead for equip. with < 125V)	
3	Other Items			
(a)	Main lighting D.B, Control panels and sub-lighting distribution boards	Mtr.	GI, 25x6mm	
(b)	Hand Rails	Mtr.	GI, 25x3	
(c)	Cable trays	Mtr.	GI, 25x3	
(d)	Tanks	Mtr.	GI, 25x3	
(e)	Junction boxes	Mtr.	GI wire, 8 SWG	
(f)	Lighting fixtures, single phase receptacles, lighting conduits,	Mtr.	GI wire, 12 SWG	
(g)	Push button stations, limit switches,	Mtr.	GI wire, 12 SWG	
(h)	Crane rail,	Mtr.	GI, 25x3 mm	
(i)	Street lighting, flood lighting poles and junctions boxes,	Mtr.	GI, 25x3mm	
(j)	Metallic noncurrent carrying structures,	Mtr.	GI, 25x3 mm	
4	Lightning Conductors	Mtr.		
(a)	Lightning protection down comers for building,	Mtr.	GI, 25x6 mm	
(b)	Lightning protection horizontal roof conductor for building	Mtr.	GI, 25x6 mm	
5	Electrodes			
(a)	Pipe electrode	Nos.	-Heavy duty GI pipe 4500 mm long, 40NB (Quantity to achieve ≤ 1 Ohm earth resistance based on 50 ohm-m or higher resistivity on the basis of actual measurement whichever is higher)	
(b)	Plate Electrode		- Minimum 4 Nos. of 600mm x	

Sr. No	Description	Unit	Particulars	To be filled By Bidder
			600mm x 3.15 mm for each transformer -Minimum 2 Nos. 300mm x 300mm x 3.5 mm for each 11 kV DP Structure	
6	Earthing Resistance to be achieved	Ohm	1	

7.0 LIGHTING & RECEPTACLE SYSTEM AND EQUIPMENT

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
1	System Particular			
(a)	Voltage			
	(i) 3 Phase, 4 wire 50 Hz system			
	<input type="checkbox"/> Rated	V	415	
	<input type="checkbox"/> Maximum	V	476	
	(ii) D.C. system			
	<input type="checkbox"/> Rated	V	110	
(b)	One minute withstand voltage		2000 V AC.	
(c)	System short-circuit level			
	(i) At 415 V, A.C.	kA (rms)	10	
	(ii) At 110 V.D.C.	kA (D.C.)	6	
(d)	Reference ambient temperature		45° C	
2	Distribution Board/Panels			
(a)	Make		As per approved list	
(b)	Applicable Standards		As per Tender Specification	
(c)	Main, floor mounted distribution boards			
	(i) Main LDB (A.C.)		As per requirement	
	<input type="checkbox"/> Bus bars		Al	
	<input type="checkbox"/> Bus bar current rating	A	As per requirement	
	<input type="checkbox"/> Incoming		As per requirement	
	<input type="checkbox"/> Outgoing		As per requirement (With Minimum 2 spare	

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
			feeders)	
	<input type="checkbox"/> Cable entry		Bottom	
	<input type="checkbox"/> Location		Indoor	
	<input type="checkbox"/> Earthing terminals		50x8 mm GI flat	
	(ii) Emergency lighting panel		As per requirement	
	<input type="checkbox"/> Bus bar		Copper	
	<input type="checkbox"/> Bus bar current rating	A	As per Requirement	
	<input type="checkbox"/> Incoming and outgoing feeders		As per requirements (With Minimum 2 spare feeders)	
	<input type="checkbox"/> Cable entry		Bottom	
	<input type="checkbox"/> Location		Indoor	
	<input type="checkbox"/> Earthing terminals		50x6 mm GI flat	
(d)	Sub DBs, wall/structure mounting panels			
i)	SLDB for indoor area		As per requirement	
	<input type="checkbox"/> Bus bars		Copper	
	<input type="checkbox"/> Bus bar current rating	A	As per requirement	
	<input type="checkbox"/> Incoming and outgoing feeders		1 No. Incoming TPN MCB * (Minimum32A) with ELCB As per requirement Outgoing 10/16A MCB SPN and DP ELCB per phase with PPI (With Minimum 2 spare feeder circuits; a single circuit consists of SPN MCBs for R,Y, B phase)	
	<input type="checkbox"/> Cable entry		Bottom/Top	
	<input type="checkbox"/> Location		Indoor	
ii)	SLDB for outdoor area		As per requirement	
	<input type="checkbox"/> Bus bars		Copper	
	<input type="checkbox"/> Bus bar current rating	A	As per requirement	
	<input type="checkbox"/> Incoming		1No.-Incoming * A TPN MCB	

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
			(Minimum 32A) with ELCB- with timer (0-24 hours)	
	<input type="checkbox"/> Outgoing		As per requirement Outgoing 10/16 A SPN MCB with switch contactors. (With Minimum 2 spare feeder circuits; a single circuit consists of SPN MCBs for R, Y, B phase)	
	<input type="checkbox"/> Cable entry		Bottom/Top	
	<input type="checkbox"/> Location		Indoor	
(e)	Paint Finish			
i)	Color shade		Interior : Glossy white	
			Exterior : Light gray semi glossy Shade 631 of I.S:5	
ii)	Epoxy paint required		Yes.	
(f)	Earthing terminals suitable for conductor			
i)	Size	mm x mm	25x3 flat	
ii)	Material		G.I.	
3	Receptacle Units			
(a)	Make			
(b)	Decorative (complete with flush/surface mounted boxes/cover plates etc.)			
i)	3 pin 1-ph & N with switch and plug tops	A	5/15 A, Indoor Type	
(c)	Industrial (complete with surface mounted, pre fabricated CRCA boxes)			
i)	3 Pin, 230V AC		As per required	
	With ELCB(30mA) & plug	A	15A, Indoor Type	
ii)	5 pin, 3 Ph, 415V		As per required	
	With ELCB(30mA) & plug	A	63A, Outdoor type	
	With ELCB(30mA) & plug	A	32A, Indoor type	
4	Lighting Wires			
(a)	Make		As per approved list	
(b)	Conductor		Stranded Copper	

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
(c)	Size (Sizes mentioned are minimum & size to be decided on circuit load & voltage drop criteria)	Core x mm ²	Lighting 2x1Cx1.5 mm ² Receptacle / Sockets Decorative 2x1Cx1.5mm ² Industrial 1ph - 2x1Cx4 mm ² 3ph – 4Cx 6 /16 mm ²	
5	Conduits			
(a)	Make			
(b)	Material		Galvanized steel	
(c)	Size	mm	20	
6	Street Light Poles And Flood Light Poles			
(a)	Make		As per Approved list	
(b)	Street Light Pole			
i)	Enclosed dwg. No.:		Ref. Typical Drawing attached with Specs.	
ii)	Total Height:	m	8.5/10/12	
iii)	Quantity:	Nos.	As per requirement	
(c)	Junction Box with Pole			
i)	Enclosed dwg. No.:		Pl. furnish.	
ii)	No. of cable entries:	Nos.	Two	
iii)	Cable entry suitable for :		4C-10/16 mm ² Al. Conductor, PVC insulated, armoured cable	
iv)	Earthing terminal suitable for		25x3 mm GS Flat	
(d)	Floodlight Light Pole			
i)	Total height	Mtr.	8.5/10/12/High Mast	
ii)	No. of floodlights to be fixed per pole	No.	Minimum One/as required	
iii)	Painted		Yes	
iv)	Earthing terminal suitable for	mm x mm	25x3	
v)	Quantity :	Nos.	As per requirement	
7	Luminaire (Lighting fixture complete with prewired control gear terminal block & suitable lamps)	LS	As per specification requirement	
8	Note			

Sr. No.	Description	Unit	Particulars	To be filled By Bidder
	Supply of conduits, wires/cables, all fixing hardware, terminal connectors, cable termination kits and associated accessories for -lighting, receptacles, earthing, cabling & wiring works, required Civil works etc. shall be included in Contractor's scope. All ELCBs for lighting circuit shall be with 100mA sensitivity. All ELCBs for receptacle circuit shall be with 30mA sensitivity.			

8.0 MAINTENANCE FREE SEALED LEAD ACID / Ni-Cd BATTERY

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
1	Application		Control & annunciation	
2	Type of battery		Maintenance free sealed lead acid	
3	Number of battery banks required (for 110V DC)	No.	* As per design requirement.	
4	Ambient conditions		Min. Temp. - 20° C	
			Max. Temp 50° C	
5	D.C. system voltage	V	110	
6	Ampere hour capacity of battery at 27 Deg. C at 10 hour rate to give final cell voltage of 1.75 volts/cell	Ah	* As per BOQ & design requirement.	
7	Momentary load/duration	A	* A for one minute	
8	Emergency load/duration	A	* A for two hours	
9	Continuous load/duration	A	* A for ten hours	
10	Cell voltage - initial/final	V	1.14/1.42 V	
11	Mounting arrangement		Multi tier	
12	Charging method proposed		Float & Float cum boost charging	

9.0 BATTERY CHARGER AND D.C. DISTRIBUTION BOARD

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
10.1	General			

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
(a)	Number required			
	(i) Battery charger	Nos	* As per design requirement.	
	(ii) D.C. Distribution board	Nos	* As per design requirement.	
	(b) DC System Voltage (Nominal)	V	110	
	(c) DC System Earthing		Unearthed	
	(d) Ambient Design Temperature	Deg. C	50	
(e)	Busbars	-	Copper	
10.2	DC Bus Load			
(a)	Total continuous DC load	A	* As per design requirement.	
(b)	Short time loads (Additional to continuous loads)			
	(i) DC lights/Facia lamps	A	* As per design requirement.	
	(ii) Starting current and duration of Largest Connected DC Motor	A Secs	* As per design requirement.	
10.3	Battery Details			
(a)	Float/Trickle charging current of battery	mA	* As per design requirement.	
(b)	Boost Charging Current of Battery (Maximum)	A	* As per design requirement.	
(c)	Boost Charging Voltage of Battery (maximum)	V	* As per design requirement.	
(d)	Maximum Time for Boost charging of Battery	hr	* As per design requirement.	
(e)	Battery capacity & no. of cells	Ah	* As per design requirement.	
		Nos.	* As per design requirement.	
10.4	AC System Data			
(a)	Supply	Voltage	V	415
		Phase		3
		Frequency	Hz	50
(b)	(i) Variation in supply Voltage	%	± 10	
	(ii) Variation in supply frequency	%	± 5	
(c)	Short Circuit level	kA	10	
(d)	Type of earthing		Solid earthing	
10.5	Performance			
(a)	DC voltage setting adjustment for float charger		±10% of nominal voltage	
(b)	Voltage stabilization for constant voltage regulator		±1% of set D.C. voltage, with AC	

Sr. No.	Description	Unit	Particulars	To be filed by Bidder
			input variation and DC load variation from 0 to 100%	
(c)	Maximum permissible variation in DC voltage (no load to full load)		± 1%	
(d)	D.C. voltage setting adjustment for boost charging		70% to 100% of max. boost charging voltage	
(e)	D.C. current adjustment for boost Charging		30% to 100% of max. boost charging current	
(f)	Current stabilization for constant current regulator for boost charger		± 2%	
(g)	Minimum permissible power factor to rated continuous load		0.8	
(h)	Permissible ripple content at rated continuous load		3% (maximum)	
10.6	Miscellaneous			
(a)	Cable entry		Bottom	
(b)	Cable Sizes			
	(i) Battery	sq.mm	* As per design requirement.	
	(ii) DC output	sq.mm	* As per design requirement.	
	(iii) AC input	sq.mm	* As per design requirement.	
(c)	Relay for auto changeover from Float to boost mode to be provided (in case of float-cum-boost charger)		Yes	
(d)	Constructional Features for Battery Charger & D.C. Distribution Board			
	(i) Thickness of sheet steel Frame, Frame enclosures, doors, covers and partition	mm	CRCA rolled 2.0	
	(ii) Degree of protection		IP 42	
	(iii) Colour finish shade		Interior RAL 7032	
			Exterior : RAL 7032	
	(iv) Earthing bus	Material	Copper	
		Size	mm 25 x 6	
	(v) Earthing conductor	Material	GS	
		Size	mm 50x 6	

10.0 MISCELLANEOUS EQUIPMENTS DETAILS

Sr. No.	Description	To Be Filled By Bidder	
	<u>Location</u>		
1.	<u>Relay</u>	Make & Model No.	Yes/ No
1.1	Instantaneous Over Current & Earth Fault Protections (50 & 50N) (Element Of Numerical Relay)		
1.2	IDMT Over Current & Earth Fault Protections (51 & 51N) (Element Of Numerical Relay)		
1.3	Master Trip / Lock Out Relay (86) (Separate Relay)		
1.4	Stand By Earth Fault Relay (51ns) (Separate Relay)		
1.5	Under Voltage/ No Voltage (27) & Over Voltage Relay (59)		
1.6	Trip Circuit Supervision Relay (95)		
1.7	Auxiliary Relay (Separate Relays Based On Requirements, With At Least One Spare Element)		
1.8	Automatic Voltage Regulator (Separate Device)		
1.9	Microprocessor Based Battery Charger Controller		
1.10	Motor Protection Relay (98) (Comprehensive Motor Protection Relay for Motor Ratings of 132 kW & above)		

2.	<u>Switchgear</u>	Application	Make & Model No.	Rating / Release Type		Yes / No
2.1	ACB	Above 630A	As Per Approved Make List	Minimum As Per BOQ & Specifications		
2.2	MCCB	Up to 630 A	As Per Approved Make List			
2.3	MCB		As Per Approved Make List			
2.3	Fuse		As Per Approved Make List			
3.	<u>Starters</u> (Including All Components For Type-2 Co-Ordination)	Application (Provide Feeder Range For Which It Is Applicable)	Make	Type -2 Co-Ordination (With MCCB) Ensured – Yes/No		Yes
3.1	D.O.L.	Up to 5.5 KW	As Per Approved Make List	Yes		
3.2	Star-Delta	Above 5.5 KW & upto 15 KW		Yes		
3.3	Auto Transformer Starter (ATS)	Above 15 KW & Upto 75 KW		--		
3.4	SOFT STARTER (µp Based)	Above 75 KW	As Per Approved Make List	Yes		
4.	Meters	Application	Make & Model No.	Type	Size	
4.1	Ammeter	Minimum As Per SLD & Specification Requirements	As Per Approved Make List			
4.2	Voltmeter					
4.3	MFM		As Per Approved Make List			

4.4	TVM /Tariff Meter (As Per Requirements)	(As Per Requirements)		
5.	Annunciators	Quantity	Make & Model No.	Indication Lamp Type
5.1	8 Window			
5.2	16 Window			
6.	Whether Detailed Literature For All The Above (Item 1 To 5) Items Enclosed With Tender (Yes / No)			

12 Diesel Standby Generator Set

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
1			BUIDCO Approved	
(a)	Set Manufacturer			
(b)	Quantity & Type	Nos	Bidder to Provide	
(c)	Applicable Standard		Bidder to Provide	
(d)	Rating	kVA	Bidder to Provide	
(e)	Method of starting		Bidder to Provide	
(f)	No. Of Phases, Rated Voltage, Frequency, PF and Speed		Bidder to Provide	
(g)	Overload capacity		Bidder to Provide	
(h)	Provision of Acoustic enclosure		Bidder to Provide	
(i)	Provision of AMF Control Panel for all the DG Sets	Yes/ No	Yes	
2	Alternator			
(a)	Manufacturer		BUIDCO Approved	
(b)	Type		Bidder to Provide	
(c)	Applicable Standard		Bidder to Provide	
(d)	Rating	kVA	Bidder to Provide	
(e)	Voltage	V	Bidder to Provide	
(f)	Number of phases		Bidder to Provide	
(g)	Frequency	Hz	Bidder to Provide	
(h)	Power Factor		Bidder to Provide	
(i)	Rated Current	A	Bidder to Provide	
(j)	Overload Capacity		Bidder to Provide	
(k)	Class of Insulation		Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(l)	Degree of protection		Bidder to Provide	
(m)	Winding Connection		Bidder to Provide	
(n)	Short circuit current		Bidder to Provide	
(o)	Type of rotor bearings		Bidder to Provide	
(q)	Provision of temperature sensors in stator windings		Bidder to Provide	
(r)	Exciter		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(s)	AVR		Bidder to Provide	
(i)	Make		Bidder to Provide	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(t)	Voltage regulation		Bidder to Provide	
(u)	Outgoing Cable		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	Size		Bidder to Provide	
(v)	Winding material		Bidder to Provide	
(w)	Rating of biggest motor which can be started on DOL		Bidder to Provide	
(x)	Details of protection		Bidder to Provide	
(y)	Efficiency		Bidder to Provide	
3	Diesel Engine			
(a)	Manufacturer			
(b)	Type		Bidder to Provide	
(c)	Applicable Standard		Bidder to Provide	
(d)	Rating	HP	Bidder to Provide	
(e)	Speed	rpm	Bidder to Provide	
(f)	Number of Cylinders		Bidder to Provide	
(g)	Number of Strokes		Bidder to Provide	
(h)	Type of Starting		Bidder to Provide	
(i)	Duty		Bidder to Provide	
(j)	Overload Capacity		Bidder to Provide	
(k)	Radiator		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Fan power		Bidder to Provide	
(iv)	Cooling air flow		Bidder to Provide	
(l)	Exhaust system		Bidder to Provide	
(i)	Type of Silencer		Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(ii)	Exhaust temperature gauge range		Bidder to Provide	
(m)	Governor		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	Class of governor		Bidder to Provide	
(n)	Cooling Water System		Bidder to Provide	
(i)	Water temperature		Bidder to Provide	
(ii)	Water Pressure		Bidder to Provide	
(iii)	System Capacity		Bidder to Provide	
(iv)	Provision of High water temperature and low water level switches		Bidder to Provide	
(o)	Lubricating oil system		Bidder to Provide	
(i)	Grade of Oil		Bidder to Provide	
(ii)	Oil Pressure		Bidder to Provide	
(iii)	Oil temperature		Bidder to Provide	
(iv)	Sump Capacity		Bidder to Provide	
(v)	Oil Consumption per 100 hours		Bidder to Provide	
(vi)	Recommended time period of Oil Change		Bidder to Provide	
(p)	Fuel		Bidder to Provide	
(i)	Fuel Specification		Bidder to Provide	
(ii)	Fuel Consumption at rated Capacity		Bidder to Provide	
(q)	Day oil tank		Bidder to Provide	
(i)	Capacity	Litres	Bidder to Provide	
(ii)	Provision of Level Gauge		Bidder to Provide	
(r)	Bulk Storage tank		Bidder to Provide	
(i)	Location		Bidder to Provide	
(ii)	Type		Bidder to Provide	
(iii)	Capacity		Bidder to Provide	
(s)	Starting system		Bidder to Provide	
(t)	Type of cooling		Bidder to Provide	
(u)	Exhaust system		Bidder to Provide	
4	AMF Control Panel			
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	Constructional Features		Bidder to Provide	
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers and partition	mm	Bidder to Provide	

Sr. No.	Description	Unit	Particulars	To be filled by Bidder
(b)	Colour finish shade - Interior		Bidder to Provide	
(c)	Colour finish shade - Exterior		Bidder to Provide	
(d)	Degree of Protection		Bidder to Provide	
(v)	AMF Features Provided as per Technical Specification	Yes/No	Bidder to Provide	
5	Protections , Alarm,Indications & Control whether provided as per Specification	Yes/No	Bidder to Provide	
6	Acoustic Enclosure		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	Constructional Features		Bidder to Provide	
(a)	Thickness of sheet steel Frame, Frame enclosures, doors covers.	mm	Bidder to Provide	
(b)	Degree of Protection		Bidder to Provide	
(c)	Acoustic material		Bidder to Provide	
(iv)	Sound level at 1m distance		Bidder to Provide	
(v)	Whether certified to meet emission norms	Yes/No	Bidder to Provide	
7	Battery		Bidder to Provide	
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	Voltage		Bidder to Provide	
(v)	Capacity at 10 hours rate		Bidder to Provide	
(vi)	Number of successive starting permissible		Bidder to Provide	
8	Battery Charger			
(i)	Make		BUIDCO Approved	
(ii)	Type		Bidder to Provide	
(iii)	Applicable Standard		Bidder to Provide	
(iv)	AC Input to Charger		Bidder to Provide	
(v)	DC Output of Charger		Bidder to Provide	

I /We are bound to supply the above Item of stated manufacture having rated capacity, material of construction and other requirements mentioned in the data sheet.

Sign. of Contractor

LIST OF APPROVED VENDORS FOR ELECTRICAL WORKS

Sl. No.	Item Description	Approved Makes
1.	11KV Switchgear	GEC / Siemens / Crompton / ECE / Alstom / ABB / CGL / GE
2.	Transformer	CGL / BBL / Voltamp / Kirloskar Elec / BHEL Alstom / Transformers & Rectifiers (I) Ltd. / GEC
3.	LT Panels (PMCC / MCC / PCC)	L&T / Siemens / Schneider / Alstom / Bienco - Lawrie / Patel Bros. / P&I / Swati Switchgears
4.	Lighting & Power Panels	Controls & Switchgear / Havells / Indo Asian / MDS Switchgear / Standard Electricals
5.	Cables	CCI / Gloster / Universal / Prime Cab / Finolex/Torrent/ Polycab / RPG Cables
6.	ACB/ MCCB/ MCB	ABB / Siemens / Schneider / GE / Crompton
7.	HRC / Control Fuses	L&T / Siemens / GE Power / Schneider
8.	Contactors	L&T / Siemens / Schneider / GE Power / Merlin Gerin / ABB
9.	Bi-metal Overload Relays	Merlin Gerin/ ABB / Siemens / L&T / C&S
10.	Meters	GEC / SIMCO
11.	Earth Leakage Circuit Breaker	Indo-Asian / GEC / S&S / MDS
12.	Indicating Lamps	L&T / Siemens / IEC / Technik / EE
13.		
14.	Lighting Fixtures / Luminaires	Philips / Crompton / Wipro / Bajaj
15.	Power Capacitor	Crompton / Universal / Asian / Meher (L&T) / Yesha / GEC / Khatau Junker / ABB / Madhav
16.	APFC Panel	L&T / Crompton
17.	Energy Meter	Jaipur / BHEL / G.E.C / I.I.T. / Universal
18.	Digital Energy Meter	Enercon / Secure / Schnieder / Krykard
19.	Control / Selector Switches	Siemens / L&T / Alstom / Havells / Kaycee
20.	Push Button	Siemens / L&T / Raas / Teknic / Schneider
21.	Timers	Siemens / L&T / BCH / Teknic
22.	Current and Voltage Transformer (cast Resin type)	Kappa / Silkanns / Gilbert / Precise / ABB / Jyoti / Ashmore / L & T
23.	Indicating Meters (Digital Type)	AEP / IMP / Meco /Nippen/Enercon / L & T / Trinity / Cologix
24.	Vacuum Circuit Breaker	Alstom / Crompton / Siemens / Bico Lawni
25.	Cable Jointing Kit	CCI / Raychem / M. Seal
26.	Variable Frequency Drive	ABB / Schneider / Eurotherm / Danfoss / Allen Bradeley
27.	D.G. Set (with AMF Panel) a) Engine b) Alternator c) AMF Panel	Kirloskar / Greaves / Caterpillar / Cummins NGEF / KEC / Crompton / Jyoti / Stamford Reputed CPRI approved vendor
28.	Ceiling / Exhaust Fans	Bajaj / Crompton / Orient
29.	Control Station (Local PB	Baliga Lighting / Bhartia / Ex-Protecta

Sl. No.	Item Description	Approved Makes
	Stn)	
30.	Ni-Cd Battery	Amco Power / HBL Nife
31.	Junction Boxes	Ex-protecta / Sudhir Swgr
32.	Numerical Relays	Siemens / L&T (P&B, U.K.) / ABB / Alstom
33.	Cable Glands	Siemens / Comet / HMI
34.	Accessories of wiring	Anchor / Jainex / Clipsal
35.	Terminal Blocks	Phoenix / Wago / Elmex / Connect Well
36.	Lugs	Dowell /Jainson / HEX
37.	APFC Relay	Enercon / Siemens / L&T / Asian / Datar
38.	Cable Trays	Indiana / Sharda / M.M. Engineering
39.	PVC Conduits & Accessories	Precision / Clipsal
40.	Flexible Wire (FRLS)	Finolex / Anchor / Havell's / RR Kabel/ L&T
41.	Elevators	Otis / Schindler / Thyssen Krupp / Kone / Mitsubishi
42.	Compact Sub Station	Siemens / Schneider / ABB
43.	H.T. VCB	Siemens / Schneider / ABB / Crompton / GE / GEC Alstom
44.	Dry Type Transformer	Voltamp / Raychem / T&R / Crompton/ Kirloskar / GEC Alstom
45.	SMF (Sealed Lead Acid Batteries)	Exide / HBL Nife / Quanta-Amara Raja
46.	UPS	Schneider (APC) / ABB/ Socomec/ Numeric
47.	Lightning Arrester	ELPRO/ OBLUM /CGL /Birla NGK Insulators
48.	Isolator	Sterling/ SMC/ ELPRO /Wigmen
49.	Load Break Switch	Siemens / Megawin /A Bond /D Penicker
50.	HT Cables	CCI/Nicco /Gloster /Torrent /Gems Cab /Polycab
51.	H. T. Cable Terminations	Raychem/ Mahindra/ CCI /ConnectWell
52.	LT Cable Terminations	Dowells /Jointwell /Lotus /Connectwell
53.	Modular Type Plug Socket	Anchor / Havels
54.	Timer (Astronomical time switch)	Legrand/ Theben (Din Rail Mounted)/ L&T/Gelco
55.	GOD	National/ Transspower

Note: The contractor shall distinctly understand that it will not be their prerogative to insist on a particular brand from the list, and final selection will be done with the approval of Engineer in charge. If any additional items are required beyond above Vendor List, Contractor should take prior approval of engineer in charge before order placement.