

Bidding Document for Procurement of Works

EPC/Turnkey Contract

(Single-stage, 2-Envelope Bidding Process with e-Procurement)

(Without Prequalification)

Open Competitive Bidding

(Single stage two-envelope process)

Volume -II

(Scope of Work and Technical Specifications)

**Design, Construction, Testing, Commissioning and
Operation & Maintenance of Infrastructure Works at
Integrated Manufacturing Cluster, Khurpia (Uttarakhand)
under Amritsar Kolkata Industrial Corridor (AKIC) “On EPC
Basis**

July, 2025

AKIC- NICDC Uttarakhand Industrial Township Limited

R.O. 29, IIE Sahastradhara Road (IT Park),

Dehradun-248001

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SECTION-A (SITE OF THE PROJECT)

(See Clauses 15.1)

1. The Site

- 1.1 The Site of the **“Construction of Trunk Infrastructure On EPC mode for IMC Khurpia under AKIC”** Project shall include Component A: Roads, Civil work, Wet Utilities, Power Civil Works & HT line realignment, ICT ducts & access chambers , Component B: CETP & STP Component C: Power Infrastructure- 3 nos. 33kV Substation and 1nos 11 kV Substation as described in **Section - A**
- 1.2 **The Authority shall make the required land available to the Contractor one month prior to the scheduled construction of the part of the project works as per Contractor’s approved work program.**
- 1.3 An inventory of the Site including land, buildings, structures, road works, trees and any other immovable property on, or attached to, the site shall be prepared jointly by the Authority Representative and the Contractor, and such inventory shall form part of the memorandum referred to in clause 15.2.1 of the agreement.
- i. Site of the project for “Roads, Bridges, Culverts, Structures and Miscellaneous Works” are given in Section- A1
 - ii. Site of the project for “Wet-Utilities” are given in Section- A2
 - iii. Site of the project for “CETP and STP” are given in Section- A3
 - iv. Site of the project for “Power” are given in Section- A4
 - v. Site of the project for “Truck Terminal” are given in Section- A5
 - vi. Site of the project for “Boundary Wall and Entrance Gate” are given in Section- A6

(Section-A)

Site

1. Site

The Site of the Project comprises of the area as shown in Location map of the Project as shown below.

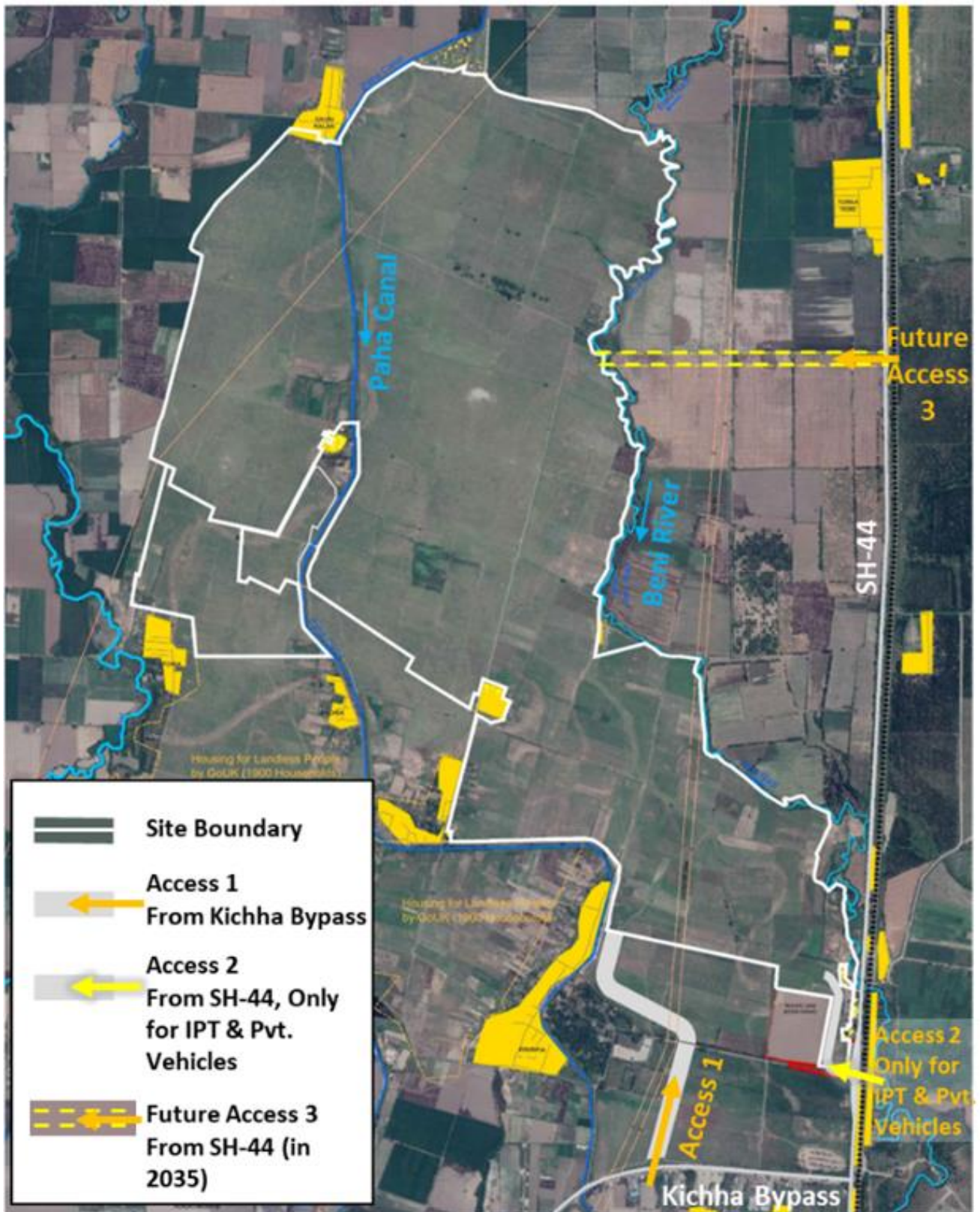


Figure A-1: Location Map of Project Site

A.1. ROADS

Road Hierarchy

Road Hierarchy is a scheme for categorising roads into groups based on a number of factors including; the function that the road is required to perform, location, category of area like industrial, recreational, residential, etc., geometric characteristics of the road, road capacity, etc.

A hierarchical road network within the Khurpia IMC has been proposed and the focus of the proposed transport network is on industrial entry points, industrial allied activities/services, and areas of traffic generating land uses such as commercial, residential, services and green & transport. The Right of Way (RoW) of proposed roads is 60m, 45 m, 30 m, 24 m, 18 m and 7 m. In general, the urban roads are classified into Arterial, Sub-arterial, Collector and Feeder roads however strict adherence to this classification is not possible in a real-life situation such as the present study area.

- 60 m RoW arterial road about 1 km is proposed to be the external road connection to Khurpia IMC from the Kichha bypass road access point 2, which enables last mile connectivity to the site.
- 45 m RoW arterial road is proposed to be the spine of the IMC; runs through the site from south to north and connects to SH-44 through access point 1;
- 30 m, 24 m and 18 m RoW roads form the sub arterial, distributor and feeder road network of industrial zone;
- 30 m RoW forms the arterial road of residential zone followed by 24 m and 18 m RoW roads; and
- 7 m RoW road is proposed along the eastern side perimeter of the site for River Beni's green belt maintenance (no other traffic expected on this).

The preliminary design of road network of the project will include but not limited to alignment and profile of the proposed road network as per the cross sections along with important features shown there on alignment including interface with the Kichha Bypass road, SH-44 and other elements of the project site. The road network of the project site falls in different type of land use and the total length of roads is about 24.11 km, Unique road reference has been given for the different categories of roads based on ROW and homogenous sections referred to master plan and details are presented in Table A-1 and road reference numbers are shown in table below.

Table A-1: Road reference numbers, lanes and RoWs followed for design.

Road_No	Length_km	Chainage	No. of Lanes	ROW
R1	2.20	(1.020 - 3.220)	6	45.00
R2	1.23	(0.000 - 1.230)	4	30.00
R3	0.60	(0.000 - 0.600)	2	18.00
R4	0.99	(0.000 - 0.990)	2	18.00
R5	1.24	(0.000 - 1.240)	4	30.00
R6	0.77	(0.000 - 0.770)	4	30.00
R7	0.88	(0.000 - 0.880)	2	18.00
R8	1.22	(0.000 - 1.220)	4	30.00
R9	0.95	(0.000 - 0.950)	2	24.00
R10	0.26	(0.000 - 0.260)	2	18.00
R11	1.19	(0.000 - 1.190)	2	18.00
R12	0.94	(0.000 - 0.940)	2	18.00
R13	0.13	(0.000 - 0.130)	2	18.00
R15	0.50	(0.000 - 0.500)	2	18.00
R16	0.83	(0.000 - 0.830)	4	30.00

Road_No	Length_km	Chainage	No. of Lanes	ROW
R17	0.22	(0.000 - 0.220)	2	18.00
R18	0.87	(0.000 - 0.870)	2	18.00
R19	0.68	(0.000 - 0.680)	2	18.00
R20	0.68	(0.000 - 0.680)	2	18.00
R21	1.31	(0.000 - 1.310)	6	45.00
R22	0.96	(0.000 - 0.960)	4	30.00
R23	0.61	(0.000 - 0.610)	IL	8.50
R24	1.12	(0.000 - 1.120)	IL	8.50
R25	1.07	(0.000 - 1.070)	IL	8.50
R26	0.43	(0.000 - 0.430)	2	18.00
R27	0.53	(0.000 - 0.530)	2	24.00
R29	0.32	(0.000 - 0.320)	2	18.00
Sub Total	22.73			
External Road Connectivity				
Road_No	Length_km	Chainage	No. of Lanes	ROW
R1	1.02	(0.000 - 1.020)	6	60.0
Sub Total	1.02			
Grand Total	23.75			

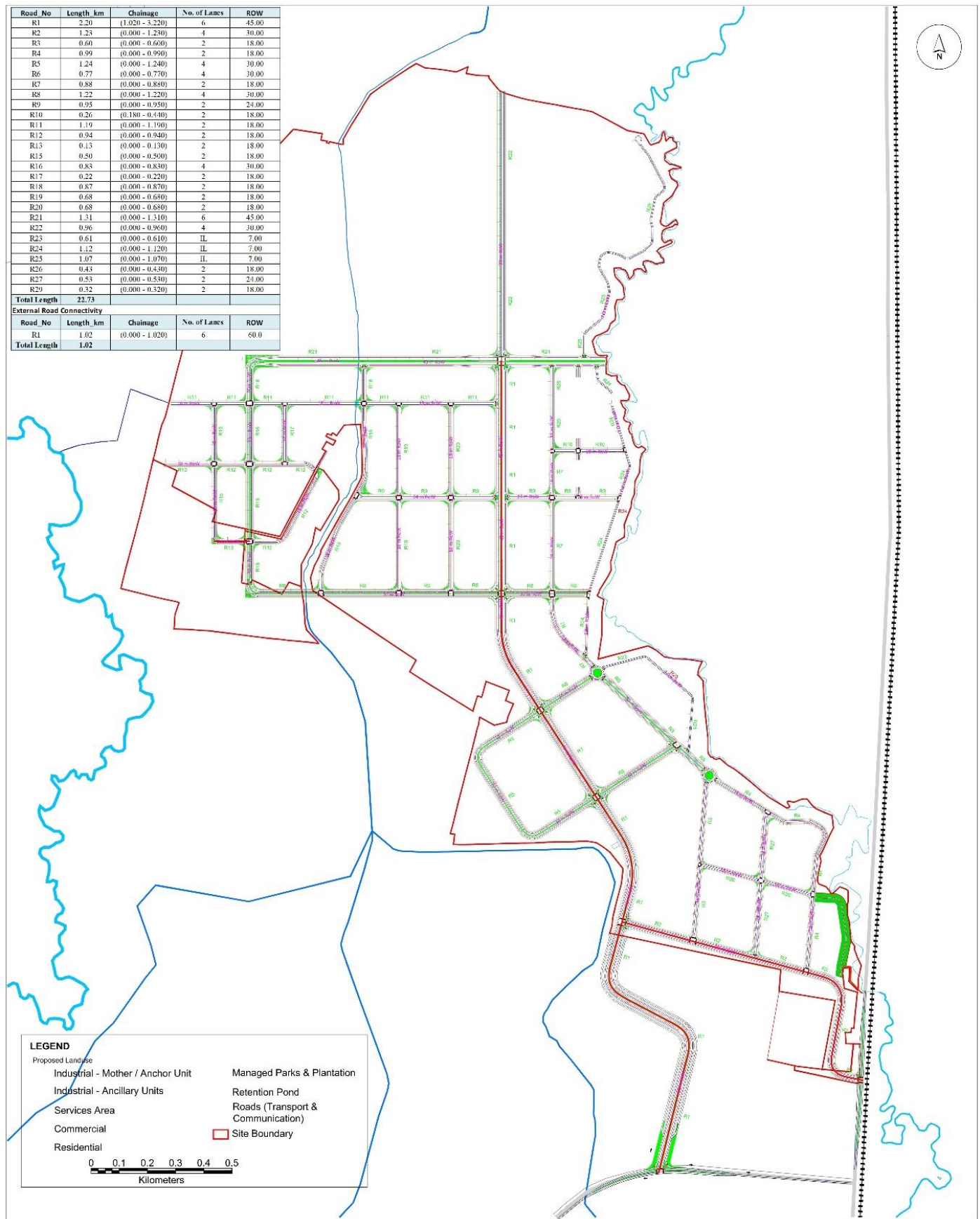


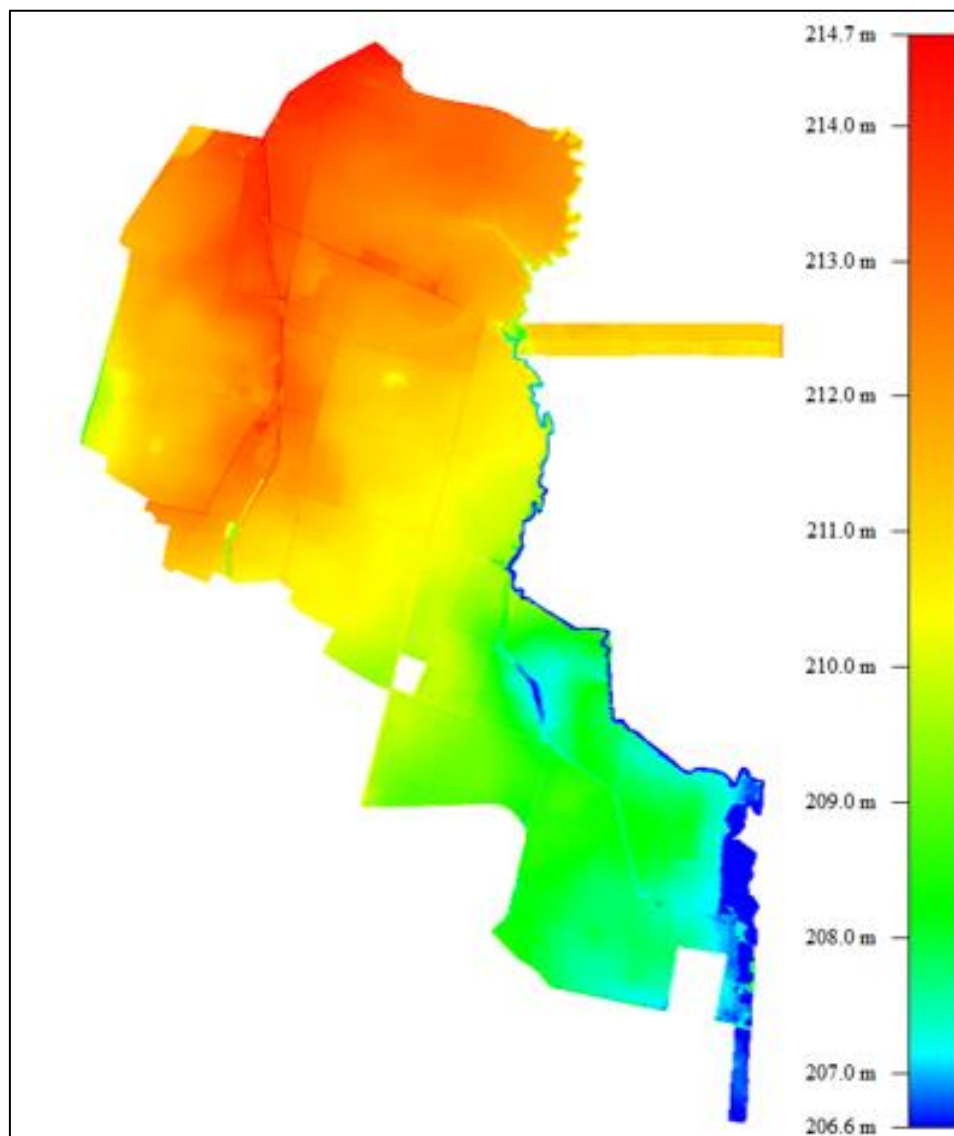
Figure A-2: Key map showing the Road Network of the Khurpia site

A.2. WET-UTILITIES

Existing Site topography and Drainage System

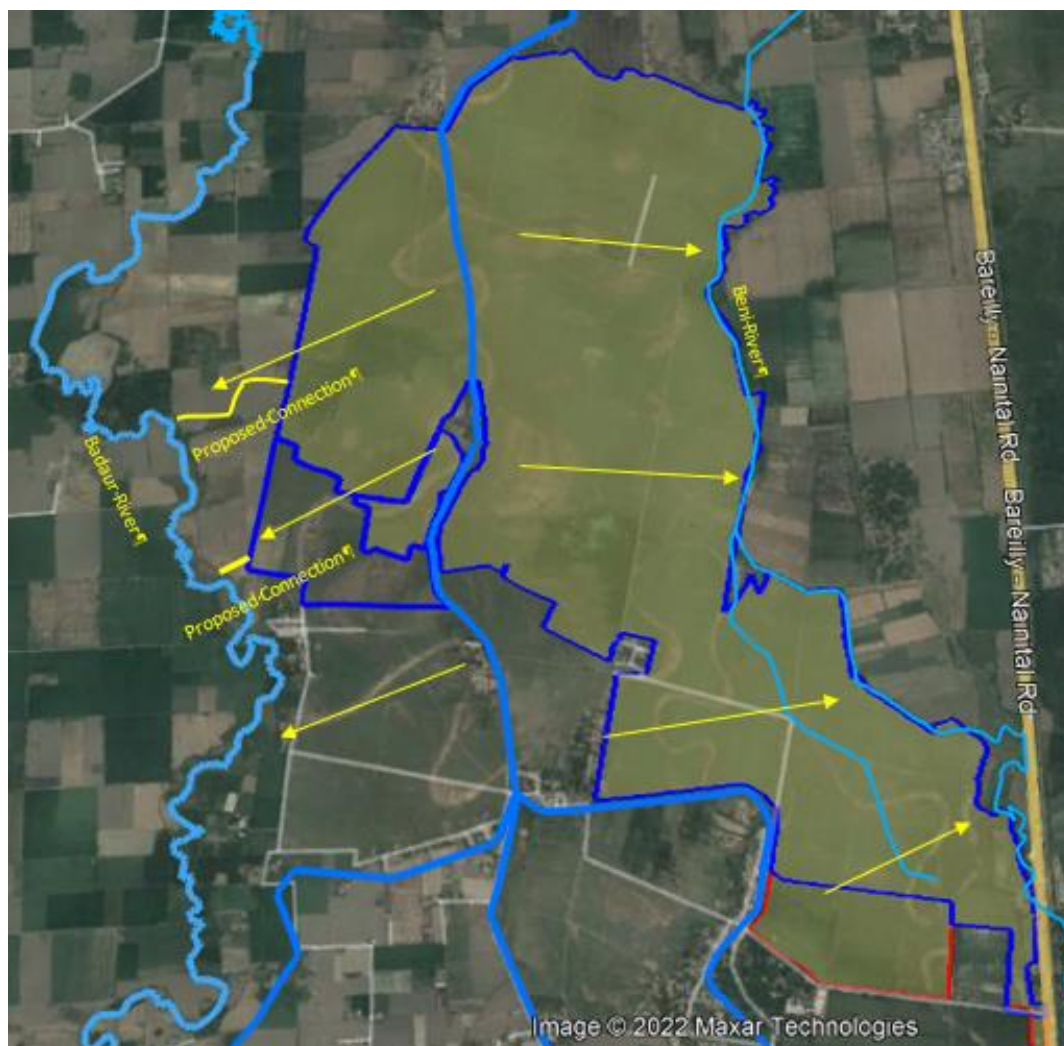
- a. The project is a Greenfield project primarily consisting of un-cultivated land which is used for cattle rearing and grazing. The drainage system shall be planned based on the natural topography of the site.
- b. The majority of the project area has a general slope from the west to east towards Beni River as well as north to south along the direction of flow of Beni River. A small portion of the project area towards the north-west has an east to west slope towards another river Badaur.
- c. Paha canal which flows through the project site forms the ridge line for the project area forming the watershed divide for the proposed storm water drainage system. The digital elevation model of the project area is presented in Figure A-3.

Figure A-3: Digital elevation model (DEM) of project area



- d. Majority of the site has a general gradient of approximately 1 in 500 from north to south and 1 in 600 from west to east. The High Flood Level (HFL) as captured from a railway bridge over River Beni nearly 50 m from site shows that maximum flood level was seen in the year 1959 and it was 207.30 m above MSL.
- e. The general slopes and major catchment to be adopted for storm water drainage from the site has been presented in the Figure A-4.

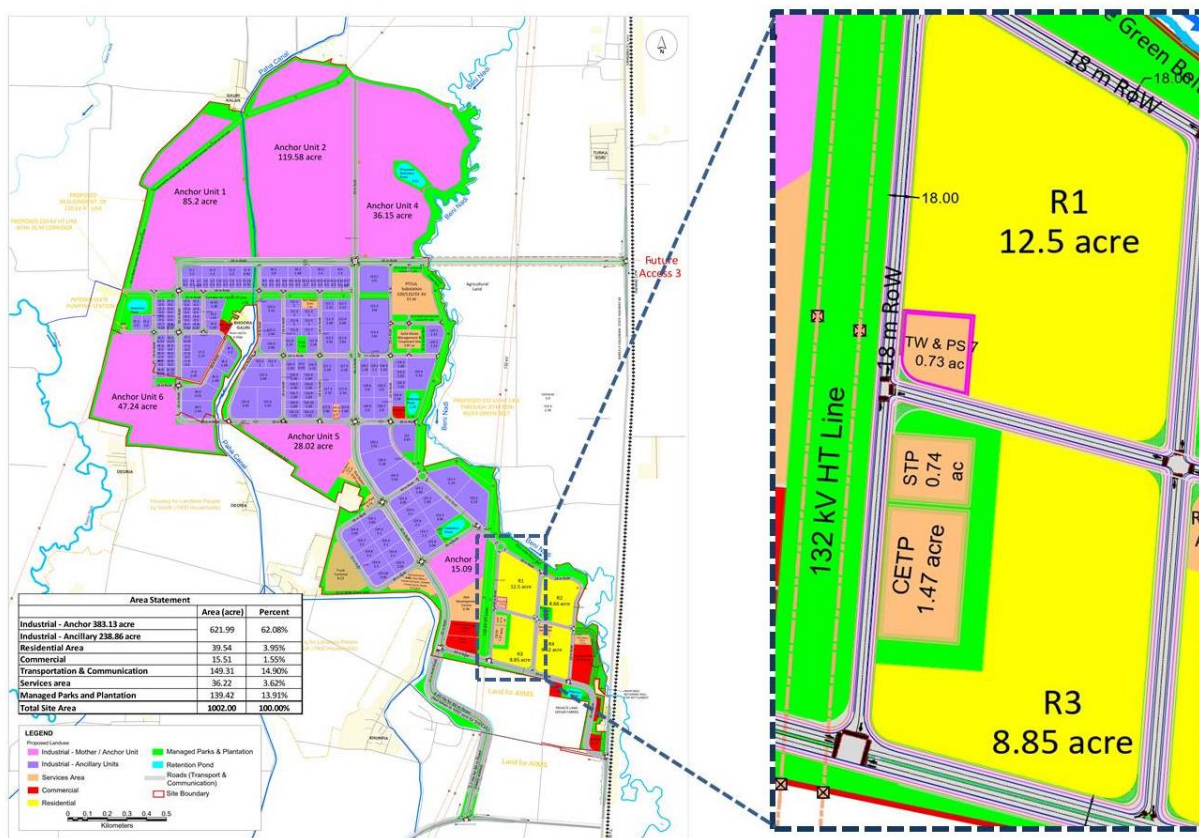
Figure A-4: Drainage pattern in IMC Khurpia project site



A.3. CETP AND STP

As per the Master Plan, the STP & CETP is proposed on the southern side. The location of CETP & STP is selected keeping in view of the slope of the site terrain, which is sloping from north to south, so that the effluent from various industrial zone will be collected by pipes through gravity. The location of these treatment plants is shown in figure below.

Figure A-5: Location of Treatment (STP and CETP) Plants in IMC Khurpia

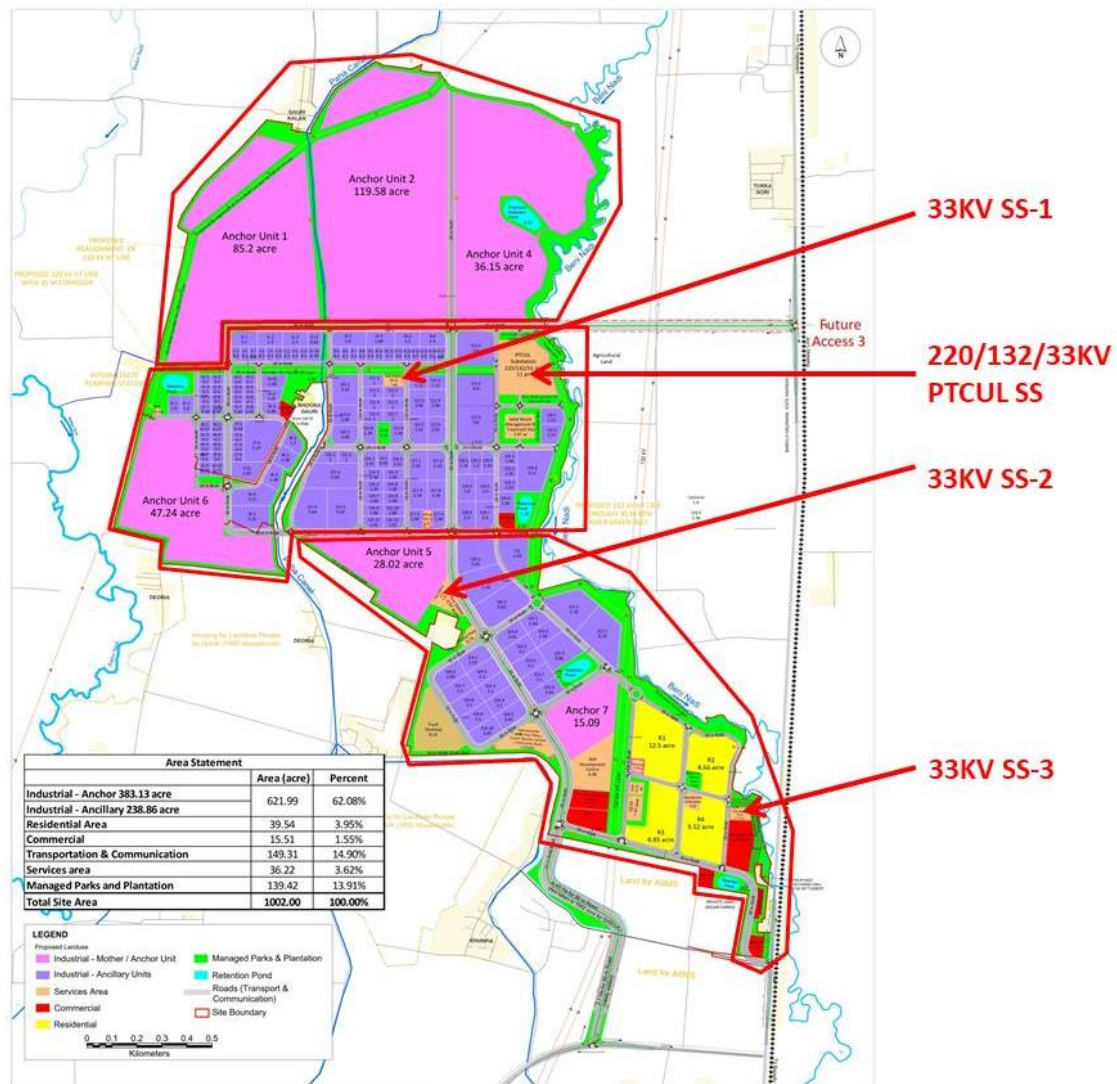


A.4. POWER

1. Electrical Substations locations

Locations for the electrical substations of the project are earmarked & are shown below.

Figure A-6: Map showing Zones & earmarked location of substations



A.5. TRUCK TERMINAL

Based on the total truck traffic and the area required for parking a single truck, the total parking area required for the Khurpia IMC in a day was estimated. Considering the area requirement for other facilities like rest area, loading/ unloading, warehousing, access road to the facility, etc., an overall requirement of the proposed truck terminal facility an 8.23 acres site is proposed in the master plan for Truck Terminal. The Contractor has to carry out his own surveys, design the truck terminal and submit the as built drawings of the truck terminal to the independent engineer/SPV.

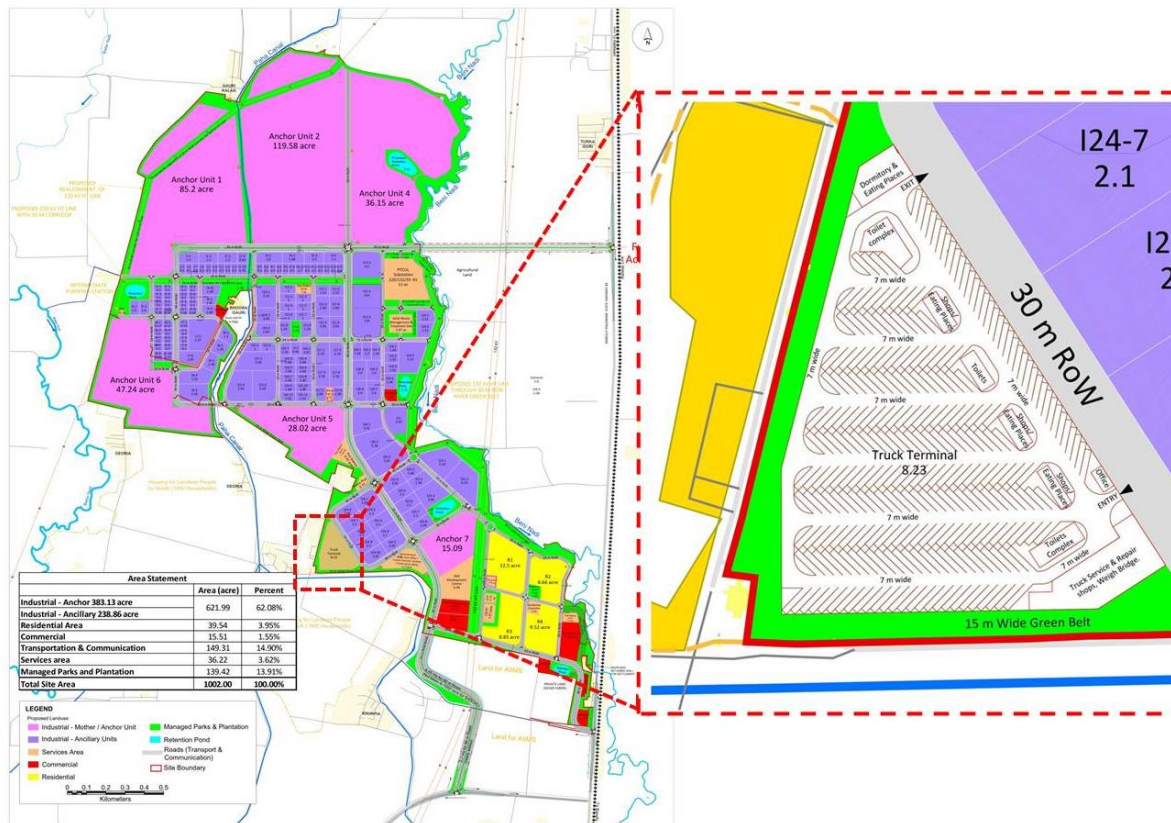


Figure A-7: Location and Tentative layout of proposed Truck Terminal at IMC Khurpia

A.6. ENTRANCE GATE AND BOUNDARY WALL

IMC Khurpia shall have 3 accesses to the site:

1. Access 1 from Kichha Bypass via a 60m RoW road;
2. Access 2 shall be only for private vehicles and Intermediate Public Transport (IPT) from SH-44 via a 30m RoW road; and
3. Future Access 3 from SH-44 which shall be built in phase 2 of the project upon acquisition of land.

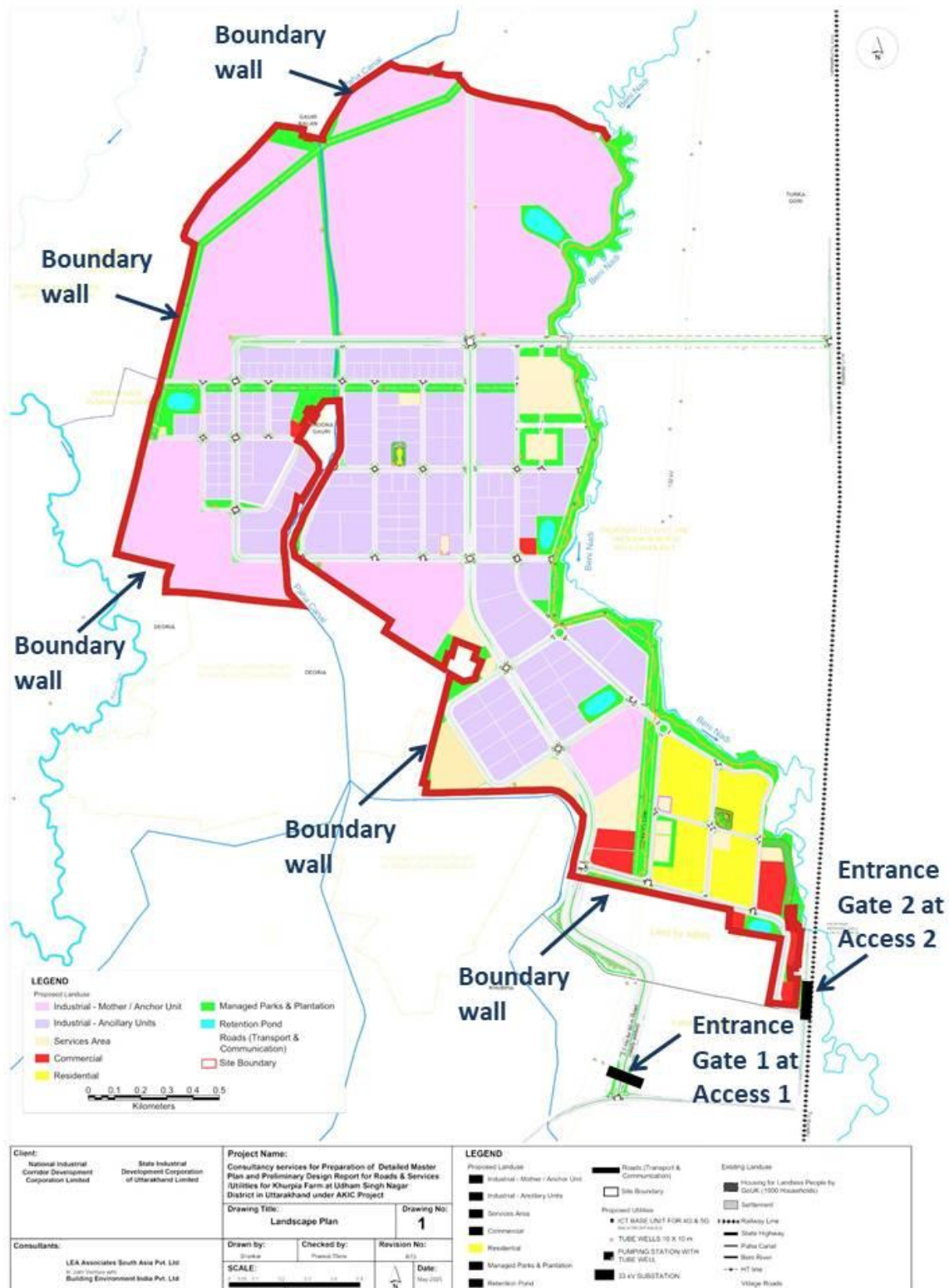
Two Entrance gates shall be developed in Phase 1 under the scope of the EPC contractor:

1. Gate 1 at Access 1 from Kichha Bypass via a 60m RoW road; and
2. Gate 2 at Access 2 shall be only for private vehicles and Intermediate Public Transport (IPT) from SH-44 via a 30m RoW road.

IMC Khurpia shall have a boundary wall encompassing the entire site to prevent encroachment and also to delineate its site boundary. The boundary wall shall be made of brick work structure with RCC band at ground level and coping at top.

The Contractor has to carry out his own surveys, design the Entrance Gates and Boundary wall, and submit the as built drawings of the Entrance Gates and Boundary Wall to the independent engineer/SPV. The following map shows both the entrance gates and the boundary wall.

Figure A-8: Map showing Entrance Gate and Boundary Wall



SECTION-B (DEVELOPMENT OF THE PROJECT)

(See Clause 9)

Development shall include “ Construction of Trunk Infrastructure On EPC mode for IMC Khurpia under AKIC” Project shall include Component A: Roads, Civil work, Wet Utilities, Power Civil Works & HT line realignment, ICT ducts & access chambers , Component B: CETP & STP , Component C: Power Infrastructure- 3 nos. 33kV Substation and 1nos 11 kV Substations” as described in this Section-B and in Section -C.

- i. Development of the project regarding “Roads, Bridges, Culverts, Structures and Miscellaneous Works” are given in Section- B1
- ii. Development of the project regarding “Wet-Utilities” are given in Section- B2
- iii. Development of the project regarding “Power” are given in Section- B3
- iv. Development of the project regarding “CETP and STP” are given in Section- B4
- v. Development of the project regarding “Truck Terminal” are given in Section- B5
- vi. Development of the project regarding “Boundary Wall” are given in Section- B6
- vii. Development of the project regarding “Entrance Gate” are given in Section- B7

Scope of Work

B.1. ROADS

1) Scope of work

The Contractor shall be responsible for the detailed Design, Construction, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier’s works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer at the need of O&M period, handling at site, complete, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis. Brief scopes are as follows which are elaborated in respective sections.

Road works including Cross Drainage Structures and Bridges

The road network of the project site falls in different types of land use and the total length of roads is about 23.75 km, unique road reference has been given for the different categories of roads based on ROW. Road network is aimed to have a reasonable hierarchy supporting efficient traffic distribution with optimum usage. The bottom of sub-grade shall be 1.0 m above the High Flood Level (HFL). Contractor has to assess HFL during detailed engineering stage & to get vetted by the PMNC/ Competent professional body approved by the Authority.

Various categories of Roads are as follows:

Arterial Road

Arterial roads would play a major role for connecting internal road network inside the project boundary as well as external road connectivity to site. The Right of way reserved for Arterial roads is 60 m & 45 m:

- a) 60 m RoW arterial road about 1 km is proposed to be the external road connection to Khurpia IMC from the Kichha bypass road access point 1, which enables access and last mile connectivity to the site
- b) 45 m RoW arterial road of about 3.5 km is proposed to be the spine of the IMC; runs through the site from south to north and connects to SH-44 through access point 2;

There are utility corridor running on either side of the corridor with cycle track, footpath, SWD/drains, all utility lines and plantation in line with master plan.

Sub Arterial Road, Distributor and Feeder road network

30 m, 24 m and 18 m RoW roads form the sub arterial, distributor and feeder road network of industrial zone and residential zone. The total length of 30m road is about 6.2 km, 24m road is about 1.5 km and 18m road is about 9km. Features like Cycle track, footpath, utility corridor, and SWD/drains and plantation are provided on either side of the corridor.

Peripheral Road

7m RoW road is proposed along the eastern side perimeter of the site for River Beni's green belt maintenance (no other traffic expected on this). The total length is about 2.8 km

Cross Drainage Structures

A man made canal called Paha canal passes through the site. Three box minor bridge structures are proposed on Paha canal.

1) Box Minor Bridge on 45 m RoW road:

As per the site conditions, Cross Drainage structure is required for discharging flow in Paha canal and storm water across a 45m RoW road. According to the discharge assessed and Canal width a RCC Triple cell box minor bridge with dimension of 2m x 2m is proposed at this location.

2) Box Minor Bridge on 18 m RoW road:

A 30 m RoW road of the Khurpia Layout passes over the Paha Canal, A Cross Drainage structure is proposed for discharging sewage water and flow in Paha canal. After the review of road profile, the location of the structure has been identified at this chainage. According to the discharge and width of the Canal at this location, a RCC Triple cell box minor bridge with dimension of 2m x 2m is adopted.

3) Box Minor Bridge on 30 m RoW road:

As per the site conditions, Cross Drainage structure is required for discharging flow in Paha canal and storm water across a 30 m RoW road. According to the discharge assessed and Canal width a RCC Triple cell box minor bridge with dimension of 2m x 2m is proposed at this location.

2) Development of the Project Roads and Utilities / Services

Development of the Project Roads and Utilities / Services shall include design and construction of the project Roads and Utilities / Services as described in this Schedule B and in Schedule C.

3) Specifications and Standards

The Project Roads and Utilities / Services shall be designed and constructed in conformity with the Specifications and Standards specified in Annexure-I of Schedule-D.

4) Project Roads and Utilities / Services

- 1** Road network (Right of Way widths varying from 7m to 60m and additional service roads) details as per Typical Cross Sections (TCSs) are given in Annex I.
- 2** Geometric design and other features are given in Annex I.
- 3** Junction details are given in Annex I.
- 4** Embankment & Pavement design details are given in Annex I.
- 5** Typical Cross Sections (TCSs) drawings are given in Annex I.
- 6** Details of Bridges are given in Annex I.

5) Change of Scope

The work specified herein above shall be treated as an approximate assessment. The actual works as required on the basis of detailed design and investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations upto $\pm 2\%$ (two per cent) in the detailed design in terms of total length for each network i.e. roads, potable water, recycle water, sewage, industrial effluent, open and covered storm water drainage, power, ICT, Junction crossings for utilities/services and length of each bridge for the works specified in this Section-B shall not constitute a Change of Scope, save and except any variations in the works arising out of a Change of Scope expressly undertaken in accordance with the provisions of this agreement.

Annex – I

(Section – B)

Description of Project

1 DEVELOPMENT OF THE PROPOSED ROAD NETWORK

1.1 The Project shall follow the proposed alignment unless otherwise specified by the Authority and shown in the alignment plans specified in the Annex I of Section -A. Geometric designs including horizontal and vertical profiles shall be as per the prescribed standards for plain terrain to the extent land is available subjected to approval of authority.

1.2 WIDTH OF CARRIAGEWAY

1.2.1 The carriageway width shall be provided in the as given in Table B-1 hereunder:

Table B-1: Width of Carriageway

Sl.No.	Road_No	Length (m)	Chainage		Carriageway Width (m)
			From	To	
1	R1	2198.00	1+020	3+220	22.00
2	R2	1232.00	0+000	1+230	15.00
3	R3	600.00	0+000	0+60	7.50
4	R4	990.00	0+000	0+990	7.50
5	R5	1240.00	0+000	1+240	15.00
6	R6	769.00	0+000	0+769	15.00
7	R7	880.00	0+000	0+880	7.50
8	R8	1223.00	0+000	1+223	15.00
9	R9	950.00	0+000	0+950	10.50
10	R10	260.00	0+180	0+440	7.50
11	R11	1185.00	0+000	1+185	7.50
12	R12	940.00	0+000	0+940	7.50
13	R13	130.00	0+000	0+130	7.50
14	R15	500.00	0+000	0+500	7.50
15	R16	830.00	0+000	0+830	15.00
16	R17	220.00	0+000	0+220	7.50
17	R18	870.00	0+000	0+870	7.50
18	R19	680.00	0+000	0+680	7.50
19	R20	680.00	0+000	0+680	7.50
20	R21	1310.00	0+000	1+310	22.00
21	R22	960.00	0+000	0+960	15.00

Sl.No.	Road_No	Length (m)	Chainage		Carriageway Width (m)
			From	To	
22	R23	610.00	0+000	0+610	7 (GSB Road)
23	R24	1124.00	0+000	1+124	7 (GSB Road)
24	R25	1070.00	0+000	1+070	7 (GSB Road)
25	R26	430.00	0+000	0+430	7.50
26	R27	530.00	0+000	0+530	10.50
27	R29	320.00	0+000	0+320	7.50
28	R1 Access Road-2	1020.00	0+000	1+020	22.00

2 GEOMETRIC DESIGN AND GENERAL FEATURES

2.1 General

Geometric design and general features of the proposed roads shall be in accordance with MORT&H and IRC-38.

2.2 Design speed

The design speed for the various roads in the proposed road network shall be given in **Table B-2**.

Table B-2: Design Speeds

Design Speed		
Sl.No.	Road Number	Design Speed (Kmph)
1	R1	40
2	R2	40
3	R3	30
4	R4	30
5	R5	30
6	R6	30
7	R7	30
8	R8	40
9	R9	40
10	R10	30
11	R11	30
12	R12	30
13	R13	30
14	R15	40
15	R16	40
16	R17	40
17	R18	40
18	R19	40
19	R20	30
20	R21	60
21	R22	40
22	R23	20
23	R24	20
24	R25	20
25	R26	40
26	R27	40
27	R29	40
28	R1 Access-2	40

2.3 Right of Way

The space standards (right-of-way) recommended for the various categories of urban roads are given in Table below.

Table B-3: Recommended Land Widths (ROW) for Roads in Urban Areas

S.No.	Type of Urban Road/Street	Land Width (m) and Type of Terrain		
		Plain	Rolling	Hilly
1	Urban Expressway	45-75	35-60	30-50
2	Arterial Road	45-60	35-50	25-40
3	Sub Arterial Road	30-45	25-35	20-30
4	Collector Street	15-30	12 - 25	12-20
5	Local Street	10-15	10-15	10-15

Source: IRC:86-2018

ROW Proposed: Based on the category of the roads, site requirements and the land use of the proposed development area, various ROWs are proposed. The Right of Way (RoW) of proposed roads are 60m, 45 m, 30 m, 24 m, 18 m and 7 m.

Details of the Right of Way are given below table B-3.

Table B-4: Right of Way details

Sl.No.	Road_No	Length (m)	Chainage		RoW
			From	To	
1	R1	2198.00	1+020	3+220	45
2	R2	1232.00	0+000	1+230	30
3	R3	600.00	0+000	0+60	18
4	R4	990.00	0+000	0+990	18
5	R5	1240.00	0+000	1+240	30
6	R6	769.00	0+000	0+769	30
7	R7	880.00	0+000	0+880	18
8	R8	1223.00	0+000	1+223	30
9	R9	950.00	0+000	0+950	24
10	R10	260.00	0+180	0+440	18
11	R11	1185.00	0+000	1+185	18
12	R12	940.00	0+000	0+940	18
13	R13	130.00	0+000	0+130	18
14	R15	500.00	0+000	0+500	18
15	R16	830.00	0+000	0+830	30
16	R17	220.00	0+000	0+220	18
17	R18	870.00	0+000	0+870	18
18	R19	680.00	0+000	0+680	18
19	R20	680.00	0+000	0+680	18
20	R21	1310.00	0+000	1+310	45
21	R22	960.00	0+000	0+960	30
22	R23	610.00	0+000	0+610	7
23	R24	1124.00	0+000	1+124	7
24	R25	1070.00	0+000	1+070	7

Sl.No.	Road_No	Length (m)	Chainage		RoW
			From	To	
25	R26	430.00	0+000	0+430	18
26	R27	530.00	0+000	0+530	24
27	R29	320.00	0+000	0+320	18
28	R1 Access Road-2	1020.00	0+000	1+020	60

2.4 Service roads

Service roads shall be constructed at the locations and for the lengths indicated below table B-4.

Table B-5: Service Road details

Sl. No.	Location of service road (from km to km)	Right hand side (RHS)/Left hand side (LHS)/ or Both sides	Length (km) of service
1	0+000 to 1+020	Both Sides	1.02

2.5 Typical cross-sections of the Proposed Roads.

Typical cross sections to be used for the proposed roads are detailed in Appendix B- I.

The typical cross sections to be used for the Project roads detailed are given in the table B-5.

Table B-6: Typical Cross Section details

Sl.No.	Road_No	Length_km	Chainage		Applicable TCS	RoW
			From	To		
1	R1	2198.00	1+020	3+220	TCS-2	45
2	R2	1232.00	0+000	1+230	TCS-3	30
3	R3	600.00	0+000	0+60	TCS-5	18
4	R4	990.00	0+000	0+990	TCS-5	18
5	R5	1240.00	0+000	1+240	TCS-3	30
6	R6	769.00	0+000	0+769	TCS-3	30
7	R7	880.00	0+000	0+880	TCS-5	18
8	R8	1223.00	0+000	1+223	TCS-3	30
9	R9	950.00	0+000	0+950	TCS-4	24
10	R10	260.00	0+180	0+440	TCS-5	18
11	R11	1185.00	0+000	1+185	TCS-5	18
12	R12	940.00	0+000	0+940	TCS-5	18
13	R13	130.00	0+000	0+130	TCS-5	18
14	R15	500.00	0+000	0+500	TCS-5	18
15	R16	830.00	0+000	0+830	TCS-3	30
16	R17	220.00	0+000	0+220	TCS-5	18
17	R18	870.00	0+000	0+870	TCS-5	18
18	R19	680.00	0+000	0+680	TCS-5	18
19	R20	680.00	0+000	0+680	TCS-5	18
20	R21	1310.00	0+000	1+310	TCS-2	45
21	R22	960.00	0+000	0+960	TCS-3	30
22	R23	610.00	0+000	0+610	TCS-6	7

Sl.No.	Road_No	Length_km	Chainage		Applicable TCS	RoW
			From	To		
23	R24	1124.00	0+000	1+124	TCS-6	7
24	R25	1070.00	0+000	1+070	TCS-6	7
25	R26	430.00	0+000	0+430	TCS-5	18
26	R27	530.00	0+000	0+530	TCS-4	24
27	R29	320.00	0+000	0+320	TCS-5	18
28	R1 Access Road-2	1020.00	0+000	1+020	TCS-1	60

3 INTERSECTIONS

All proposed intersections, minimum requirements shall be provided as per MORT&H and IRC: SP:41–1994.

Properly designed intersections shall be provided at the locations and of the types and features given in the Table B-7

Table B-7: Junctions details

Junctions (At grade)				
Sl.No.	Road Number	Junction Number	Type of Junction	Remark
1	R1	R1-J2	3 arms	
2		R1-J3	4 arms	
3		R1-J4	4 arms	
4		R1-J5	4 arms	
5		R1-J6	4 arms	
6		R1-J8	3 arms	
7		R1-J9	4 arms	
8	R2	R2-J1	3 arms	
9		R2-J2	3 arms	
10		R2-J3	3 arms	
11		R2-J4	3 arms	
12	R3	R3-J1	3 arms	
13		R3-J2	3 arms	Roundabout
14	R4	R4-J1	3 arms	
15		R4-J2	3 arms	
16	R5	R5-J1	4 arms	staggered
17	R6	R6-J1	4 arms	Roundabout
18	R7	R7-J1	4 arms	
19		R7-J2	4 arms	
20		R7-J3	3 arms	
21	R8	R8-J1	3 arms	
22		R8-J2	3 arms	
23		R8-J3	3 arms	
24		R8-J4	3 arms	
25	R9	R9-J1	3 arms	

Junctions (At grade)				
Sl.No.	Road Number	Junction Number	Type of Junction	Remark
26		R9-J2	4 arms	
27		R9-J3	4 arms	
28		R9-J4	3 arms	
29		R9-J5	3 arms	
30	R10	R10-J1	4 arms	
31		R10-J2	3 arms	
32	R11	R11-J1	3 arms	
33		R11-J2	4 arms	
34		R11-J3	3 arms	
35		R11-J4	4 arms	
36		R11-J5	3 arms	
37	R12	R11-J6	3 arms	
38		R12-J1	4 arms	
39		R12-J2	4 arms	
40		R12-J3	3 arms	
41	R21	R12-J4	4 arms	
42		R21-J1	3 arms	
43		R21-J2	3 arms	
44		R21-J3	5 arms	staggered
45	R26	R26-J1	4 arms	
46	R1	R1-J1	3 arms	

4 ROAD EMBANKMENT AND CUT SECTION

4.1 Construction of new road embankment/ cuttings shall conform to the Specifications and Standards given in section 4 of the Manual and the specified cross sectional details. Deficiencies in the plan and profile of the existing road shall be corrected.

The proposed roads average embankments shall be the following below table B-7.

Table B-8: Road embankment details

Road No	Average Height of FRL at Centre line of road (m)	Average Height of Embankment at centre line of road at Subgrade level (m)	Average Height of road at Left RoW edge (m)	Average Height of road at Right RoW edge (m)
R1	0.774	0.274	1.183	1.101
R2	0.714	0.214	0.781	0.895
R3	0.928	0.428	1.072	1.132
R4	0.915	0.415	1.247	1.109
R5	0.768	0.268	0.954	0.927
R6	0.913	0.413	1.05	1.127
R7	0.71	0.21	1.056	0.874
R8	0.78	0.28	0.923	0.974
R9	0.471	-0.029	0.874	0.634
R10	0.62	0.12	0.953	0.802

Road No	Average Height of FRL at Centre line of road (m)	Average Height of Embankment at centre line of road at Subgrade level (m)	Average Height of road at Left RoW edge (m)	Average Height of road at Right RoW edge (m)
R11	1.097	0.597	1.495	1.238
R12	0.448	-0.052	0.837	0.602
R13	0.751	0.251	0.945	0.853
R15	0.12	-0.38	0.489	0.289
R16	0.467	-0.033	0.665	0.604
R17	0.713	0.213	1.138	0.798
R18	1.398	0.898	1.806	1.697
R19	0.623	0.123	0.916	0.85
R20	0.626	0.126	0.953	0.831
R21	1.297	0.797	1.442	1.461
R22	0.633	0.133	0.794	0.807
R23	0.687	0.207	0.808	0.739
R24	0.958	0.478	1.056	1.024
R25	0.793	0.313	0.889	0.868
R26	0.821	0.321	1.177	0.971
R27	0.613	0.113	1.022	0.805
R29	0.813	0.313	1.141	0.991
Maximum	1.398	0.898	1.806	1.697
Minimum	0.12	-0.38	0.489	0.289
Average	0.757	0.260	1.025	0.926

5 PAVEMENT DESIGN

5.1 Pavement design shall be carried out in accordance with IRC:37-2018.

5.2 Type of Pavement

Type of pavement shall be flexible pavement; details are mentioned in the given table B-8.

Table B-9: Type of Pavement

Main Carriageway	Service Roads/ Bus bays	Cycle Track	Footpath
Flexible	Flexible	CC interlocking paver blocks	CC interlocking paver blocks

5.3 Design Requirements

5.3.1 Design Period and strategy

Flexible pavement shall be designed for a minimum period of 20 years.

5.3.2 Design Traffic

Notwithstanding anything to the contrary contained in the Sections, the Contractor shall design the pavement for minimum MSA as given below in

Table B-10

Table B-10: Design Traffic

Road ROW	60 m	45 m	30 m	24 m	18 m	7 m

Traffic (MSA)	10	10	10	10	10	5

Note: Granular layers shall be designed for minimum 10 MSA traffic for 60m, 45m, 30m, 24m, 18m, and 5 MSA traffic 7m ROW roads.

5.3.3 Cycle Track Pavement

Cycle Track Pavement shall be of Interlocking Paver Blocks as per the guidelines given in IRC: SP: 63-2004. The proposed composition is as given below in Table B-11.

Table B-11: Cycle Track Pavement

Cement Concrete Block	60 mm
Sand Bed	35 mm
Base	200 mm

5.3.4 Footpaths

Footpaths Pavement shall be of Interlocking Paver Blocks as per the guidelines given in IRC: SP: 63-2004. The proposed composition is as given below in Table B-12.

Table B-12: Footpaths Pavement

Cement Concrete Block	60 mm
Sand Bed	35 mm
Base	200 mm

5.3.5 Granular Sub-Base Layer

Minimum thickness of Granular Sub-base layer shall be 150 mm in carriageway, cycle track and Footpath area

6 ROADSIDE DRAINAGE

As per section B.2.3

7 Design of Structures

7.1 General

All bridges, culverts and structures shall be designed and constructed in accordance with section 7 of the Manual and shall conform to the cross sectional features and other details specified therein. The below structures shall be provided on Road No.8, 11 and 21.

Table B-13: list of structures

Sl.No.	Chainage (km)	Road Nos.	Span Arrangement (c/c of wall)	Formation Width (m)	Type of Structure
1	0+590	R8	3 vents 2x2	30	RCC Multi- cell Box
2	0+400	R11	3 vents 2x2	18	RCC Multi- cell Box
3	0+400	R21	3 vents 2x2	45	RCC Multi- cell Box

8 PROTECTION WORKS

The Contractor is required to provide required protection measures wherever necessary for the proposed elements in road network followed by the consultation with Authority's Engineer and is required to provide protection measure such as retaining walls/toe walls on the Project.

9 TRAFFIC CONTROL DEVICES AND ROAD SAFETY WORKS

9.1 Traffic control devices and road safety works shall be provided in accordance with standards and specifications of IRC & MORT&H followed by the directions and requirements of Authority.

9.2 Specifications of the reflective sheeting: As per MORT&H and IRC 35 & 67, it shall be High intensity micro prismatic retro-reflective element material.

10 ROADSIDE FURNITURE

10.1 Roadside furniture shall be provided in accordance with the provisions of MORT&H & IRC 35&67.

10.2 Overhead traffic signs: location and size

The Overhead traffic signs shall be provided as requirement of proposed project below, and the locations shall be finalized in consultation with Authority Engineer.

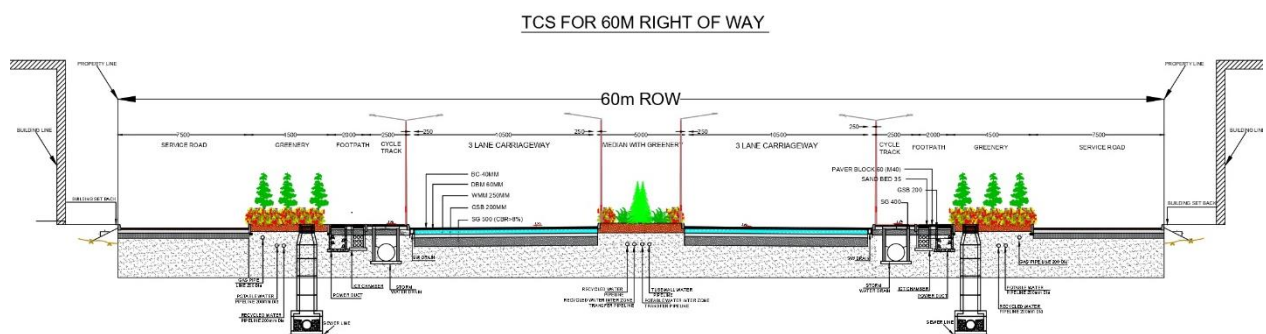
11 COMPULSORY AFFORESTATION

As stipulated in Manual of Standards and Specifications as referred in Section –D, trees shall be planted & maintained by the Contractor as compensatory afforestation. The Contractor shall also maintain all existing trees on the proposed road in good condition.

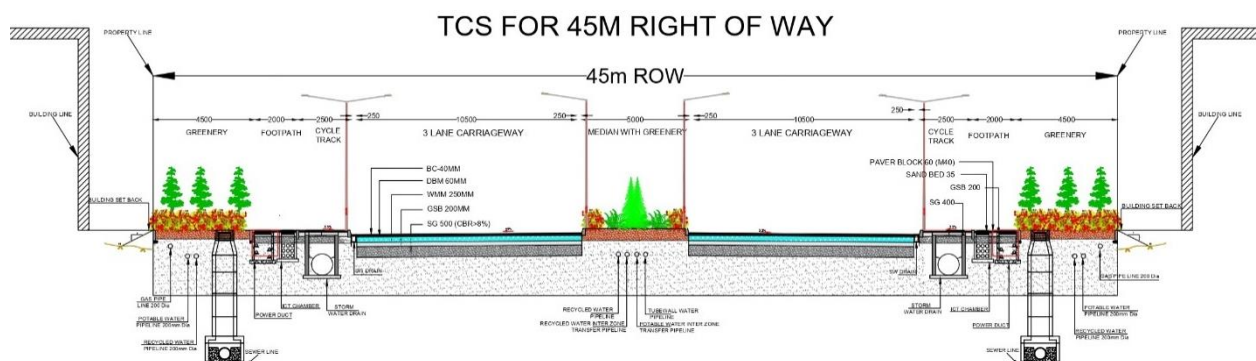
Typical Cross Section Drawings (Section B)

Typical Cross Section Drawings

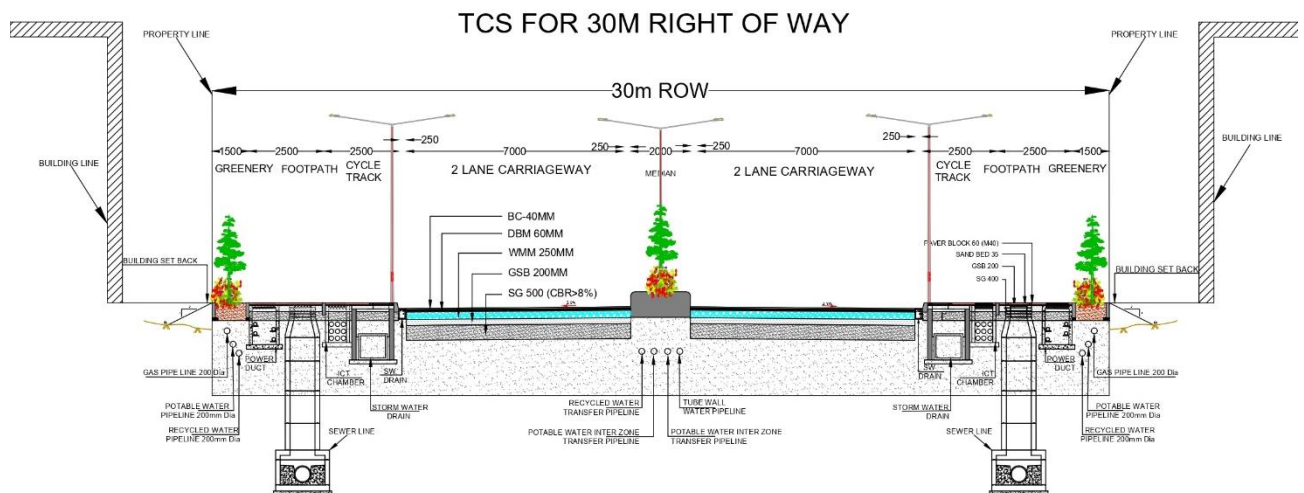
Proposed Typical Cross sections for ROWs of 60m, 45m, 30m, 24m, 18m and 7m.



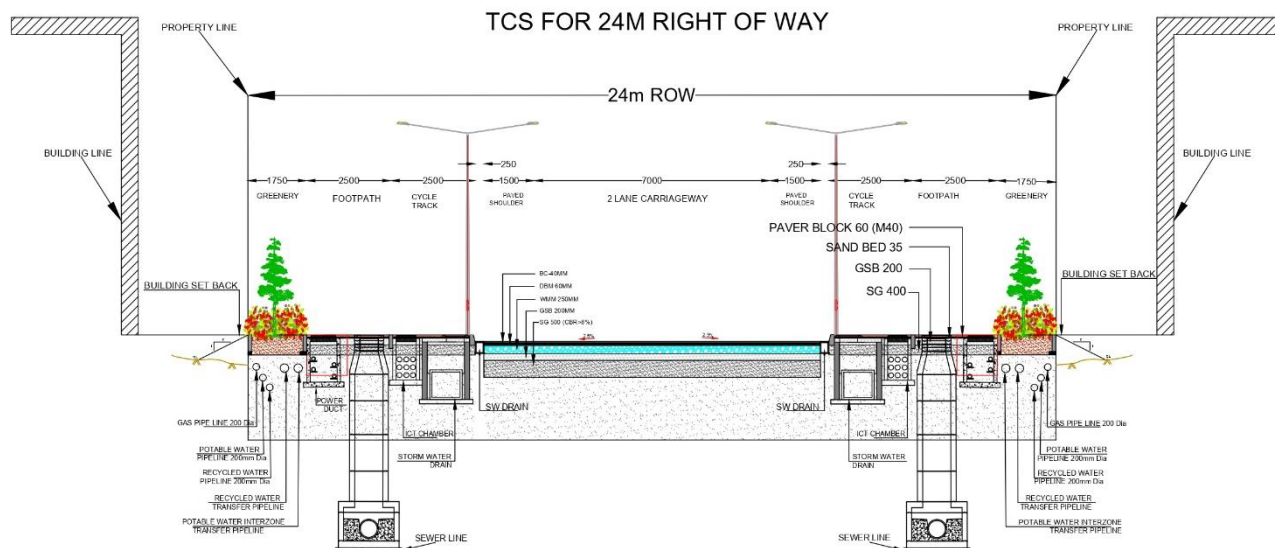
Typical Cross Section for 60 m Right of Way



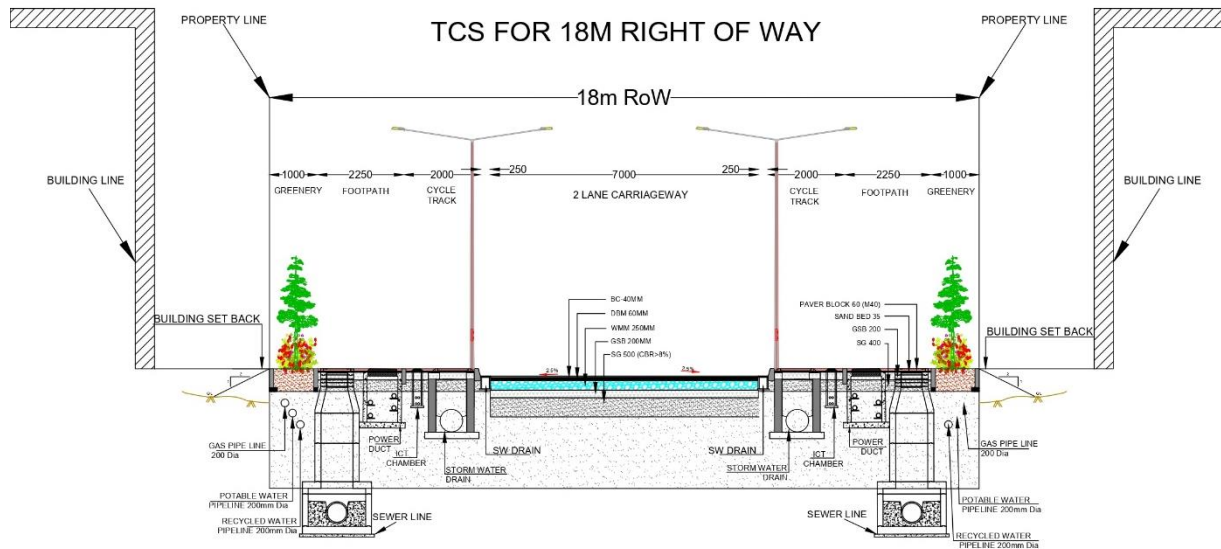
Typical Cross Section for 45 m Right of Way



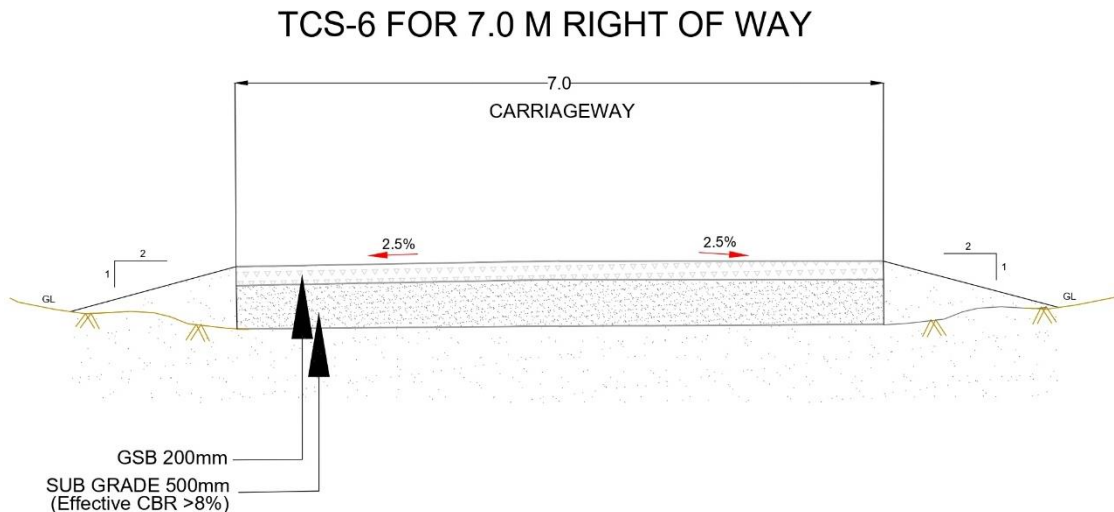
Typical Cross Section for 30 m Right of Way



Typical Cross Section for 24 m Right of Way



Typical Cross Section for 18 m Right of Way



Typical Cross Section for 7 m (GSB Road) Right of Way

B.2. WET-UTILITIES

1. Potable and Recycled Water Supply Network

The scope for Potable and Recycled Water Supply scheme shall include complete raw water from tube wells, recycled water from CETP / STP up to the Industrial & Residential zone pumping stations and further to the individual plots in IMC Khurpia along with all the associated infrastructures like tube wells and Pumping Stations as required according to the design.

Raw water will be extracted from tube wells and recycled water from CETP / STP and shall be pumped to the reservoirs in Industrial and Residential Zone Pumping Stations. Chlorination shall be done at these pumping stations and the treated water from these pumping stations shall be pumped up to the plot boundaries.

Contractor has to design the complete potable and recycled water distribution system including tube wells, Pump house, raw water transmission network from tube wells and CETP / STP to the pumping station. Clear water Clear water distribution from the pumping station to service connection points till

plot boundary in the entire Project area. The contractor scope shall also include surge analysis for the complete water network and shall provide surge protection equipment wherever necessary.

a. Introduction

i. Water Demand

The water demand for various uses in IMC Khurpia has been derived based on the Final masterplan. The various references / assumptions considered for demographic / process water estimation according to plot classification and land use patterns have been described as below:

- i. Based on market demand assessment, the total industrial work force has been assessed as 7,671 in anchor unit and 13,161 in ancillary units.
- ii. An additional work force population of 1,286 for commercial and service employment has been estimated as per the assumption below:
 - a. Commercial: 1 pp 100m² of area
 - b. Hotel: 50 rooms twin bed considered
 - c. Skill Development Centre: 1pp 200m² of Built-Up Area (as per prevalent density), ITI polytechnic FAR of 2.1 (Uttarakhand Building Bye Laws-Page 46)
 - d. Truck Terminal: 1pp 200m²
 - e. Substation: 6 people assumed
 - f. PTCUL Substation: 30 people assumed
 - g. Solid Waste Management site: 30 people assumed
 - h. CETP / STP: 20 people assumed
 - i. Fire Station: 20 people assumed
 - j. Gas DRS: 10 people assumed
 - k. Tube well standalone: 3 people assumed
 - l. Effluent / Water Pumping station: 6 people assumed
- iii. Based on FSI of 2.1 as per Uttarakhand Building Bye Laws, total 2,238 DUs have been calculated and considering a household size of 4, total residential population has been calculated as 8,952
- iv. For calculating the process water demand, benchmarking of existing 2 wheeler and 4 wheeler plants was done by visiting the plants of Hero Motocorp- Gurugram, Yamaha-Greater Noida and Maruti Suzuki – Gurugram. The per hectare process water demand for these plants are 34 KL/Ha, 20.42 KL/Ha and 42.50 KL/Ha respectively. Hero and Maruti plants are very old and have very low footprint for number of vehicles manufactured while Yamaha plant is not running at its full capacity. Based on these figures, an optimum process demand of 30 KL/Ha of industrial plot area has been considered for IMC Khurpia. The comparative analysis of these benchmarking has been presented in Appendix 5.1.
- v. As prescribed by CPHEEO manual, a water consumption of 135 lpcd has been considered for residential usage.
- vi. For industrial, commercial, and institutional usage, a water consumption of 45 lpcd has been adopted as per page no. 12 of CPHEEO manual on water supply and treatment, 1999.
- vii. For hotel, a demand of 180 per bed has been considered as per CPHEEO water manual 1999, Page 11
- viii. As prescribed by CPHEEO, a return factor of 80% of water supplied has been adopted for domestic usage while 75% of the process water supply is expected for wastewater disposal as per the market assessment.
- ix. Water for horticulture has been adopted as 22,500 litres per Ha/day as per UDPFI guidelines and shall be supplied through treated wastewater from the CETP and STP.
- x. A firefighting demand of 1% of the total water demand has been considered as recommended by the CPHEEO manual.

Based on the above, the water demand summary has been presented in Table B-14.

Table B-14: Water Demand in IMC Khurpia

S. N	Particulars of users	Population / Area Ha		@ litres /Unit/ day	Water Dema nd (MLD)
		Quantity	Unit		
1	Industrial Area process demand including HVAC	252.05	Ha	30,000	7.56
2	Industrial Employment	20,832	Perso ns	45	0.94
3	Floating population for commercial, community hall, institutes, Service area etc	1286	Perso ns	45	0.058
4	Hotel	100	Perso ns	180	0.02
5	Residential Population	8952	Perso ns	135	1.21
6	Fire fighting demand	1	Perce nt		0.098
7	Urban Greens including Road Side Greens	60.78	Ha	22,500	1.37
	Total				11.25
8	Sewage/ Waste Water Generation				7.51
10	Infiltration			5%	0.38
11	Sewage/ Effluent reaching CETP / STP				7.89
12	Recycled Water to be used for Urban greens & Industrial use (5% treatment losses and 15% tranfer and distribution losses)				6.37
13	Net Fresh Water Demand at consumer end				4.88
14	Transmission & Distribution losses assuming local tube wells as source 15%				0.86
	Total Demand at source with recycling				5.74
	Yearly Net Water Demand in MCM with recycling				2.10

ii. Source of Water Supply

The freshwater demand of IMC Khurpia project area is proposed to be fulfilled by ground water.

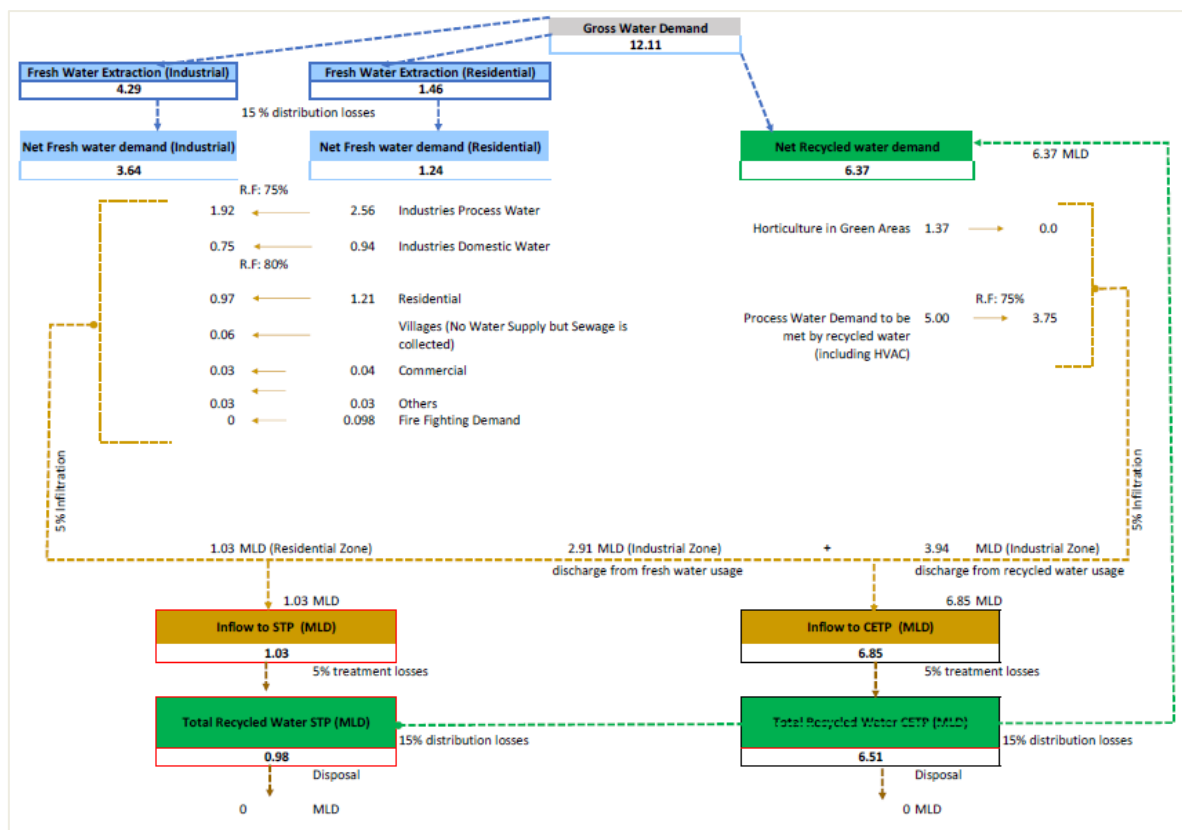
iii. Planning of Water Supply System – Potable and Recycled Water

Water demand for the IMC Khurpia project area has been calculated based on national standards, benchmarks and acceptable norms. The piped water supply is required to be designed to provide adequately for:

- Industrial use: For proposed industries as per market demand assessment including HVAC requirements.
- Domestic needs in various workplaces: For institutional, utilities, commercial and industrial needs.
- Domestic needs in residential areas: Includes drinking, cooking, bathing, and washing, flushing of toilets, individual gardening, etc.
- Horticulture needs: For public parks and urban greens.
- Fire Fighting needs.
- Unaccounted for Water: Including transfer and distribution losses.

The strategy for supplying water for various usage in IMC Khurpia is to utilize the entire treated wastewater within project area. The water balance showing details of freshwater, sewage/effluent and recycled water quantities can be referred to in the Figure B-1.

Figure B-1: IMC Khurpia Water Balance for Ultimate Phase



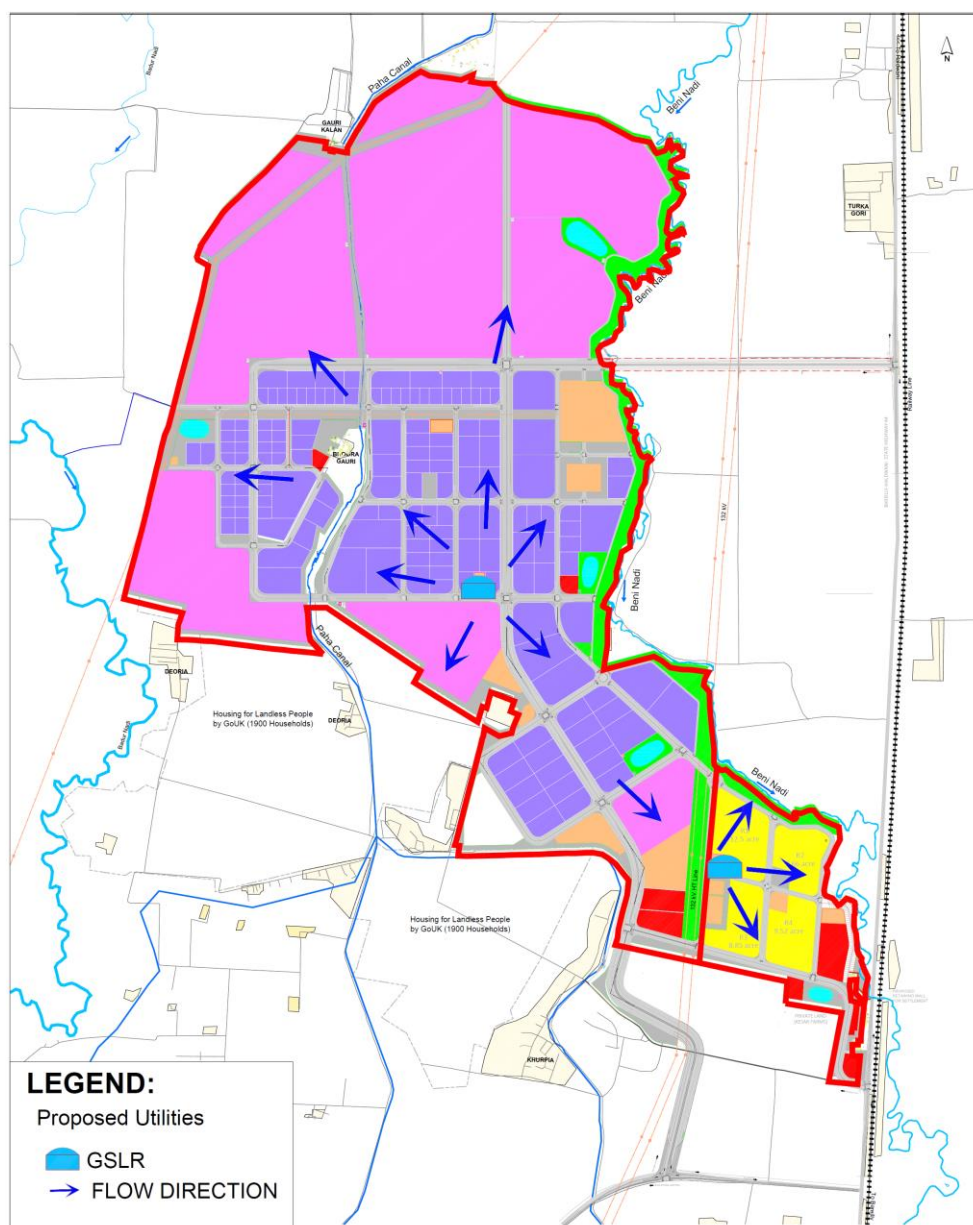
The distribution of the water shall be by direct pumping through variable speed pump sets controlled by Industrial Internet of Things (IIoT) and a hydropneumatics system to provide better aesthetic appearance as compared to OHTs. Suitable capacity backup diesel generator sets at each tube well / Ground Service Reservoir (GSR) / pumping station are proposed so as to maintain uninterrupted water supply in cases of power failure.

iv. Strategy for supplying fresh water and reusing the treated wastewater

All the wastewater generated is planned and proposed to be used to meet the horticultural and industrial process water needs of the project area as shown in the water balance diagram in Figure B-1 above.

Based on the topography and land use zoning, IMC Khurpia has been divided into 2 freshwater water zones i.e. Industrial Zone and Residential Zone as shown in Figure B-2. The zoning has been done following a decentralised approach duly considering the proposed zoning plans of the wastewater collection, treatment and re-use so as to provide greater efficiency in operations and maintenance.

Figure B-2: IMC Khurpia Fresh Water Zoning Map



Based on the freshwater zones, the overall demand for each zone is estimated and balanced with the recycled water availability in the respective zones. The summary of the zone-wise water balance has been presented in Table B-15.

Table B-15: IMC Khurpia Zone-wise Water Balance Calculation

Sl. No.	Item Description	Industrial Zone	Residential Zone	Cumulative (MLD)	Unit
1	Fresh water demand	3.64	1.24	4.88	
	Industries	3.501	0.000		
	Residential	0.000	1.209		
	Commercial	0.027	0.014		
	Others	0.031	0.003		
	Fire fighting Demand	0.086	0.012		
2	Recycled water demand	6.09	0.27	6.37	
	Horticulture in Green Areas	1.09	0.27		
	Process Water Demand to be met by recycled water (including HVAC)	5.00			

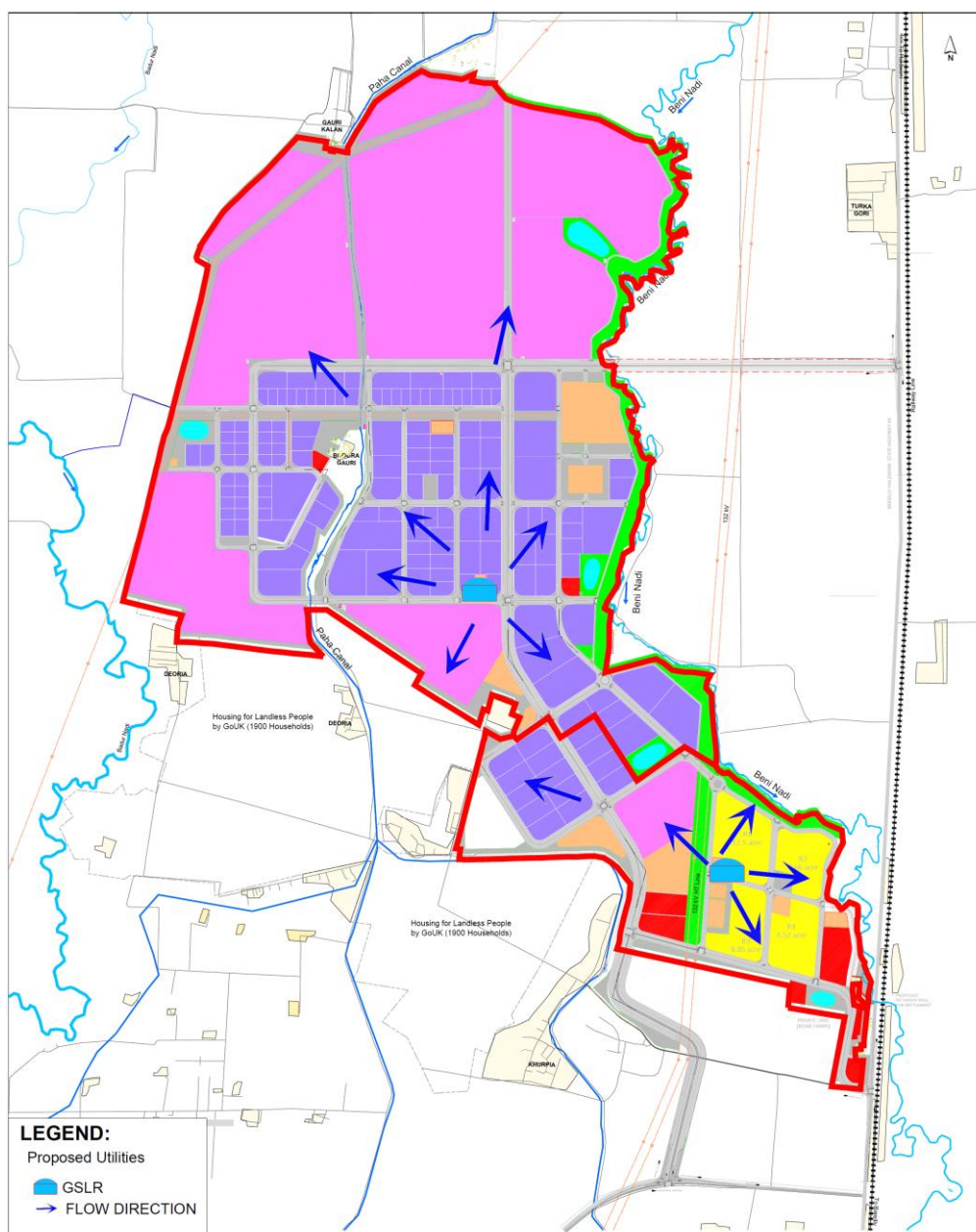
Sl. No.	Item Description	Industrial Zone	Residential Zone	Cumulative (MLD)	Unit
3	TOTAL WATER DEMAND (Sum of sl.1 to sl.2)	9.74	1.51	11.25	MLD
4	Total Sewage available for treatment	0.85	0.99	1.84	MLD
5	Total Effluent available for treatment	5.67		5.67	MLD
6	Infiltration in wastewater collection network	0.33	0.05	0.38	MLD
7	Net Available Recycled/ Reclaimed water	5.53	0.84	6.37	MLD
8	Total Recycled Water demand	6.09	0.27	6.37	MLD
9	Extra Net Fresh Water Requirement (for reuse)	0.00	-0.56	0.00	MLD
10	Net Fresh Water Requirement from Ground Water Source	3.64	1.24	0.00	MLD
11	Gross Fresh Water Requirement from Ground Water Source	4.29	1.46	5.74	MLD
12	Total Water requirement			12.11	MLD
	Yield of 1 tubewell	1800	1800		LPM
	Hours of Operation	12	12		hours
	Nos. of tubewell required	3.31	1.12		
	Nos. of tubewell provided	5	2		
	Fresh Water CWR provided	1	1		
	Recycled Water CWR provided	1	1		

As shown in the table above, 5 tubewells are proposed in Industrial zone while 2 are proposed in residential zone in order to meet the freshwater requirement in IMC Khupia.

The treated wastewater is proposed to be re-used to meet the entire horticultural demand and majority of the industrial process water demands.

However, since Residential zone have recycled water utilization in horticulture only, its recycled water generation is in surplus of its requirement. Thus, the excess recycled water from Residential zone is supplied to part of Industrial zone thereby utilising the entire liquid waste. Thus, Industrial Zone is able to meet 62.5% of its water needs through recycled water. Hence, the zoning of recycled water has been shifted to utilize surplus treated wastewater from residential zone to Industrial zone. The zoning of recycled water in IMC Khurpia has been shown in Figure B-3.

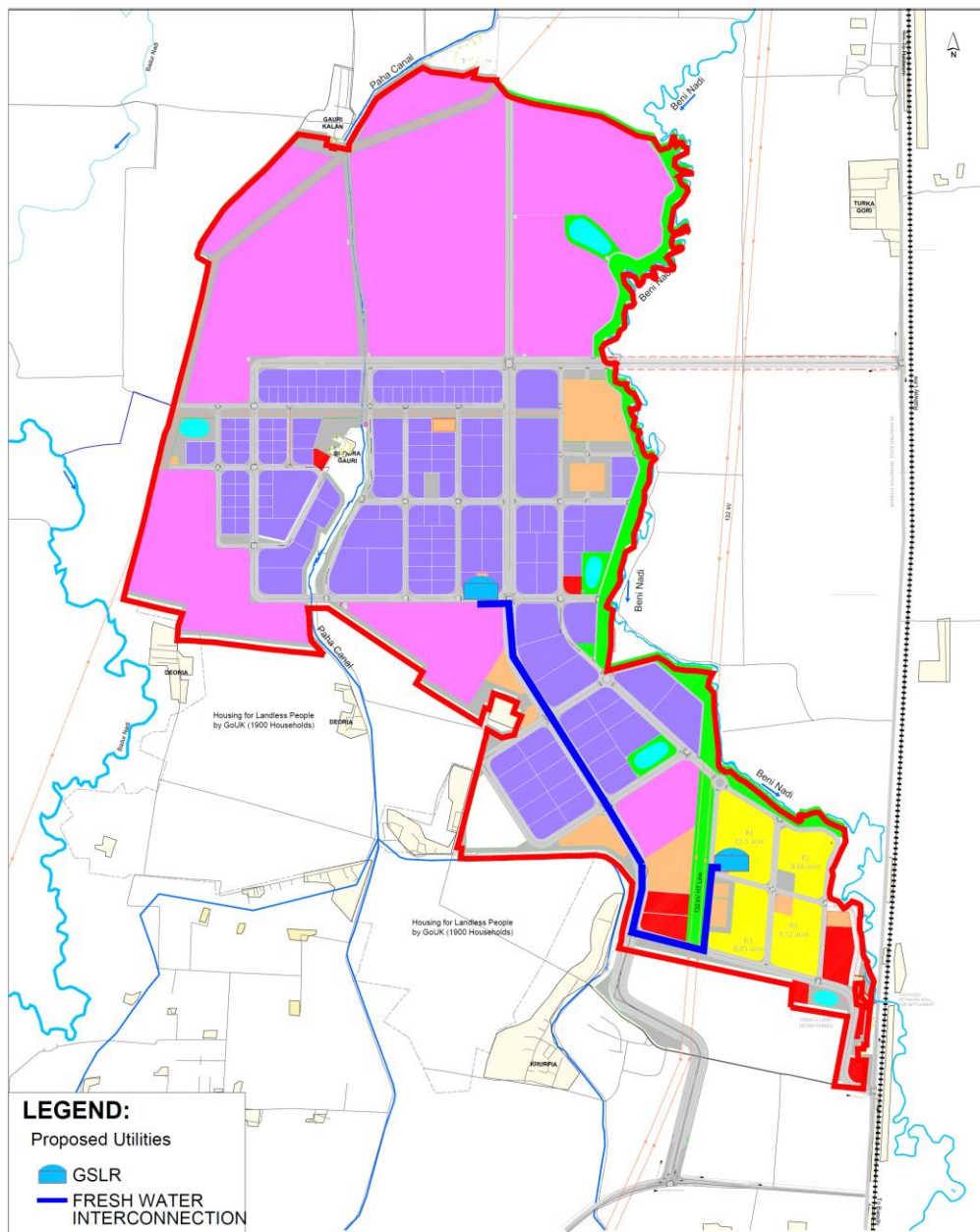
Figure B-3: IMC Khurpia Recycled Water Zoning Map



v. Inter-zone transfers of Fresh / Recycled Water

Keeping in view the robustness of the system, it has been proposed to connect freshwater / recycled water GSR in each zone through a rising main along with a pumping set to meet additional demand / production of one production zone. Therefore, in case of failure of any tube well or disruption in treated wastewater in one zone may be compensated from any other production zone. A rising main interconnection (Thick Blue Line) has been shown in the Figure B-4. Through this rising main, interzone transfer of water may be done with suitable valve operations and automation. There would be two separate pipelines to connect freshwater and recycled water transfer from one zone to another.

Figure B-4: Inter-zone water transfer through interconnection of GSRs



b. Design Philosophy

i. Water Supply from source

The freshwater for utilization in IMC Khurpia is proposed to be extracted from ground water through deep tubewells. Total seven number of deep tubewells are proposed to meet the project area water demand. Further, treated wastewater generated from the project area shall be utilized completely, thus reducing the freshwater demand from the tube wells.

The domestic and industrial wastewater shall be treated in zone-wise CETP / STP upto the tertiary level. After tertiary treatment, the recycled water shall be pumped into the recycled water GSRs catering to their respective zones. As discussed in section a.iv, the zone boundary of Industrial and Residential shall be different for freshwater and recycled water due to difference in recycled water consumption in two zones.

ii. Ground Storage Reservoir (GSR) and distribution tank

Water from the tubewells shall be supplied to the two proposed Ground Storage Reservoir (GSR). Similarly, the recycled water GSRs shall be filled through the treated wastewater from the CETP and STP of the respective zones. The capacity of the GSR shall be calculated as per the zonal water requirements (separately for fresh and recycled water) of the project area, with an aim to carry out cost optimizations. The GSR for both fresh and recycled water for each zone shall be constructed within same premise to have better control over the distribution in each zone.

Sizing of the GSR shall be done as per the mass balance curve which would feed water to a hydro-pneumatic tank for further distribution.

Hydro-pneumatic tanks with variable frequency drive (VFD) pumps are proposed to be used to pump and distribute water to the consumers.

iii. Transmission / Transfer Mains

Transmission Main is the pipe network connecting the tube well or CWR in CETP/ STP to proposed GSRs. The inter-zonal transfer of water shall be done through a common rising main connecting the 2 GSRs through controlling valves. It would provide flexibility in operations as water from one zone could be used in another zone in case of any breakdown in the zone's source water system. Separate lines for transmission / transfer mains shall be provided in the utility corridor along the road between the source and GSRs.

iv. Distribution System

The distribution system shall be pumped one from the GSRs where the water shall be pumped as per requirement in the industrial and residential areas. The pumping shall be done through variable frequency drives, hydropneumatics system and supported by SCADA system to provide a smart and energy efficient water supply system in IMC Khurpia as discussed in 3.6.3 above.

Since the topography of the area is gently sloping without any undulation and ideal for supply water to the consumers at required pressures without any pressure reducing valves or any other complicated devices which may be required in sites with many undulations.

A dual piping system having separate fresh and recycled water supply shall be proposed all along the utility corridor up to the plot boundaries as per the specific requirements of the plot area. However, the Residential Zone shall have only a fresh water supply line as there may be less acceptance from the consumers to use recycled water for potable and domestic purposes.

v. Design Period for Various Components

Water supply projects are designed to meet the future requirement of a stipulated design period. This period, with regard to certain components of the project, depend on their useful life or the facility for carrying out extensions whenever required. Thereby expenditure far ahead of its utilization is avoided and capital expenditure incurred on the project does not remain idle due to underutilization of these facilities. For the purpose of designing such systems, a 30-year project period is recommended. The design period normally considered and proposed for various components of this project is as under:

Civil structures	30 years
Pumping Mains	30 years
Mechanical and Electrical Components	15 years
Distribution System	30 years

Source: CPHEEO Manual on Water Supply and Treatment, 1999

However, Based on market assessment the development in the IMC Khurpia is expected to reach 50% of its ultimate needs by the end of first phase in 5 years and its full capacity only by 14th year. Therefore, the electromechanical components shall be designed accordingly.

vi. Peak Factor

As far as the design of distribution system is concerned, it is the hourly variation in consumption that matters. The fluctuations in consumption are accounted for, by considering the peak rate of consumption as rate of flow in the design of distribution system.

The following peak factors have been adopted as recommended in CPHEEO manual for potable water supply:

Table B-16: Peak Factors for Contributory Population for Potable Water Supply

Contributory Population	Peak Factor
< 50,000	3
50,000 to 2,00,000	2.5
> 2,00,000	2

Source: CPHEEO Manual on Water Supply and Treatment, 1999

The peak factor depends upon contributory population on the respective lines of different clusters which shall be chosen for design of the distribution network as per the above Table B-16.

Since the contributory populations for both Residential and Industrial Zones lie within 50,000 persons a peak factor of 3.0 has been adopted for design of the freshwater water network for both Residential and Industrial freshwater supply zones.

For Recycled water network a peak factor of 2.0 has been considered for considering two shifts of 8 hours each.

vii. Pipe Diameter

Minimum pipe sizes (diameter) recommended by CPHEEO for potable water supplies are 100 mm for towns having population up to 50,000 and 150 mm for those above 50,000. Diameter less than 100 mm can be adopted in the following exceptions:

- **For dead ends**
- **In grid system, where no further expansion is contemplated.**

For Freshwater and Recycled water network minimum nominal diameters of 110 mm (Outer Diameter) shall be adopted.

Table B-17: Minimum pipe diameter for Potable and Recycled Water Network

Network Type	Minimum Nominal Pipe Size (Outer Diameter)	Condition
Freshwater and recycled water network	110 mm	Entire network
For recycled water supply in the median of 45m and 30m roads	63mm	Entire network

viii. Excavation Depth

All potable water supply pipes (potable and recycle network) are generally be laid below ground with a minimum clear cover of 1 m above the crown of the pipes. This would ensure that the pipe is subjected to lesser dynamic loads thus protecting the integrity of the pipes thereby enhancing their life and durability.

In IMC Khurpia, the potable water distribution lines are proposed with clear cover of 1.0m and recycled water pipelines are proposed with a clear cover of 1.2m above the crown of the pipes. This would minimize the clashes between the two while executing the laying of pipelines. The typical details of excavation and bedding details have been presented in drawing no. 5-5.

ix. Residual Pressure

As per the CPHEEO manual on water supply and treatment, for a single storied building a minimum residual pressure of 7 m at ferrule point is suggested. For two-storied buildings the minimum pressure should be 12 m and for three-storied buildings 17 m.

In IMC Khurpia, it is proposed to adopt a minimum residual head of 7m for both freshwater and recycled water considering supply up to a single storied building. Any residential and industrial establishment requiring greater residual pressures shall need to make their own arrangement to receive the water supply into an underground sump from where it would be pumped to the respective individual tanks over the buildings or as per their internal design.

Since leakage in any distribution network is pressure dependent adopting this minimum pressure requirement would ensure lesser losses and UFW.

x. Pipe Material

The following pipe materials and class are proposed to be used for IMC Khurpia.

Table B-18: Proposed Pipe Material and class for Fresh and Recycled Water Network

Location	Pipe Material	Class	Standard
In distribution system upto 355mm OD	High Density Polyethylene Pipes (HDPE)	PE 80, PN 8	IS 4984
Internal Piping in Pumping Station upto boundary wall and >350mm in distribution system	Ductile Iron (DI)	K7	IS 8329
Piping in Transmission and Pumping Main	Ductile Iron (DI)	K9	IS 8329

Ductile Iron pipes will have internal Cement Concrete Lining (CC) lining in accordance with IS 11906 or ISO 4179 and outside fusion bonded epoxy coating for prevention for corrosion.

xi. Design Formula

Hazen-William's formula has been used for the pressure network hydraulic analysis. The Hazen-Williams Co-efficient (HWC) or C value to be used for the pipeline hydraulics shall be based on the relevant standards. The following table presents the recommended C values which would be used for design as per CPHEEO manual on water supply and treatment.

Table B-19: Hazen William's Coefficient

Pipe Size	HWC or C Value
High Density Polyethylene Pipes (HDPE)	140
Ductile Iron Pipe (DI)	130

xii. Hydraulic simulation

The hydraulic model for the entire network shall be created, designed, and simulated using the latest engineering software so as to ensure an accurate simulation in order to achieve the most optimum design solution. WaterGEMS shall be used for modelling of both freshwater and recycled water network.

xiii. Bedding

The class of bedding have been designed considering the required external loading conditions, geotechnical requirements such as sub soil and bearing capacity of soil encountered in respective water line, type, class, and material of pipe used for the laying purposes as per CPHEEO manual. Fine sand or screened/select excavation material type of bedding will be provided depending on the soil condition, depth of pipeline, backfill pressure & type of pipe.

HDPE pipes requires no special bed preparation for laying the pipe underground, except that there are no sharp objects around the pipe. However, while laying in rocky areas suitable sand bedding is to be provided around the pipe and compacted.

Where DI pipes are to be bedded directly on the bottom of the trench, it is to be trimmed and levelled to permit even bedding of the pipeline and should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation is made at the joints of the pipes so that the water main is supported along its entire length. Where excavation is through rocks or boulders, the pipeline is bedded on concrete bedding or on at least 150 mm of fine-grained material, or other means are used to protect the pipe and its coating. However, since in IMC Khurpia such soil type is not envisaged, no special bedding is proposed in laying the pipelines.

xiv. Protection while Pipe crossing the road

As per the typical cross sections for various RoW, the fresh / recycled water pipelines are proposed to be laid under footpath / green belt / median and hence, no heavy loading on the underground pipe is expected. However, at places where pipes are crossing the road, a sleeve of RCC NP4 pipe under the carriageway has been proposed to protect the pipes from sudden point load by the loaded trucks.

xv. Valves and Fittings

For operation and maintenance of transmission and distribution system valves are necessary. The transmission and distribution mains shall be provided with the following appurtenances and specials as per the following criteria.

- **Sluice Valves**

Resilient seated sluice valve of standard make as per IS 14846 have been proposed at different locations as per requirements to isolate portions of the network for operation and maintenance.

- **Non-Return Valve**

Non-Return Valves of standard makes as per IS 5312 have been proposed at different locations as per requirements to prevent any backflow.

- **Air Release Valves**

Double acting air release valves with EPDM of standard make shall be proposed at suitable summit locations in the rising mains and distribution network to protect the line from both air blocks and suction. The valves are proposed to be provided at a minimum spacing of 800 m. For double acting valves, the valve diameter is generally kept about 1/8th of the diameter of pipe.

- **Scour Valves**

Scour valves of standard make shall be installed in the rising mains and distribution system at lower points in the line to drain silt and water from the line whenever required.

All the valves are proposed to be enclosed in valve chambers with cover.

xvi. Instrumentation and Smart Monitoring

IMC Khurpia being a high value industrial township is proposed to have advanced instrumentation to monitor and control the operation and maintenance of the system. It is proposed to not only monitor the water quantity using bulk flow meters and consumer meters but also the quality of water supplied; to protect public health and increase consumer trust and confidence. Further, this would also help efficient trouble shooting of issues and taking up preventive maintenance to ensure least disruption and downtime in service. The following are the instrumentation equipment proposed to be used for the water supply system in IMC Khurpia.

All the equipment is proposed to be wirelessly connected with the ICCC and Pumping Stations through the LoRaWAN protocol for monitoring and control.

xvii. Bulk flow meters

Providing for bulk flow meters and consumer meters along with optimum creation of DMAs would ensure identifying and minimizing physical leaks in the system and thereby ensure equitable supply of water on a continuous 24x7 basis. Selecting the best flow meter for the application is essential to obtaining accurate flow data. It's also necessary to understand the characteristics of different meter types to determine a best fit. Thus, it is proposed to install full bore electromagnetic bulk flow meters at the inlets and outlets of the fresh water and recycled water tanks as well as various locations within the fresh water and recycled water distribution system to monitor and isolate DMA level consumption through Isolation valves with actuators and leaks for effective targeting of NRW reduction.

The bulk flow meters are proposed to have a wireless communication module based on LoRaWAN technology to transmit data to the ICCC proposed within the project site so as to ensure real time monitoring of the system.

xviii. Smart consumer meters

Incorporation of bulk flow meters would measure only the water into the system. However, for the calculation of the NRW/leakage, it is also essential to measure the consumption or the water out of the system. By the use of the modern smart automatic reading meters enables us to measure the water consumption at the desired interval without the need for any human meter reader. Apart from this convenience it also serves to sensitize the consumer about judicious water use. Further it could also serve to alert the consumers (and operator) of any significant anomaly/increase in water consumption which could be on account of any internal leak/open tap within the property thus saving the precious resource.

Multi or single jet AMR type smart water meters are proposed at the consumer end with 100% coverage for both fresh and recycled water supply. The AMR meters are proposed to be fitted with a wireless communication module based on LoRaWAN protocol to transmit data to the ICCC where these data could be used for monitoring and preparation of bills. Since, AMRs are normally available upto 40mm size, 50mm and 80mm magnetic flow meters have been used for water supply in anchor units

xix. Pressure transmitters

Water systems would need pressure monitoring at various locations such as pump delivery lines, inlet and outlet of tanks and certain critical points within the distribution system to ensure efficient operation of the system. Further, the VFD pump outlets in the hydropneumatics based water distribution system would also need pressure monitoring to detect changes in consumptions and pressures and accordingly change pump working and speeds. The pressure monitoring in the distribution system would ensure that a minimum pressure of 7m is maintained in the system. Further, the pressure transmitters in the distribution system would help calibration of the hydraulic model with the real time data and could be used to alert any system anomaly such as excess consumption, leaks, bursts, etc. thereby helping in identifying and rectifying any issues in the system at the earliest.

Thus, is proposed to install pressure transmitters within the freshwater and recycled water system which would be wirelessly linked to the ICCC and Pumping Stations through the LoRaWAN protocol for monitoring and control. For monitoring and control through Isolation Valve with actuators.

xx. Residual Chlorine sensors and Transmitters

There are a variety of reasons to employ water quality sensors in water distribution systems. Contamination by cross-connections with non-potable water, contaminated water entering the distribution system through leaking pipes in an area of low pressure, or microbial growth in the distribution system pipes are the possible reasons necessitating water quality monitoring. Water quality sensor data are used for decision-making on a variety of management issues.

Thus, it is proposed to install residual chlorine sensors within the fresh and recycled water systems for IMC Khurpia.

Measuring residual chlorine concentration within the system is most important requirement. As chlorine measurement would require pH corrections, they usually come integrated with pH, etc. The multiparameter sensors proposed in IMC Khurpia are pH compensated chlorine sensors and transmitters

By measuring the residual chlorine concentrations within the system would not only give a real time indication on the chlorine concentration within the potable supply lines but also indicate in the event of any cross contamination as this would result in a rapid consumption of the residual chlorine in the event. This would enable the operator to effectively monitor and take actionable decisions in such events thereby protecting the public health.

c. Proposed Potable / Recycled Water Supply System

The proposed Potable / Recycled Water Supply System as designed in preliminary design has been presented in the sections below. The proposed system is for reference only and contractor is required to design the system keeping in mind the design philosophy given in preceding sections with effort to further improve the design with respect to site conditions and best practices in the industry.

i. Tube wells for extracting Ground Water

For meeting the freshwater demand as per the water balance presented in earlier sections, 2 Nos. Tube wells are proposed in Residential Water Supply zones while 5 Nos. tube wells are proposed in Industrial Zone. The location of these tube wells and their transfer pipelines to respective potable water reservoirs has been presented in Drawing No. 5-1A/B/C/D. The details of these tube wells are presented in the Table B-20.

Table B-20: Summary of Tube wells for groundwater extraction for IMC Khurpia

Tube well No.	Zone	Total depth of bore	Depth of blind pipe	Depth of slotted pipe	Dia of casing	Depth of submersible pump	Discharge	Pipeline from TW to reservoir	Length of Pipeline (m)
TW-1	Industrial Zone	120m	0-80m	80-120m	300mm	30m	1800 lpm	250mm DI K-9	1188
TW-2	Industrial Zone	85m	0-45m	45-85m	300mm	30m	1800 lpm	250mm DI K-9	1219
TW-3	Industrial Zone	135m	0-95m	95-135m	300mm	30m	1800 lpm	250mm DI K-9	30
TW-4	Industrial Zone	135m	0-95m	95-135m	300mm	30m	1800 lpm	250mm DI K-9	518
TW-5	Industrial Zone	110m	0-70m	70-110m	300mm	30m	1800 lpm	250mm DI K-9	1185
TW-6	Residential Zone	85m	0-45m	45-85m	300mm	30m	1800 lpm	250mm DI K-9	899
TW-7	Residential Zone	85m	0-45m	45-85m	300mm	30m	1800 lpm	250mm DI K-9	43

Out of the total 7 tube wells, it is proposed to install 4 out of 5 tubewells for the Industrial Zone and 1 out of 2 tubewell for Residential Zone in the Phase-I development to meet the initial water demand. The remaining 2 tubewells are proposed to be installed in the phase-II development plan of the project. It is proposed that the tubewells which is to be located within GSR premise be installed in the second phase so as to avoid any road cutting for laying transfer mains from tube well to GSR.

1. Other components of Tubewell Premises

The contractor shall make his own assessment for all the components required for a smooth operation of the tubewells. An area of 100m² has been allocated for each tubewell The other components (but

not limited to) which are necessary for the seamless operation of the pumping station have been presented as below.

- Tubewell Building
- Chain Pulley arrangement for lifting the pump
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Sluice Valve
- Electromagnetic Flowmeters
- Non-Return Valve
- Pressure Transmitter
- Internal Lighting and Area Lighting
- Electrical Panel
- 40 KVA 30KW DG set

ii. Treated Wastewater from STP / CETP

The tertiary treated wastewater from STP / CETP is proposed to be transferred in recycled water reservoirs in Residential and Industrial Zone respectively. The location of STP/CETP and their transfer pipelines to respective recycled water reservoirs has been presented in Drawing No. 5-2A/B/C/D/E/F.

The treated wastewater supplied from STP to Residential Pumping Station Reservoir shall be supplied through a 150mm DI K-9 pipeline with a length of 187m while from CETP to Industrial Pumping Station Reservoir shall be supplied through a 400 mm DI K-9 pipeline with a length of 1807m. Both the pipelines are proposed to be laid in the median of 18/30/45m wide road as per Typical Cross Sections.

Since, STP will not have any equalization tank, the peak factor of treated sewage from STP has been considered as 3 same as the peak factor of Sewerage System. For CETP, an equalization tank has been proposed to take care of quantitative and qualitative variation in the influent and therefore the supply of treated wastewater from CETP has been considered as 1.5 and same has been incorporated in the design of CETP

iii. Potable and Recycled Water Pumping Stations

1. Reservoirs

The hours of storage for potable and recycled water reservoirs in Industrial and Residential Zones has been done by developing Mass Curves for inflows and outflows from the reservoirs. The calculations for developing the mass curve have been presented in Appendix 5.5 and their Mass curve diagrams have been presented in

Figure **B-5** and Figure B-6.

Based on the mass curve calculations, the storage required in the reservoir was around 8 hours and same has been adopted in the storage volume of the reservoirs.

Figure B-5: Mass Curve Diagram for Industrial fresh / recycled water reservoirs

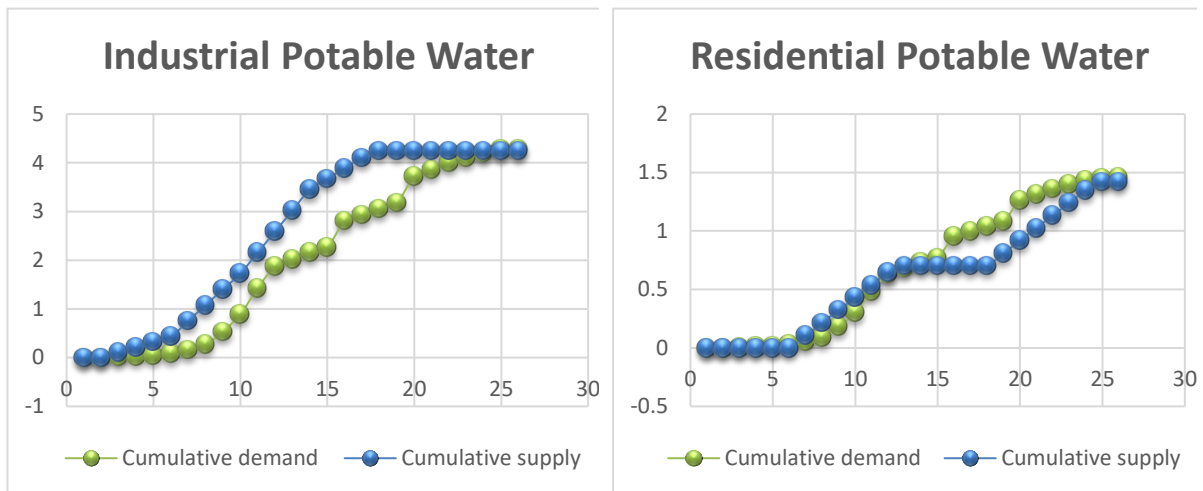
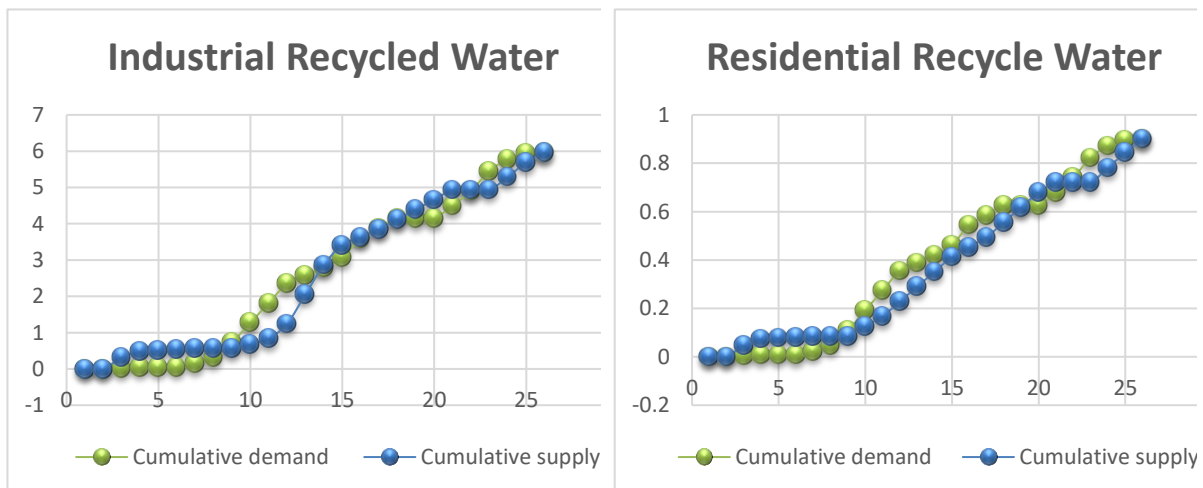


Figure B-6: Mass Curve Diagram for Residential fresh / recycled water reservoirs



In addition to normal supply in freshwater an additional storage for any incidental firefighting water demand has been considered. The details of reservoir volume calculations have been presented in Appendix 5.6 and 5.8 for industrial and residential respectively. The layout and section drawings of these pumping stations have presented in Drawing Nos. 5-3C/D for Industrial Zone and in Drawing Nos. 5-4C/D/E for residential zone. The volumes potable and recycled reservoirs in Industrial and Residential zones have been presented in Table B-21

Table B-21: Summary of reservoir volumes for distribution of fresh / recycled water

S. No	Purpose/Area	Application	Reservoir Volume (m ³)
1	Residential	Potable Water	760
2	Industrial	Potable Water	1770
3	Residential	Recycled Water	360
4	Industrial	Recycled Water	2330

2. Pumps and Machinery

For distribution of fresh and recycled water in the residential and industrial zones, variable frequency drive (VFD) operated centrifugal pumps with hydropneumatics system has been proposed. The summary of the pumps for distribution has been presented in Table B-22.

Table B-22: Summary of pumps for distribution of fresh / recycled water

S. No	Purpose/Area	Application	Pump Parameters	Flow Variation	Pump Configuration
1	Residential	Potable Water	50.13 l/s @ 15.14m head	8.35l/s - 50.13l/s	2D+S
2	Industrial	Potable Water	145.65l/s @ 19.28m head	24.27l/s - 145.65l/s	4D+2S
3	Residential	Recycled Water	22.75 l/s @15.14m head	5.68l/s - 22.75l/s	D+S
4	Industrial	Recycled Water	150.6l/s@ 18.22m head	37.65l/s - 150.6l/s	4D+2S

Apart from the pumping for distribution network, fixed speed emergency pumps have also been proposed for interzone transfers. The summary of the emergency pumps for interzone transfer has been presented in Table B-23.

Table B-23: Summary of potable / recycled water pumps for interzone transfer

S. No	Purpose/Area	Application	Pump Parameters	Flow Variation	Pump Configuration
1	Industrial to Residential	Potable Water	50.13l/s @ 33.27m head	Fixed speed	1W
2	Residential to Industrial	Potable Water	25.0l/s @ 14.43m head	Fixed speed	1W
3	Industrial to Residential	Recycle Water	22.75l/s @ 31.1m head	Fixed speed	1W
4	Residential to Industrial	Recycle Water	11.37l/s @ 13.90m head	Fixed speed	1W

The treatment of freshwater through tube wells and recycled water from STP and CETP shall be chlorinated in the reservoirs through chlorination gas feed system of 1.0Kg/hr for Industrial potable & recycled water and 0.5Kg/hr for Residential potable & recycled water.

The PIDs, layout and sections of the Industrial and Residential Pumping station have been presented in Drawing Nos. 5-3A/B/C/D and 5-4A/B/C/D/E respectively.

3. Electrical and IloT System

Electrical and IloT system for Industrial and Residential pumping station includes Transformer, Electrical and IloT Panel. The IloT Panel is a control panel which can receive feed from field level instruments and control the operation of the pumps based on the demand fluctuation in the distribution system.

The load list of the panel has been presented in Appendix 5.7 and 5.9 for Industrial and Residential Pumping Station respectively. The Single Line Diagram (SLD) of the pumping station has been presented in Drawing No. 5-3E and 5-4F for Industrial and Residential respectively.

4. Interzone Transfer Pipelines

In case of emergency the fresh water shall be transferred from Industrial Zone to Residential Zone and visa versa through a single pipeline which can transfer the flows in both directions through valve arrangement. Similarly, there will be a recycled water pipeline to connect both the zones through a single pipeline. Both the pipelines shall be laid in the median of 30m wide road as presented in Drawing Nos. 5-1B/C and 5-2C/D for potable water and recycled water interzone transfer respectively.

For the fresh water interzone transfer, a 300mm DI K-9 pipeline of length 2039m is proposed. Similarly, for recycled water interzone transfer, a 250mm DI K-9 pipeline of length 2039m is proposed.

5. Other components of Pumping Station

The contractor shall make his own assessment for all the components required for a smooth operation of the pumping station. The PIDs, layout, sections and Electrical SLD of the Industrial and Residential Pumping station have been presented in Drawing Nos. 5-3A/B/C/D/E and 5-4A/B/C/D/E/F respectively. The other components (but not limited to) which are necessary for the seamless operation of the pumping station have been presented as below.

- Pump House Building
- Electrical & SCADA Panel Building
- Chlorination Building
- Electrically Operated Travelling Crane (2T)
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Gate Valves / Check Valves / Pressure Gauge Transmitter / Gate Valve (actuated)
- Electromagnetic Flowmeters
- Ultrasonic Level Transmitters
- Chlorine Gas Feed System 1.0Kg/hr for Industrial potable and recycled water
- Chlorine Gas Feed System 0.5Kg/hr for Residential potable and recycled water
- Pressure Vessels for Potable and Recycled Pumping System
- Internal Lighting and Area Lighting
- Electrical Panel
- 300kVA 11KV / 433V outdoor off load tap changer type transformer for Industrial PS
- SCADA System with 750 tags for Industrial PS
- SCADA System with 500 tags for Residential PS
- 200KVA 160KW DG set for Industrial
- 62.5KVA 50KW DG set for Residential

d. Distribution Network

Based on design philosophy described in section b.iv, the freshwater and recycled water network has been designed. The layout of the overall distribution network for freshwater and recycled water network has been presented in Drawing Nos. 5-1A/B/C/D and 5-2A/B/C/D/E/F respectively. The summary of components in the distribution system has been presented in the following sections.

i. Pipelines

The summary of potable and recycled water network in the distribution has been presented in Table B-24.

Table B-24: Summary of potable / recycled water pipeline

Potable Water Network			Recycled Water Network	
Pipe	Industrial Zone Length (m)	Residential Zone Length (m)	Pipe	Length (m)
110 mm OD PE-80 PN8	14,520	3,110	63 mm OD PE-80 PN8	7,225
160 mm OD PE-80 PN8	3,110	708	110 mm OD PE-80 PN8	35167
225 mm OD PE-80 PN8	5,820	652	160 mm OD PE-80 PN8	7095
280 mm OD PE-80 PN8	1,659	45	225 mm OD PE-80 PN8	3673
315 mm OD PE-80 PN8	94		280 mm OD PE-80 PN8	1030
355 mm OD PE-80 PN8	318		315 mm OD PE-80 PN8	135
300 mm dia DI K-7		24	355 mm OD PE-80 PN8	822
350 mm dia DI K-7	109		400 mm OD PE-80 PN8	76
400 mm dia DI K-7	19		200 mm dia DI K-7	29
			350 mm dia DI K-7	76
			400 mm dia DI K-7	31
Total	25,649	4,539		55,359

Recycled Water Network from Residential Zone STP is also covering part of Industrial zone and therefore, zone-wise lengths for recycled water has not been shown.

ii. Warning Tape over HDPE pipelines

All the HDPE pipelines shall be protected against damage while digging later on, by a Polyethylene Warning Tape. This shall be placed 400mm above the pipeline while backfilling the trenches after laying of pipeline. Please refer drawing no. 5-5

iii. Valves

The summary of valves in potable and recycled water network has been presented in Table B-25 and Table B-26 respectively.

Table B-25: Summary of valves in potable water pipeline

CI Valves Isolation with actuators	Nos.	CI Scour Valve	Nos.	CI Air Release Valves Double Acting	Nos.
100 mm dia	26	100 mm dia	14	50mm dia	25
150 mm dia	11	150 mm dia	2	80mm dia	1
200 mm dia	16	200 mm dia	4		
250 mm dia	10	250 mm dia	9		
300 mm dia	1	300 mm dia			
350 mm dia	1	350 mm dia			
400 mm dia	1	400 mm dia			
Total	66		29		26

Table B-26: Summary of valves in recycled water pipeline

CI Valves Isolation with actuators	Nos.	CI Scour Valve	Nos.	CI Air Release Valves Double Acting	Nos.
50 mm dia	20	50 mm dia	0	50mm dia	23
100 mm dia	49	100 mm dia	10	80mm dia	1
150 mm dia	18	150 mm dia	3		
200 mm dia	9	200 mm dia	4		
250 mm dia	6	250 mm dia	1		
300 mm dia	1	300 mm dia	0		
400 mm dia	2	400 mm dia	0		
Total	107		18		24

The valve chambers 1.2mX 1.2m have been considered for all the valves. The typical details of valve chambers have been presented in drawing no. 5-6A/B/C.

iv. Instrumentation and Smart Monitoring

Based on description given in section b.xvii, the numbers of full-bore magnetic flowmeters have been presented in Table B-27

Table B-27: Summary of full-bore magnetic flow meters in potable / recycled water network

Dia	Nos	
	Potable Water	Recycled Water
100mm dia	25	49
150mm dia	11	12
200mm dia	13	7
250mm dia	8	4
300mm dia	3	4
350mm dia	1	1
400mm dia	1	52
Total	62	77

Based on description given in section b.xix, the number of Pressure Transmitters in the potable and recycled water network is same as magnetic bulk flow meters as **63 and 80** respectively. A common

chamber has been proposed for both the devices. The typical details of valve chambers have been presented in drawing no. 5-7A

Based on description given in section 0, the numbers of residual chlorine sensors and transmitters have been proposed as **17 and 30** for potable and recycled water network respectively. A separate chamber has been proposed for housing the device. The typical details of valve chambers have been presented in drawing no. 5-7B

2. Sewerage Network

a. Introduction and Overview

i. Zoning, Wastewater Conveyance & Treatment Plan

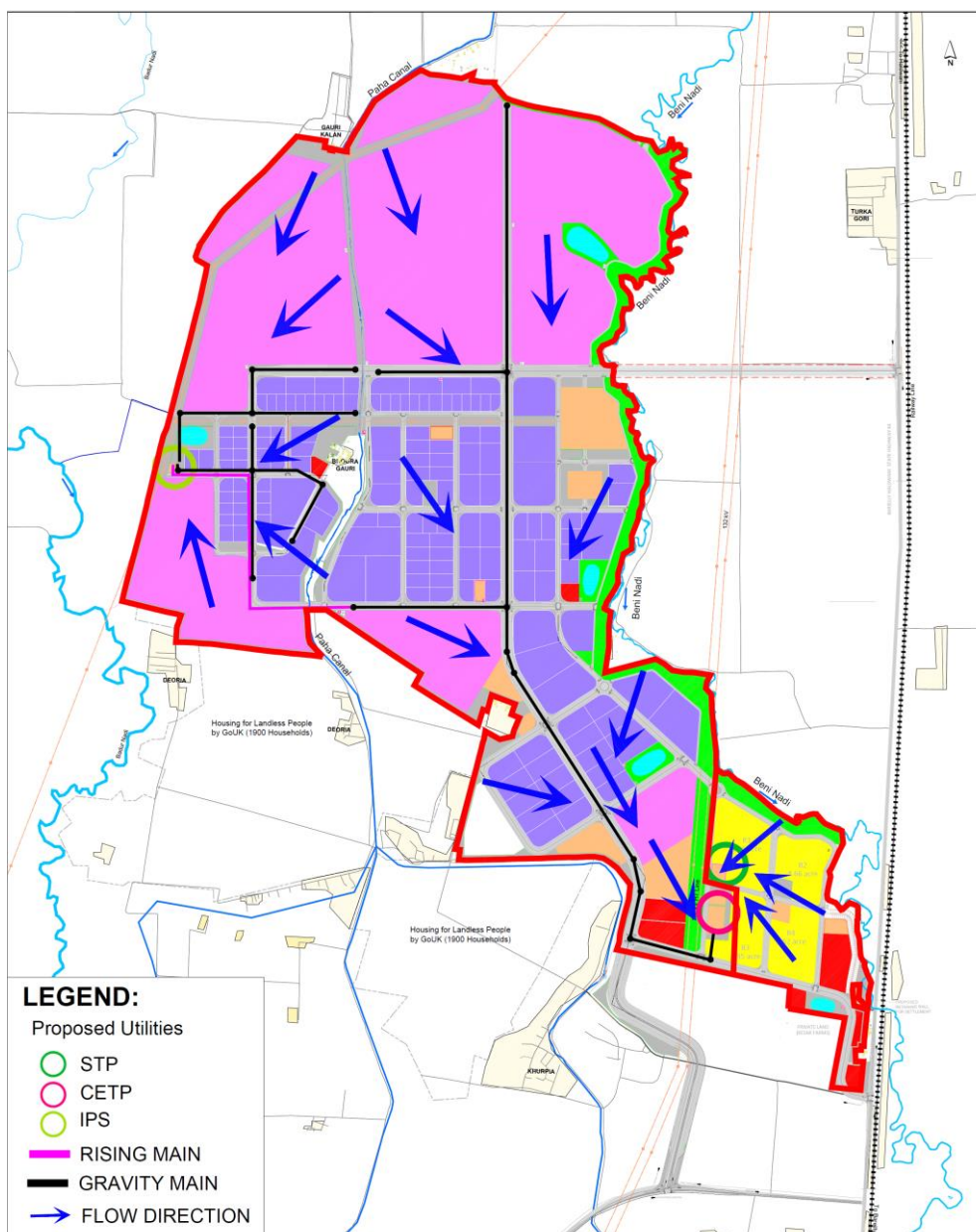
IMC Khurpia has been divided into two wastewater zones for the purpose of wastewater collection and treatment. Each of the zones would have their separate treatment plants located at the lower elevation in the zones.

Industrial Zone covers most of the project area on either side of Paha canal (which forms a ridge) and predominantly comprises the industrial land use without any residential areas. The wastewater generated from area on the western side of Paha canal is proposed to be collected by gravity at an Intermediate Pumping Station (IPS) near western boundary of the project area. From this IPS, the wastewater shall be pumped to the first manhole across the Paha canal on the eastern side, after which the flow shall be conveyed to the CETP by gravity. The zoning plan showing the zone boundaries, treatment plant / Intermediate Pumping Station locations and flow directions are presented in Figure B-7.

The Residential Zone is located on the southern west part of the project area and comprises predominantly the entire residential and common amenities land use with no industrial land use.

The wastewater zoning of the project area has been done keeping in mind the topography and natural gradients of the project site as well as considering other manmade features (e.g. Paha canal) to ensure an optimum gravity-based wastewater conveyance system with only one Intermediate Pumping Requirement to avoid an additional CETP. Further, the wastewater zoning has been planned in a decentralized manner so as improve operational efficiency and flexibility and reduce the pumping needs and distance in terms of wastewater collection and treatment as well as supply of recycled water as well.

Figure B-7: Zoning for Effluent / Sewage Generation & Treatment for Final Site Master Plan



ii. Wastewater Generation

The wastewater to be generated in Khurpia IMC has been estimated at 80% of the domestic supply and 75% of the industrial/process water supply. The details of water demand estimation and subsequent wastewater generation is given in Table B-28. The zone wise domestic and industrial effluent generations are given in Table B-29.

Table B-28: Water Demand and Wastewater generation in IMC Khurpia

S. N.	Particulars of users	Population / Area Ha		@litres /Unit /day	Water Demand (MLD)	Sewage generation	Remarks
		Quantity	Unit				
1	Industrial Area process demand including HVAC	252.05	Ha	30000	7.56	5.67	75% of water demand
2	Industrial Employment	20,832	Persons	45	0.94	0.75	80% of water demand
3	Commercial, Services Employment and others	1286	Persons	45	0.06	0.05	80% of water demand

S. N.	Particulars of users	Population / Area Ha		@litres /Unit /day	Water Demand (MLD)	Sewage generation	Remarks
		Quantity	Unit				
4	Hotel	100	Persons	180	0.02	0.01	80% of water demand
5	Residential Population	8952	Persons	135	1.21	0.97	80% of water demand
6	Villages*	510	Persons	135		0.06	80% of water demand
7	Fire fighting demand	1	Percent		0.10	0.00	No sewage generation
8	Urban Greens including Road Side Greens	60.78	Ha	22,500	1.37	0.00	No sewage generation
9	Infiltration (@5%)			5%		0.38	
	Total (MLD)				11.25	7.89	

*The sewage of two villages which are just upstream of IMC Khurpia have been considered for treatment along with wastewater generated at the site. The villages have their own rural water supply scheme and hence are not supplied from the IMC Khurpia water supply scheme. However, since the villages do not have their treatment facility, the sewage from these villages are considered in the IMC Khurpia sewerage scheme, otherwise, it may find way to storm water drainage system in IMC Khurpia

Table B-29: Zone wise wastewater generation

Sl. No.	Item Description	Quantity (MLD)		CUMULATIVE (MLD)
		Industrial Zone	Residential Zone	
1	Domestic sewage generation	0.00	1.03	1.03
2	Industrial effluent generation	6.86	0.00	6.86
	TOTAL	6.86	1.03	7.89

It may be noted here that although water would not be supplied to a few villages which are contiguous to IMC Khurpia the sewage that is generated from them would be collected and considered in our design. This is done as it would not be feasible for the individual villages to have their respective treatment facilities which would result in them discharging their liquid wastes into the stormwater drains which would flow into the project area causing unhygienic and unpleasant conditions. Three habitations namely Bhoora Gauri, Gauri Kalan and a small habitation at the southeast are either engulfed or just upstream of project area. These habitations are proposed to be provided with sewerage system as part of the social responsibility and their sewage be treated in the treatment units provided in IMC Khurpia.

Thus, the total wastewater generated in IMC Khurpia including infiltration which is considered at 5% of wastewater generation would be 7.89 MLD.

iii. Proposed Wastewater Treatment Plants CAPACITIES

Two treatment plants are proposed at IMC Khurpia for the purpose of treatment of its liquid wastes and subsequent re-use of the treated water. The following are the treatment plant capacities proposed.

Table B-30: Zone wise proposed treatment plants and capacities Ultimate Phase

ZONE	TREATMENT PLANT	PROPOSED CAPACITY
Industrial	CETP	6.90 MLD
Residential	STP	1.00 MLD
TOTAL		7.90 MLD

b. Planning of wastewater Conveyance System

i. Sewerage Design Parameters

The design criteria for the design of sewerage systems have been framed as per the guidelines laid by

- CPHEEO Manual for Sewerage and Sewage Treatment, 2013
- SP 7 (2016): National Building Code of India, 2016
- Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014
- SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987
- Manual on norms and standards for environment clearance of large construction projects, MoEF

The wastewater collection and conveyance system will be designed to collect the liquid wastes generated in the IMC Khurpia from all its activities. Industrial Zone collection networks will collect the industrial effluents from the industries as well as the domestic sewage from the industry and amenity areas and convey it together to the CETP.

Residential Zone network will collect the domestic sewage generated in the residential and amenity land use areas and would separately convey it to the STP.

The sewage/industrial Effluent network shall be designed as a gravity system based on the proposed zoning which is done considering the topography of the area. However, discharge from Industrial area on western side of Paha canal shall be collected at an Intermediate Pumping Station from where it shall be pumped to the first manhole on eastern side of Paha canal from where it shall be conveyed by gravity to the CETP. All sewer lines/effluent have been designed for the peak flow generation.

ii. Design Period

Sewerage projects are designed to meet the future requirement of a stipulated design period. This period, with regard to certain components of the project, depend on their useful life or the facility for carrying out extensions whenever required, so that expenditure far ahead of its utilization is avoided and capital expenditure incurred on the project does not remain idle due to underutilization of these facilities. For the purpose of designing such systems, a 30-year project period is recommended. The design period considered for various components is as under:

Table B-31: Proposed design period for wastewater components

COMPONENT	DESIGN PERIOD
Sewers and it's appurtenances	30 years
Pumping Mains	30 years
Mechanical and Electrical Components	15 years

However, based on market assessment the development in the IMC Khurpia is expected to reach 50% of its ultimate needs by the end of first phase in 5 years and its full capacity only by 14th year. Therefore, the electromechanical components shall be designed accordingly.

iii. Population and Design flows estimation

Methods of estimation of water and wastewater flows have been discussed in section a.ii. This has been done based on the masterplan of the area based on a combination of land use planning, projected populations and area-based demands and liquid waste generation.

iv. Peak Factor

As far as the design of sewerage network is concerned, it is the hourly variation in consumption of water that matters. The fluctuations in consumption are accounted for, by considering the peak rate of consumption as rate of flow in the design of sewerage network. The flow in sewers varies considerably from hour to hour and also seasonally, but for the purposes of hydraulic design it is the estimated peak flow that is adopted. The peak factor or the ratio of maximum to average flows, depend upon contributory population and the following values have been adopted as suggested in CPHEEO manual and are tabulated below:

Table B-32: Peak Factors for Contributory Population for Per Capita Sewage Flow

Contributory Population	Peak Factor
For population less than 20,000	3.00

Contributory Population	Peak Factor
For population range of 20,000 to 50,000	2.50
For population range of 50,000 to 750,000	2.25
For population above 750,000	2.00

The peak factors also depend upon the density of population, topography of the site, hours of water supply and therefore it is desirable to estimate the same in individual cases, if required.

The total contributory population for IMC Khurpia is estimated at about 20,000 workers for industrial, commercial/service and 7,248 residential populations which are divided into two wastewater zones. Thus, since the contributory population to each zone would be less than 20000 persons a peak factor of 3 is proposed to be considered for design of the conveyance system.

v. Ground Water Infiltration

Estimation of flow in sanitary sewers may include certain flows due to infiltration of ground water through joints. The rate of infiltration into sewers also depends upon the ground water table and permeability of the surrounding soil. Since sewers are designed for peak discharges, allowance for ground water infiltration for the worst condition in the area is proposed to be made as in Table B-33 below.

Table B-33: Ground Water Infiltration

	Minimum	Maximum
Litres/Ha/day	5,000	50,000
Litres/km/day	500	5,000
LPD/manhole	250	500
However, the infiltration has shall be limited to a maximum of 10% of the average sewage flow.		

Since most of the sewer lines have been designed to be laid upto a depth of 4m below existing ground level in IMC Khurpia and good craftsmanship shall be ensured for this prestigious project, the ground water infiltration has been considered at 5% of total sewage / effluent generation.

vi. Depth of Cover

To protect sewers from external loads, the minimum clear cover of 1 m is above the crown of sewer has been considered. However, care has been taken while planning the depth of sewers so that all the plots especially bigger anchor units can be connected to the manholes on the RoW through gravity only. The typical details of excavation and bedding of sewer line has been presented in drawing no. 6.3.

vii. Wastewater Network Scheme

A gravity-based sewer system is proposed for both industrial and residential zones. Since, in industrial area sewage generated from domestic usage by the industrial workers and other floating population is just about 10-15% of the total effluent to be generated in the industrial area, a combined collection network has been designed for collection of sewage / effluent from industrial zone to the CETP. For residential zone also, a separate network has been designed to collect and convey the sewage from the residential zone to the STP.

The collection network has been planned considering the natural topography and planned grade levels. The domestic sewage and industrial effluent from the entire area would be collected via sewer and effluent collection system and the same will be treated in the proposed STP and CETP and reused entirely within IMC Khurpia.

The sewers would be designed on the assumption that although silting might occur at minimum flow, it would be flushed out during peak flows. In case of sewers in which the desired minimum (self-cleaning) velocity may not be achieved due to low flows, it is recommended to implement suitable arrangements for cleaning and flushing of those sewers.

The collection network of both sewage and effluent shall be designed, analysed and optimized using latest engineering software.

viii. Storm water Runoff

The sewers are not expected to receive any storm water flows. A separate stormwater drainage network is proposed for this purpose which would be discussed in the subsequent sections. Strict inspection, vigilance, and proper design and construction of sewers and manholes should eliminate this flow or bring it down to a very insignificant quantity.

ix. Hydraulics of Sewage Network

The Manning's formula for gravity flow has been used to design the sewerage and effluent networks. The Manning's coefficient of roughness 'n' used for the pipeline hydraulics is based on the pipe material. The following table presents the recommended values of Manning's n for design as per CPHEEO Manual.

Table B-34: Manning's Coefficient

Pipe MoC	Manning's n
Double Wall Corrugated Polyethylene Pipes (DWC-PE)	0.010
Reinforced Cement Concrete Pipes S&S (RCC)	0.013

x. Design Capacity of Sewers

It is considered that the sewers will not run full as otherwise the pressure will rise above or fall below the atmospheric pressure and condition of open channel flow will cease to exist. Moreover, from consideration of ventilation, sewers should not be designed to run full. In case of circular sewers, the Manning's formula reveals that:

- The velocity at 0.8 depth of flow is 1.14 times the velocity at full depth of flow.
- The discharge at 0.8 depth of flow is 0.98 times the discharge at full depth of flow.

Accordingly, the maximum depth of flow (d/D) in design has been kept limited to 0.8 of the diameters at ultimate peak flow.

xi. Minimum Size of Sewers

As per the CPHEEO Manual the minimum diameter may be adopted as 200 mm for cities having present / base year population of over 1 lakh. However, depending on growth potential in certain areas even 150 mm diameter can also be considered.

However, since it is an industrial township carrying the industrial effluent, a minimum pipe diameter of 200 mm (Inside Diameter) has been adopted for IMC Khurpia.

xii. Velocity in sewers

To ensure that deposition of suspended solids does not take place, self-cleansing velocities using Shield's formula is considered in the design of sewers. As per the Shield's formula the velocity required to transport material in sewers is mainly dependent on the particle size and specific gravity and slightly dependent on conduit shape and depth of flow. The specific gravity of grit is usually in the range of 2.4 to 2.65. The proposed gravity sewers shall as far as possible be designed for the velocities as in Table B-35 below. However, in certain cases wherein the minimum self cleansing velocities are not achieved due to factors such as low flows during initial years of project or starting/head reaches of sewers a provision for regular flushing arrangement would need to be ensured during the operation and maintenance phase of the project.

Table B-35: Velocity in sewers

No.	Criteria	Value
1	Minimum velocity at initial peak flow	0.6 m/s

2	Minimum velocity at ultimate peak flow	0.8 m/s
3	Maximum velocity	3 m/s

xiii. Manhole size, depth, and type

Concrete manholes have been proposed for the collection network. The channels in manholes at junctions and bends are considered to be smooth with gradual transitions to avoid turbulence and deposition of solids. Manholes are usually constructed directly over the line of the sewer. They are circular, rectangular, or square in shape. Manholes should be of such size that will allow necessary cleaning and inspection. As per IS 4111 (Part 1), circular type manholes are much stronger than rectangular and arch type manholes and thus these are favoured over rectangular as well as arch type manholes. Therefore, circular manholes are proposed on all sewer lines for all depths. Diameter of manhole varies with change in depth of manhole.

Table B-36: Manhole Sizing

Range of Depths (m)	Maximum Diameter up to	Manhole Size
above 0.90 m and up to 1.65 m	500 mm	900 mm dia.
above 1.65 m and up to 2.30 m	600 mm	1200 mm dia.
above 2.30 m and up to 6.0 m	900 mm	1500 mm dia.
above 6.0 m and up to 14.0 m	1200 mm	1800mm X 1800mm square.

The typical details of different sizes of Manholes have been presented in drawing no. 6-4.

xiv. Spacing of Manholes

As per IS 4111 (Part 1), for inspection, cleaning and testing of sewers manholes have been proposed at intersections, changes in horizontal direction, major change in slopes, change in size and at regular intervals. The sewer has been kept in a straight line between two manholes. Maximum distance between service manholes has been kept at 30 m

For Outfall sewers with no service connections the spacing shall be increased. The spacing of manholes in gravity sewers not receiving house service sewers has been presented in Table B-37.

Table B-37: Manhole Spacing for outfall sewers without service connections.

Sewer size	Maximum Manhole spacing
Up to 600 mm	up to 60 m
600 mm to 900 mm	90 m
900 mm to 1200 mm	120 m
1200 mm to 1500 mm	150 m

xv. Material of Construction for Manholes

Considering the high ground water table in the project area, Precast RCC manhole have been adopted as the construction time would be reduced as well as issues related to uplifting and infiltration due to high GWT shall be addressed.

Cover Frame

As per IS-4111 (Part 1), the size of manhole covers should be such that there should be clear opening of not less than 560 mm diameter for manholes exceeding 0.9 m depth. Manhole cover and frame will be SFRC (Steel Fibre Reinforced Concrete) conforming to the IS 12592.

Table B-38: Manhole Cover Details as per IS 12592

Manhole Type	Load withstanding capacity	Suitable Locations
L.D (Light Duty)	2.50 MT	Footpaths, Two wheelers
M.D (Medium Duty)	10.00 MT	Light four wheelers
H.D (Heavy Duty)	20.00 MT	Heavy vehicles
E.H.D (Extra Heavy Duty)	35.00 MT	Heavy traffic roads

xvi. Materials of Pipeline

Since IMC Khurpia has a high water table heavier RCC pipes have been favored over DWC pipes. The industrial effluent being corrosive in nature, NP4 pipes have been proposed throughout IMC Khurpia.

xvii. Plot Connection

It is proposed to include the scope of Plot connection from within the plot boundary or just outside the plot boundary up to nearby sewer manhole. Plot connection will be terminated with an inspection chamber just outside the Plot or inside the Plot boundary to which the individual plot owner would connect the sanitary/effluent line. By constructing an inside Plot chamber with connection would prevent future road cutting and dismantling and reconstruction of drains and utility ducts. It would also avoid conflict with other utilities which could be an issue when each Plot owner starts developing in future. The finished Ground Level of each plot will be developed in accordance with the level and location of the proposed Plot connection to transfer the flow by gravity to the main network. The location of the Plot connection / chamber would be at the corner of the plot closest to the road and on the downstream side of the pipe as far as possible. The typical details of Sewer plot connection have been presented in drawing no. 6-6.

Table B-39: Pipe material and diameter for Plot Connection

Description	For Sewerage Network	For Industrial Effluent Collection Network
Pipe material	PVC Pipes	PVC Pipes
Minimum Pipe diameter (OD)	160 mm	160 mm

xviii. Hydraulic Design Approach for Domestic and Industrial Sewer Network

Hydraulic model of the sewerage system for IMC Khurpia shall developed as per the proposed utility corridors for different ROW's within the project area. Manholes have been assigned at every change of diameters, change of slope, junction limiting the maximum distance to 30 m for sewer lines having house connections as discussed in the earlier section. The effluent and sewage collection system and pumping mains would be modelled using the latest engineering software so as to arrive at the most accurate and optimum designs.

Network shall build in SewerGEMS.

Peaking factor formula as per the criteria shall be entered in SewerGEMS under extreme flow setup option. Model has been validated against any possible errors, computed under steady state and designed and optimized in accordance to the assigned design constraints.

c. Effluent lift pump station

Based on the topography of the project area, one Intermediate Pumping Station at the western boundary of project area is proposed to pump the sewage collected from the western side of Paha Canal to eastern side of Paha Canal. Further, two numbers of terminal sewage/effluent pumping stations are proposed at the respective treatment plants to lift the wastewater into the treatment plan units.

i. Design basis & Peak Factor

- As recommended in CPHEEO manual the design of SPS/EPS has been designed based on the peak flow.
- The storage volume in the wet well considered at 10mins of peak flow volume.
- Velocity in pumping main range is considered 0.6 - 1 m/s for suction or inlet pipe and 1.5 m/s for discharge at peak flows.
- Minimum residual head is considered as 3m for pump head design.
- The Pumping station will have inlet chamber where sluice gates and bar screens will be provided. The wet well shall be designed as per 4 start/stops of pump per hours, submersible vertical axis pumps will be installed in it with level switches.

- The superstructure will consist of hoist for lifting the pumps, electrical panel, Instrumentation panel, loading/unloading bay, etc.

ii. Other components of Pumping Station

The contractor shall make his own assessment for all the components required for a smooth operation of the pumping station. The PIDs, layout, sections and Electrical SLD of the IPS have been presented in Drawing Nos. 6-2A/B/C. The other components (but not limited to) which are necessary for the seamless operation of the pumping station have been presented as below.

- Electrical & SCADA Panel Building
- Zib Crane for lifting pumps
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Gate Valves / Check Valves / Pressure Gauge Transmitter / Gate Valve (actuated)
- Electromagnetic Flowmeters
- Ultrasonic Level Transmitters
- Internal Lighting and Area Lighting
- Electrical Panel
- SCADA System with 500 tags for Residential PS
- 62.5KVA 50KW DG set

d. Instrumentation and Smart Monitoring

Clogging of sewer lines results in the backing up of sewage and its overflow onto roads and streets through the manholes creating not just an ugly sight but also putting public health in grave danger. In the conventional method of sewer network maintenance, the identification and clearing of sewers are done only after the sewage has overflowed onto streets. Thus, in order to prevent such happenings, it is proposed to install ultrasonic / radar-based level sensors under sewer manhole covers sometimes called as “smart manholes cover” so as to give an early warning in the event of any clog and abnormal rise in sewage level within the manhole. The level sensors would be LoRaWAN based so as to wirelessly communicate on a real time basis with the ICC and Intermediate Pumping Station and send alarms in case of any clogged sewer line. This would enable early rectification of the problem before the sewage overflows onto the streets

e. Proposed Wastewater Collection System

The proposed Sewerage System as designed in preliminary design has been presented in the sections below. The proposed system is for reference only and contractor is required to design the system keeping in mind the design philosophy given in preceding sections with effort to further improve the design with respect to site conditions and best practices in the industry.

i. Collection Network

Based on design philosophy described in section b, the sewerage network has been designed. The layout of the overall collection network for sewerage network has been presented in Drawing Nos. 6-1A/B/C/D. The summary of components in the distribution system has been presented in the following sections.

1. Pipelines and Manholes

The summary of sewage and effluent collection network in IMC Khurpia has been presented in Table B-40.

Table B-40: Summary Sewerage Network in IMC Khurpia

Pipe	Industrial Zone	Residential Zone	Manhole	Nos.
	Length (m)	Length (m)		
200mm dia RCC NP4	20,021	3,721	RCC 1.0m Dia	226

Pipe	Industrial Zone	Residential Zone	Manhole	Nos.
	Length (m)	Length (m)		
250mm dia RCC NP4	826	179	RCC 1.2m Dia	216
300mm dia RCC NP4	918	31	RCC 1.5m Dia	585
400mm dia RCC NP4	2,374		RCC 1.8mX1.8m	9
450mm dia RCC NP4	150			
600mm dia RCC NP4	1,020			
700mm dia RCC NP4	535			
Total	25,843	3,931		1036

2. Instrumentation and Smart Monitoring

Based on description given in section d, total **13** numbers of ultrasonic level sensors and transmitter have been proposed in residential zone and **53** number have been provided in industrial zone.

The locations of such manholes have been identified based on low FRL of the road where the overflow is expected to happen first as compared to other manholes so that an early warning could be given, and corrective measures could be taken. The locations of such manholes have been marked on the layout drawing no. 6-1A/B/C/D. Typical details of manhole with overflow sensor has been presented in drawing no. 6.5.

ii. Intermediate Sewage Pumping Station

1. Reservoirs

Based on maximum numbers of starts and stops of submersible pumps to lift the maximum flow of 49.2lps in the IPS, the reservoir capacity has been calculated as 18m³. The calculation for the design of reservoir has been presented in Appendix 6.2. The PID and the layout of the IPS has been presented in Drawing No. 6-2A/B/C

2. Pumps and Machinery

Submersible Pumps 1 working + 1 standby arrangement with duty condition 66.68lps@16m head has been proposed in the intermediate sewage pumping station to lift the industrial effluent generated in industrial area located in the western side of Paha canal.

The calculation for the design of pumps has been presented in Appendix 6.2. The PID and the layout of the IPS has been presented in Drawing No. 6-2A/B/C

3. Electrical and IloT System

Electrical and IloT system for IPS includes Transformer, Electrical and IloT Panel. The IloT Panel is a control panel which can receive feed from the level instruments in the sump and control the operation of the pumps based on the inflow fluctuation. Further the feed of overflow sensors in the manholes are also received in the IloT Panel at the IPS.

The Single Line Diagram (SLD) of the pumping station has been presented in Drawing No. 6-2D.

4. Rising Main from IPS to receiving Manhole

The effluent lifted from the IPS on the western side of Paha canal is proposed to be pumped to the first manhole on eastern side of Paha canal as presented in Drawing No. 6-1B.

The rising main is proposed to be 300mm dia DI K-9 pipeline with a length of 1077m. The pipeline is proposed to be laid in the median of 30m wide road and between sewer line and electrical trench for 18m wide road as per Typical Cross Sections.

3. Storm Water Drainage

a. Design Objectives and Planning of Proposed Storm Water Drainage System

The primary objective of storm water drainage design is to provide an efficient drainage network system which ensures critical infrastructure like roads, industrial, residential and utilities zones are free from flooding for the chosen design storm event. The drainage system is designed to collect surface storm water run-off from roadway surface and right-of-way along with runoff from adjacent plots and convey it through the storm water network discharging into receiving body/outfall without causing adverse site impacts.

Storm water collection systems shall be designed to accommodate adequate surface drainage. Surface runoff is a function of rainfall intensity, land use details, terrain slopes, transverse & longitudinal slopes of catchment, inlet spacing and inlet capacity.

The discharge design facilities for storm water collection and conveyance systems include consideration of storm water quantity and quality. The general considerations in design of storm water drain are:

- Drains shall be designed for appropriate design frequency/return period depending on importance of development and economic considerations.
- Drains shall be planned considering the ground levels, terrain slope and the land uses planned for urban development which shall to the maximum extent possible be in conformity with the existing natural drainage pattern of the site.
- Drains shall be planned to get good longitudinal slope, accounting the natural terrain and soil. Storm water drainage network layout shall be planned based on the proposed land-use pattern following the road network. Aim shall be to dispose the runoff to the nearest possible outlet meeting all the design criteria.
- Efficiency in maintenance of drainage system is an important consideration in selecting the size, shape and the location. The specification of the drain shall also aim at preventing the possibility of ingress of other extraneous materials, debris, vegetation etc.
- Flood mitigation using retention ponds before discharge for the major catchments would be considered which would serve the purpose of preventing and reducing the impact of flooding due to extreme storm events, while also help in reducing required storm drain sizes and capacities.

b. Proposed Design Basis and Methodology

i. Proposed Drainage Scheme

The proposed drainage system includes the road side channel, circular and rectangular conduit drains with manholes, storm water retention ponds and outfall structures. The surface runoff from road carriage way, parking lanes, pathways as well as overland flow from the plots will be collected and led into the closest storm drain by the individual properties. The proposed drains will run on either side of the road in drainage corridor for 18m RoW and above.

ii. Design Assumptions

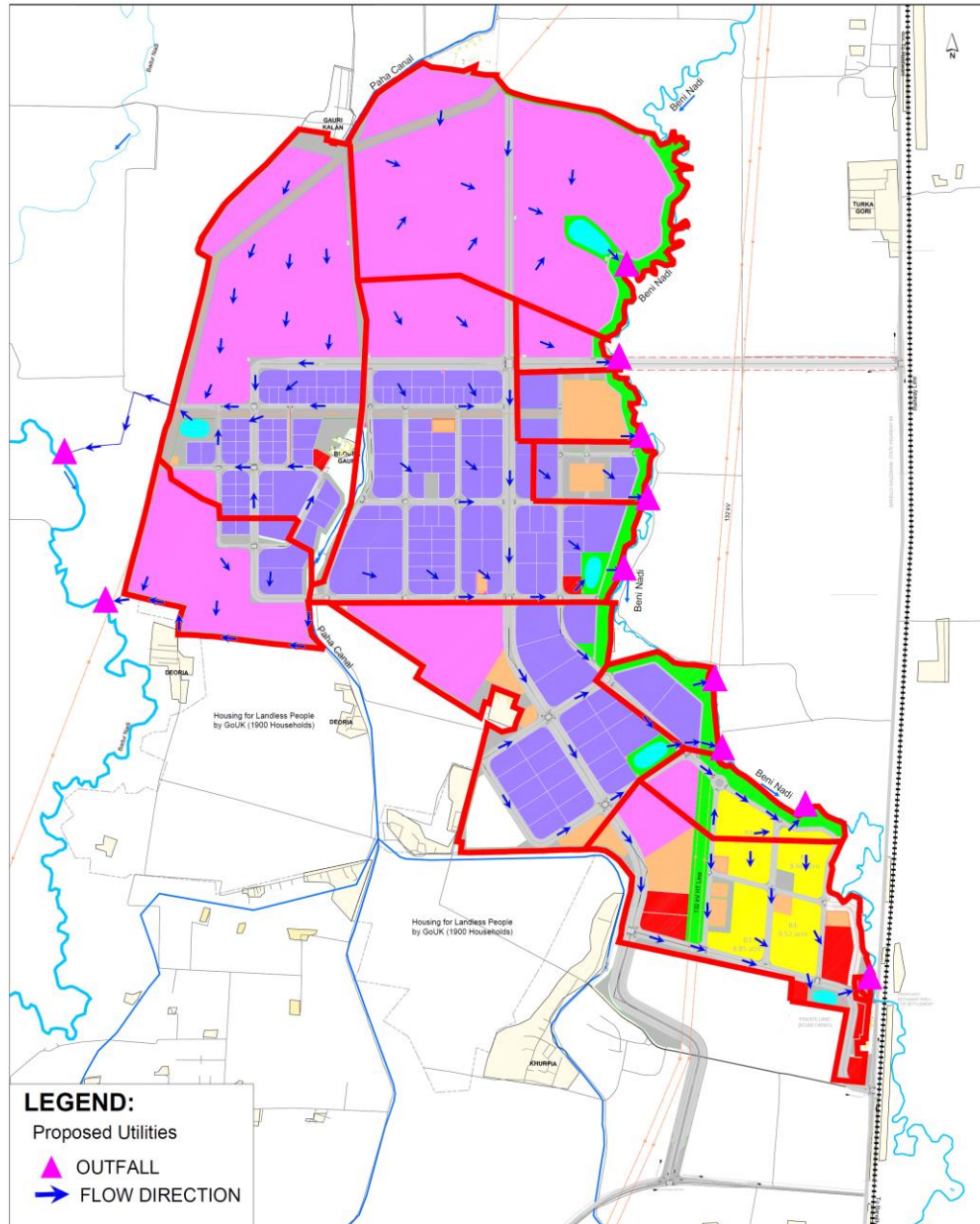
The following are the key design assumptions and need to validate in the following design stages:

- The proposed drainage outfalls into the natural stream, i.e. Beni river to the east and Badaur river on the west as per the existing pre-development drainage / water shed pattern.
- When the plots get developed in future, they should have enough elevations to drain the plot runoff into the road side drainage network
- Peak flow occurs when the entire watershed is contributing to the flow.
- Design storm event is the same over the entire drainage area.
- The coefficient of runoff is the same for all storms of all recurrence probabilities.
- The minimum time of concentration of 15 minutes' duration is considered to estimate the critical rainfall intensity.

iii. Catchment Delineation

The proposed drainage catchments and sub-catchments have been identified based on the natural site topography as well as the proposed masterplan and development plan. The catchment delineation for the site is shown in Figure B-8 below.

Figure B-8: Catchment delineation for Storm Water Drainage



iv. Calculation of Stormwater Runoff

The catchment flows are estimated using Rational method. Storm runoff is that portion of the precipitation which drains over the ground surface. Estimation of such runoff is dependent on the intensity and duration of rainfall, characteristics of tributary area and the time required for such flow to reach the drain.

A hydraulic model shall be built to estimate the catchment flows and to design the proposed drainage network. The catchments were delineated by considering the site gradient, road pattern and master plan plot boundaries. When adjacent plots get developed in future, they should have enough elevations to drain the plot runoff into the road drainage network. The Rational method is widely used

for estimating the peak runoff rates for urban drainage system. The Rational method formula is as given below.

$$Q = 10. C. i. A$$

Where:

Q = Runoff, m³/hr

C = dimensionless runoff coefficient

i = Intensity of rainfall in mm/hr corresponding to given time of concentration and design frequency

A = Area of drainage catchment in hectares

1. Time of Concentration

The storm duration chosen for design is equal to the time of concentration. Maximum discharge in drainage system occurs when the entire catchment is contributing to the flow. The time of concentration, (tc) is the time required for a given drop of water from the most remote part of watershed to reach the point of interest. Minimum time of concentration is assumed as 15 min for catchments.

2. Design Frequency / Return Period

The design return period of a storm is an average period of time after which it reoccurs, for a given rainfall magnitude or more corresponding to a particular duration of time. This is integral part of IDF curve developed, based on analysis of past rainfall data, for designing of storm water drainage systems. Depending on importance of the drainage area, socio-economic conditions of the city and other constraints such as funding for infrastructure and availability of space for construction of drains, the design return period of storm should be judiciously adopted in estimation of storm runoff. In view of the above, the design return period of storms as recommended by CPHEEO Manual on Storm Water Drainage published in 2019 is given in Table B-41 for estimation of storm runoff.

Table B-41: Recommended Design Return Period for various types of urban catchments

S. No.	Urban Catchment	Return Period	
Class I Cities**		Class I Cities**	Other cities***
1.	Central Business and commercial	Once in 5 years	Once in 2 years
2.	Industrial	Once in 5 years	Once in 2 years
3.	Urban Residential	Once in 5 years	Once in 2 years
4.	Airports and other critical infrastructure*	Once in 100 years	Once in 50 years
*Critical infrastructure includes Railway Stations, Power stations, etc.			
** Class I Cities are cities having population 1 Lakh and above			
*** Other cities are cities having population less than 1 lakh			

Since the proposed industrial area in IMC Khurpia is a high value industrial area coming close to the vicinity of various other industrial area/clusters a return period of **1 in 5 years** is considered optimum for design.

3. Design Storm Intensity

In the preliminary design, the design storm event for IMC Khurpia based on the rainfall analysis has been calculated for a design return period of 1 in 5 years as 58.93 mm/hr for a 1-hour duration storm event.

The critical rainfall intensity to be used in the rational formula is the rainfall corresponding to the time of concentration or time of flow for the respective catchments up to the point under consideration for drainage design. However, for a small catchment, considering a minimum time of concentration of 15 mins, the maximum critical rainfall intensity would be 141.43 mm/hr (for 15 min storm event)

4. Runoff Coefficient

The coefficient of runoff (C) is a function of the nature of surface and assumed to be the same for all storms of all recurrence probabilities. Recommended values of C on various surface types of the catchments are given in Table B-42. While choosing the values for C, the ultimate development of the catchment as per the master plan should be taken into consideration.

Table B-42: Runoff co-efficient of various surfaces

S. No.	Type of Area	Runoff Coefficient
1	Commercial Area	0.70 – 0.95
2	Industrial Area	0.60 – 0.90
3	Institutional Area	0.70 – 0.95
4	Residential Area -High Density -Low Density	0.60 - 0.75 0.40 - 0.60
5	Recreational areas	0.10 - 0.25
6	Pavement: - Asphaltic Pavement - Concrete Pavement - Brick Pavement	0.70 - 0.95 0.80 – 0.95 0.70 - 0.85
7	Roof Catchment: - Tiles - Corrugated metal sheets - Concrete	0.8-0.9 0.7-0.9 0.7-0.90

Whereas the use of the runoff coefficient implies there is a constant ratio of rainfall to runoff, the actual ratio will vary over the course of a storm due to the condition of the area and the variability of the rainfall pattern. A common practice is to use average coefficients for various types of areas and assumed that the coefficients will be constant throughout the duration of the storm.

Weighted average runoff coefficient of catchment area containing different character of surfaces for a flow concentrating at a point may be estimated as follows:

Weighted average of 'C' values of different type of urban surfaces should be calculated by the following formula

$$C = \frac{C_1A_1 + C_2A_2 + C_3A_3 + \dots}{A_1 + A_2 + A_3 + \dots}$$

Where,

C₁, C₂, C₃ are runoff coefficients of urban surfaces

A₁, A₂, A₃..... are areas of respective urban surfaces

Considering the mixed nature of development in IMC Khurpia a combined average runoff co-efficient of 0.65 shall be assumed for design purpose. The weighted average calculation for IMC Khurpia is presented below in Table B-43.

Table B-43: Weighted average of runoff co-efficient of discharge for IMC Khurpia

S.N.	Particulars	%age	Area (acre)	C value considered
1	Industrial area	61.62%	622.83	0.70
2	Residential Area	3.91%	39.54	0.60
3	Urban Greens	14.84%	150.20	0.20
4	Roads	14.62%	148.03	0.80
5	Commercial Area	1.54%	15.58	0.70

S.N.	Particulars	%age	Area (acre)	C value considered
6	Common Services	3.58%	36.25	0.70
Total		100%	405.56	0.64
Weighted average of C				

c. Instrumentation and Smart Monitoring

i. Multiparameter water quality sensors

It is proposed to install multiparameter water quality sensors within IMC Khurpia for the monitoring of the storm water in the storm drains and retention ponds. This would not only give us a fair idea of the prevailing water quality within the retention ponds but also serve to detect any illegal discharge of pollutants by industries into the drains. This would help take early action thereby protecting the environment and surface and ground water resource from contamination.

Although, the multiparameter sensors would be similar to the ones proposed for water distribution it would need to pick up different quality parameters. The main parameter of interest herein would be DO (Dissolved Oxygen). It is proposed to have about 10 such location for monitoring in the five proposed retention ponds which would be wirelessly linked to the ICCC through the LoRaWAN protocol for monitoring of the quality of water in the pond.

d. Proposed Stormwater Drainage System

The proposed Storm Water Drainage System as designed in preliminary design has been presented in the sections below. The proposed system is for reference only and contractor is required to design the system keeping in mind the design philosophy given in preceding sections with effort to further improve the design with respect to site conditions and best practices in the industry.

i. Collection Network

Based on design philosophy described in section b, the stormwater drainage network has been designed. The layout of the overall collection network for sewerage network has been presented in Drawing Nos. 7-1A/B/C/D/E/F. The summary of components in the distribution system has been presented in the following sections.

1. Pipelines and Manholes

The summary of Stormwater drainage collection network in IMC Khurpia has been presented in Table B-44.

Table B-44: Summary Stormwater drainage Network in IMC Khurpia

Pipe	Length	Manhole	Nos.
300mm dia RCC NP3	1353	RCC 1.2m Dia	241
400mm dia RCC NP3	3048	RCC 1.5m Dia	487
450mm dia RCC NP3	1128	RCC 1.8mX1.8m	187
500mm dia RCC NP3	1964	RCC 2.1mX2.1m	250
600mm dia RCC NP3	5211	RCC 2.4mX2.4m	37
700mm dia RCC NP3	4212	RCC 2.7mX2.7m	66
800mm dia RCC NP3	3398		
900mm dia RCC NP3	1820		
1000mm dia RCC NP3	2463		
1100mm dia RCC NP3	2471		
1200mm dia RCC NP3	2523		
1400mm dia RCC NP3	5186		
1.5 x 1.5 m RCC square conduit	1081		
1.75 x 1.75 m RCC square conduit	2184		

Pipe	Length	Manhole	Nos.
2.0 x 2.0 m RCC square conduit	2981		
Total	41,023		1,268

The typical details of different types of manholes in storm water drainage system is presented in drawing no. 7-3 while the excavation and bedding details have been presented in drawing no. 7-2.

2. Road side channel to collect road runoff

The rainfall received on the road RoW is proposed to be collected in the road side channel as per the Typical Cross Section of the Road and shall be conveyed to the nearest storm water drainage manhole through 150mm dia DWC pipe. The total length of this road side channel has been estimated as **36.95km**.

3. Stormwater collection from the plots

The storm water falling on the plots shall be collected through an inspection chamber located just outside the plot or inside the plot boundary as per the space constraints to lay all the utilities. However, this has been proposed to avoid any footpath cutting to provide connection. 300mm dia DWC pipe has been considered for plot connections to the drainage manhole. The typical details of plot connection and connection from road side channel has been presented in drawing no. 7-4.

4. Retention Pond

In the drainage system of IMC Khurpia, 5 Nos. retention ponds have been proposed before the final outfall to Badaur or Beni. The location of the ponds have been marked on the drawing no. 7-1A/B/C/D/E/F and the summary has been presented in Table B-45

Table B-45: Summary of retention ponds in IMC Khurpia

Pond	Peak flow (Q) 5 yrs return period (m ³ /s)	Area of Pond (m ²)	Top of Pond	TWL	Invert level of outgoing pipe	Depth of attenuation (m)	Storage (m ³)	Attenuated Peak flows (m ³ /s)	Reduction in peak flow
Pond-1	10.71	5993.65	210.85	210.55	208.57	1.98	11867.43	4.12	62%
Pond-2	14.15	10201.32	212.90	212.23	209.96	2.27	23156.99	5.57	61%
Pond-3	8.26	5062.12	211.13	210.06	207.97	2.09	10579.83	4.34	47%
Pond-4	5.51	6351.43	208.90	208.5	206.30	2.20	13973.15	2.92	47%
Pond-5	4.94	3876.29	207.70	207.39	205.19	2.20	8527.85	2.57	48%
	43.57							19.53	

As shown in the table, the peak flow in the drainage system for 1 in 5 years' rainfall is reduced from 47% to 62% by introduction of retention pond in the system, with overall reduction of 55%.

5. Retention Pond outlet control structure

The outlet control structure controls the outlet flow from the pond while keeping the surplus storm water within the pond so that the pond acts as a buffer against the flash flood on the downstream of the system.

The summary of the outlet control structure in 5 retention ponds has been provided in Table B-46

Table B-46: Summary of outlet control structures in 5 retention ponds

Orifice and Weir Details For	Pond-1	Pond-2	Pond-3	Pond-4	Pond-5	Unit

Orifice dia required	428	590	393	437	339	mm
Orifice bottom level	208.57	209.96	207.97	206.30	205.19	m AMSL
Orifice top level	209.00	210.55	208.36	206.74	205.53	m AMSL
Orifice centre level	208.78	210.25	208.17	206.52	205.36	m AMSL
Length of wier (L)	4.50	4.14	4.83	3.89	3.63	m
Height of wier (H)	600	750	600	500	500	mm
Weir Bottom level	209.95	211.48	209.46	208.00	206.89	m AMSL
Weir Top level	210.55	212.23	210.06	208.50	207.39	m AMSL

The standard drawing of the pond with outlet control structures has been provided drawing no. 7-5.

6. Instrumentation and Smart Monitoring

Based on description given in section c, total **10** numbers of Dissolved Oxygen Sensor and Transmitter have been proposed, 2 in each pond – one near inlet and one near outlet. These transmitters shall supply feed to the ICCC to monitor the entrance of any pollutants in the storm water drainage network.

7. Outfalls

Total 11 number of outfalls have been proposed out of 2 are towards Badaur river and 9 in Beni river. Including all major and minor catchments the peak discharge for 1 in 5 years designed rainfall has been presented in Table B-47. Among these outfalls, Beni-2 outfall is on either side of Beni River, which makes the number of outfalls to 12. In the given table below, the total peak discharge of the outfall has been given.

Table B-47: Summary of outfalls in IMC Khurpia

Outfall	Attenuated Peak flows (m ³ /s)
Badaur - 1	4.12
Badaur - 2	3.65
Beni - 1	5.57
Beni - 2	4.94
Beni - 3	1.93
Beni - 4	1.56
Beni - 5	4.34
Beni - 6	1.82
Beni - 7	2.92
Beni - 8	2.48
Beni - 9	2.57
	35.91

The details of outfalls have been presented in the drawing nos. 7-1A/B/C/D/E/F. The typical detail of outfall structure in the river has been presented in drawing no. 7-6. However, the outfall structures shall be constructed by Uttarakhand Irrigation Department in coordination with wet utility contractor.

Specifications and Standards

The Project shall be designed and constructed in conformity with the Specifications and Standards specified in Annex-I of Section-D.

B.3. POWER

Description of the electrical scope is to provide the complete electrical system including civil works, complete in all respects and covers design, engineering, procurement and manufacturing of electrical equipment's, testing at works, packing, transportation to site, storage, installation, testing, commissioning, handing-over in complete working order all the equipment's including all items as per contract, spares, manuals, etc. and O&M for the in IMC Khurpia project. The detailed scope is as under.

a) 33/11kV Indoor Substation:

ii. In consist of major items follows:

- 33kV GIS switchgear panel along with all relays, meters, breakers etc.
 - 11kV AIS based switchgear panel along with all relays, meters, breakers etc.
 - 33/11kV Outdoor type transformers along with OLTC, RTCC+AVR
 - 33kV touch proof termination kits
 - 11kV termination kits along with the right-angle boots
 - 33kV & 11kV XLPE Power cables
 - 33/11kV Substation indoor and outdoor lighting system
 - GI Cable tray and trenches for inside the substation.
 - Earthing system & lightning protection system
 - 110V DC Battery & Battery Chargers
 - Control panels, Separate PMS SCADA system for each of Substation, Lighting Management System including all aspects for each Substation.
 - 11/0.415kV, outdoor type auxiliary transformers -02 Nos (1Working + 1 Stand by) for each 33/11kV substation.
- b) 33kV & 11kV Ring Main Units (RMU) along with FRTU's, metering.
- c) 11kV/433V Compact Substation (CSS) for the LV plots and street lighting system.
- d) 33kV, 11kV, 1.1kV XLPE Cables and all other necessary equipment's
- e) Laying 33 kV cable from 220/132/33 KV sub station to 33/11kV substation.
- f) From the 33/11kV substation to RMU/CSS, cables shall be laid in the FRP cable trays along with the trench work, Supports, terminations, jointing works, cable tags etc.
- g) Low voltage 415V Feeder Pillars for the LV Plots and street lighting system.
- h) All cabling, terminations, jointing and necessary related works as required to take the power supply from PTCUL MRSS substation and connect this to each 33/11kV substation and to establish an interface between transmission and distribution network battery limits. Scope doesn't include the PTCUL MRSS substation, but the cable supply from MRSS substation to 33/11 kV substations within KIMC is in scope of the present contract requirement. Further, anchor units 132kV power supply shall be provided by UPCL. However, required ROW along with the HDPE ducts supply, laying upto each anchor unit will be in the contractor scope.
- i) Instrumentation and Fiber Optics cables, their jointing for SCADA
- j) External & Internal Lighting:
- k) RCC trench along with FRP Trays for MV & LV Power Cables
- l) Fiber & ELV Cables shall be laid in ICT ducts.
- m) DG Sets for emergency power supply to street lighting system and substations
- n) Earthing system for 33/11kV indoor primary substations, RMU, CSS & Street Lighting
- o) Mandatory Spares (5%) & Operational Spares for all Major Equipment's
- p) Civil works complete in all respects
- iii. The electrical work required to be done under this contract is detailed in the specifications section. The contractor shall design and construct the complete works necessary at site required to properly, safely and efficiently operate the electrical system and meet the electrical needs of the development and all facilities. Facility should be designed with SMART & Digital technology available in the market & should be future proof.
- iv. Substation & outdoor electrical Installation
- For Substation installation, contractor shall install the same on ground floor, on about 500mm plinth base shall be provided subject to the flood level. Contactor shall check the high flood level and accordingly substation shall be designed and constructed.
 - Substation shall be provided such a way that proper space planning and routing for incoming and outgoing cables. MV & LV Cable bending radius shall be considered as per related IS standards and further there should not be any sharp bends inside the substation.

- Inside the substation building, the cables should be routed in covered concrete trenches with cable trays of GI material so as to avoid any steel structural works.
- Compact Substation which are installed outside the building, contractor shall place the same on 500mm plinth base, design of which shall be approved by Engineer.
- The plinth size may be increased beyond if area is likely to have flood water above 500mm.
- Under no case water should enter the substation. This shall be checked with the civil team for maximum flood level and accordingly CSS shall be installed from ground level.
- DG sets shall be installed by contractor for substation, Utility areas including treatment plants, Street lighting etc. DG sets shall be installed in the shed and it shall be subject to approval of Engineer. All civil works, concerning the installation of DG sets shall be in contractor's scope.
- MV, LT XLPE cables and optical fiber cables shall be laid in concrete cable trenches.
- The size of cable trench on respective ROW shall be decided based on the cable sizes and overall diameter of the cable. It is essential that all MV cables shall be laid in the cable trenches with one diameter spacing. Other LV, Fiber optic cables shall be laid in the separate cable trenches. all cables shall be laid with FRP cable trays along with the roads.
- Earthing system, complete in all respects including the provision of earth pits, laying of earthing conductors their termination jointing etc. shall be provided at all the required sites.
- Street Light poles, lighting fixtures, High Mast, lighting panels, cabling, etc. as required, for street lighting, parking area lighting to complete the works in all respects shall be in the scope of contractor. Street lighting system shall be designed based on the LORA gateway system. The entire system and all its components shall be SCADA compatible for remote monitoring lighting system.
- Substation internal lighting lux level for substation rooms / internal buildings shall be **22 lux** as per latest NBC (National Building Code) & For specific areas within substations like switchrooms, meter rooms, and oil plants, the recommended lux level ranges from 100 to 200 lux.
- Each Substation should have separate Power Management SCADA System controlling all the substation equipment's (GIS, AIS, PT, MCCB etc.) & associated RMU, CSS over Fiber Optic. Whereas Separate LORA based Lighting Automation System should be proposed for outdoor Street Lighting powered through that substation. Both the System should connect to ICT over redundant communication.
- All the required civil works such as foundations, trenches, fencing, duct laying, etc. shall be in contractor's scope.

Any other works not included above but required to complete the works as per specification and project requirements.

B.4. CETP AND STP

It is proposed to develop 6.85 MLD common effluent treatment plant (CETP) and 1.03 MLD sewage treatment plant (STP) to treat the industrial effluent and domestic wastewater generated from IMC. In the initial phase of the project, the contractor shall develop 3.45 MLD CETP and 0.5 MLD STP complying with the specifications and standards set forth in Section D of this tender document.

The proposed land use in IMC of Khurpia node consisting of industrial area, residential area, commercial area, transportation & communication area, services area, and green cover, is expected to generate both industrial effluent and domestic wastewater. The automobile & engineering cluster sector (consisting of Automobiles, Auto Components and Light Engineering units) is proposed in Khurpia node, which consumes large quantities of water for various production process and also generates large volumes of effluent consisting of diverse pollutants with high COD, BOD, TSS, presence of metals and toxic components, etc.

The scope of works shall include but not be limited to following:

Common Effluent Treatment Plant (CETP):

The contractor has to design & construct the Common Effluent Treatment Plant (CETP) located within the Project area.

1) Design of CETP

- The Bidder shall be responsible for the Design, Construction, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier's works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take-over/hand over by Employer at the need of O&M period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis.
- Submission of process design, design calculations, plant layout and hydraulic flow diagram, Process & Instrumentation diagram, electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations & technical information, instrumentation & control system, Erection of all mechanical, electrical items including, testing, commissioning, performance testing of process units & trial run for a period of one months, illumination of the entire CETP, laboratory with necessary reagents and testing facilities.

2) Site Clearance

- Prepare the site including clearing site, soil cutting/filling, levelling, tree cutting if any, cleaning debris, etc.
- Boundary wall with fencing for the required perimeter of site.

3) Civil works of CETP and Utilities

- All civil works including ancillary works for completion of the project.
- Office, Laboratory in complete for efficient operations of the plant.
- Construction of Internal Roads, including connecting road to site from existing road to have a separate and independent entry to plant/site.
- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal,
- Drinking water & sanitation water system, lighting, fencing, etc.
- Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction
- Vehicle shed if required

4) Supply and installation of electro-mechanical items

- Supply/fabrication of all mechanical items including piping items as per the design / system requirements
- Supply of electrical items as per design / system requirements
- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g., Pipes, Plates, Valves, etc).
- Automation & Control
- PLC based automation system with application software. Automation to control blowers, VFDs, limit switches and Instrumentations in the plant and other units of sewage treatment plant, including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- Standalone/ or integrated PLC panel having Suitable PLC
- Ultrasonic level transmitter on all sump/ tank.
- Flow meter in rising main of effluent transfer pumps to equalization tank, treated effluent transfer pumps
- Complete SCADA based operation for monitoring the plant at every stage of operation.
- Utilities-solar Street lighting, ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for handling of equipment during maintenance.

- Commissioning spares
 - Supply and installation of lab equipment
 - Other items/ materials required for installation & commissioning of CETP.
- 5) Statutory Compliances
- Complete design of CETP should meet the requirements of SPCB and confirm to ISO 14001 norms.
 - All statutory clearances / approvals in respect of CETP shall be taken for meeting all the statutory obligations and local inspectorates pertaining to works carried out by the contractor.
 - The contractor should prepare all working drawings and obtain approval from competent authorities for construction and operations of the plant
 - The contractor shall get the equipment and installations inspected and approved from competent authorities as required.
 - Monitoring and control of industrial influent for all industry members as per tri-partite agreement. Finalizing, implementing the enclosed draft tri-partite with industry members with approval of Employer.
 - Carry out inlet and outlet sampling, its analysis by SPCB approved lab, submission of satisfactory lab reports, obtaining SPCB certification for successful commissioning of the plant.
 - Disposal of CETP residuals like but not limited to screenings, grit, dewatered sludge (primary sludge, secondary sludge) shall be disposed of at the nearest Common Hazardous Waste Treatment Storage & Disposal facility (CHWTSDF), including all cost of transportation and treatment charges.
- 6) O&M: Prior to commencement of the work, the Contractor shall submit the following:
- Trial runs / performance guaranteed test for one month to perform the guarantees for treated effluent and others (power, chemicals consumption) after successful commissioning and stabilization of common effluent treatment plant.
 - Upon completion of the Performance Test and issue of Completion Certificate, defect liability period starts with operation and maintenance of the plant for four (4) years.
 - The contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
 - Foundation Plan and Loading Data for Civil Design and drawings.
 - Layouts, general arrangements, dimensional elevations, and cross-sectional drawing for all the project components, equipment, structures, and facilities of the works.
 - Flow diagrams, hydraulic gradient diagram, Process & Instrumentation Diagrams, piping isometric, composite layout and fabrication drawings, piping engineering Diagrams, pipe and fittings Sections, valve Sections, pipe support Sections.
 - Hydraulic & Mechanical design calculations
 - Technical data sheets and calculations for all bought out and manufactured item
 - Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment 's, piping, valves, Electrical systems, Control and instrumentation systems and civil works.
 - Single line diagram, schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets
 - Instrument Section, measuring point list, I/O list, interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
 - Power distribution scheme indicating the equipment 's rating
 - Protection system diagrams.
 - List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.

- Control system configuration diagrams and card circuit diagrams and maintenance details
- Detailed software manuals & source software listing
- Type test reports
- Functional & guarantee test procedures and test reports
- Documentation in respect of Quality Assurance System
- The facilities shall require minimum skilled manpower for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
- Training of client Operating and Maintenance personnel before handing over.

7) Safety

- The Contractor shall at all times maintain a safe system of working and working environment and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work.
- The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.
- All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.
- Work safety measures such as use of PPE (masks, helmet, gloves, safety belts, etc.) by the workers
- Necessary scaffolding, lifting tools and tackles to be used for loading, unloading and shifting of heavy equipment.
- The contractor should take insurances as applicable for covering the risk associated with the project.
 - Erection all risk policy during erection phase
 - Transportation all risk policy during transit and erection phase
 - Workmen compensation insurance during erection and commissioning phase
 - Fire and natural perils insurance during erection and commissioning phase

8) Others

- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.
- The Contractor shall ensure that all designs and equipment for which the contractor is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

Sewage Treatment Plant (STP):

The contractor has to design & construct the Sewage Treatment Plant (STP) located within the Project area.

1) Design of STP

- The Bidder shall be responsible for the Design, Construction, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier's works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up

to time of take-over/hand over by Employer at the need of O&M period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis.

- Submission of process design, design calculations, plant layout and hydraulic flow diagram, Process & Instrumentation diagram, electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations & technical information, instrumentation & control system, Erection of all mechanical, electrical items including, testing, commissioning, performance testing of process units & trial run for a period of one months, illumination of the entire STP, laboratory with necessary reagents and testing facilities.

2) Site Clearance

- Prepare the site including clearing site, soil cutting/filling, levelling, tree cutting if any, cleaning debris, etc.
- Boundary wall with fencing for the required perimeter of site.

3) Civil works of STP and Utilities

- All civil works including ancillary works for completion of the project.
- Office, Laboratory in complete for efficient operations of the plant.
- Construction of Internal Roads, including connecting road to site from existing road to have a separate and independent entry to plant/site.
- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal,
- Drinking water & sanitation water system, lighting, fencing, etc.
- Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction
- Vehicle shed if required

4) Supply and installation of electro-mechanical items

- Supply/fabrication of all mechanical items including piping items as per the design / system requirements
- Supply of electrical items as per design / system requirements
- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g., Pipes, Plates, Valves, etc).
- Automation & Control
- PLC based automation system with application software. Automation to control blowers, VFDs, limit switches and Instrumentations in the plant and other units of sewage treatment plant, including I/Os with 20 % spares, power supplies, UPS, etc. complete.
- Standalone/ or integrated PLC panel having Suitable PLC
- Ultrasonic level transmitter on all sump/ tank.
- Flow meter in rising main of effluent transfer pumps to equalization tank, treated effluent transfer pumps
- Complete SCADA based operation for monitoring the plant at every stage of operation.
- Utilities-solar Street lighting, ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for handling of equipment during maintenance.
- Commissioning spares
- Supply and installation of lab equipment
- Other items/ materials required for installation & commissioning of STP.

5) Statutory Compliances

- Complete design of STP should meet the requirements of SPCB and confirm to ISO 14001 norms.
- All statutory clearances / approvals in respect of STP shall be taken for meeting all the statutory obligations and local inspectorates pertaining to works carried out by the contractor.

- The contractor should prepare all working drawings and obtain approval from competent authorities for construction and operations of the plant
 - The contractor shall get the equipment and installations inspected and approved from competent authorities as required.
 - Monitoring and control of industrial influent for all industry members as per tri-partite agreement. Finalizing, implementing the enclosed draft tri-partite with industry members with approval of Employer.
 - Carry out inlet and outlet sampling, its analysis by SPCB approved lab, submission of satisfactory lab reports, obtaining SPCB certification for successful commissioning of the plant.
 - Disposal of STP residuals like sludge shall be used as manure within the plant / industrial park for green areas.
- 6) O&M: Prior to commencement of the work, the Contractor shall submit the following:
- Trail runs / performance guaranteed test for one month to perform the guarantees for treated effluent and others (power, chemicals consumption) after successful commissioning and stabilization of common effluent treatment plant.
 - Upon completion of the Performance Test and issue of Completion Certificate, defect liability period starts with operation and maintenance of the plant for four (4) years.
 - The contractor shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
 - Foundation Plan and Loading Data for Civil Design and drawings.
 - Layouts, general arrangements, dimensional elevations, and cross-sectional drawing for all the project components, equipment, structures, and facilities of the works.
 - Flow diagrams, hydraulic gradient diagram, Process & Instrumentation Diagrams, piping isometric, composite layout and fabrication drawings, piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
 - Hydraulic & Mechanical design calculations
 - Technical data sheets and calculations for all bought out and manufactured item
 - Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment 's, piping, valves, Electrical systems, Control and instrumentation systems and civil works.
 - Single line diagram, schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets
 - Instrument schedule, measuring point list, I/O list, interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
 - Power distribution scheme indicating the equipment 's rating
 - Protection system diagrams.
 - List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
 - Control system configuration diagrams and card circuit diagrams and maintenance details
 - Detailed software manuals & source software listing
 - Type test reports
 - Functional & guarantee test procedures and test reports
 - Documentation in respect of Quality Assurance System
 - The facilities shall require minimum skilled manpower for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
 - Training of client Operating and Maintenance personnel before handing over.

7) Safety

- The installation layout and system design shall not allow any item of plant to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents, electrical cables and rotating machinery.
- All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.
- Work safety measures such as use of PPE (masks, helmet, gloves, safety belts, etc.) by the workers
- Necessary scaffolding, lifting tools and tackles to be used for loading, unloading and shifting of heavy equipment.
- The contractor should take insurances as applicable for covering the risk associated with the project.
 - Erection all risk policy during erection phase
 - Transportation all risk policy during transit and erection phase
 - Workmen compensation insurance during erection and commissioning phase
 - Fire and natural perils insurance during erection and commissioning phase

8) Others

- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.
- The Contractor shall ensure that all designs and equipment for which the contractor is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.

B.5. TRUCK TERMINAL

The minimum Truck Terminal area to be developed shall be approximately 8.23 acres. Which include the area of the bus bays (alighting, boarding and idle parking) and facilities like Truck Service & Repair shops, Weigh Bridge, Dormitory & Eating Places, 2-3 Nos Toilet complexes, 2-3 Nos Shops/ Eating Places and office building. The works shall include all the construction works to be carried out in the Truck Terminal for its development to cater to the future requirements.

1. The scope of works covers the detailed design for project execution, detailed engineering and preparation of all related drawings concerned with the execution of the Truck Terminal Facility.
2. Provision of passenger amenities like retail shops, parking areas for public, private and intermediate public transport, toilets, drinking water chambers, waiting halls, seating arrangements, dustbins etc.
3. Truck Terminal Facilities like bus bays (alighting, boarding and idle parking), circulation area, enquiry counters, and information centers, Truck Service & Repair shops, Weigh Bridge, Dormitory & Eating Places, 2-3 Nos Toilet complexes, 2-3 Nos Shops/ Eating Places and office building
4. Design and construct supporting infrastructure facilities related to Rain Water Harvesting, Water Supply and Sanitary Installations, Communication System.
5. Public Utilities (Toilets, Drinking Water Chambers etc.)
6. Co-ordination of different activities in terms of functional and spatial interrelationships.
7. Display Boards, Digital Displays and Variable Message Sign Boards
8. Security Guard Cabins are to be provided near the Truck terminal entry and exit gates.

9. 60kW Rooftop solar Generation system shall be installed on the rooftop of 'Truck Service and Repair shops, weigh bridge' building of the Truck terminal.
10. The Contractor shall provide a state-of-art communication system which shall primarily consist of telecommunication and networking equipment's. These shall form the basic infrastructure for implementing the Management Information System in the truck terminal. Different departments/maintenance staff of the Contractor should be accessible on call at all times. Preferably walky-talkies and wireless local.

Guidelines for Facilities Development:

The guidelines for commercial facilities development are:

1. Minimum conflict points related to the connectivity between the commercial/industrial development and the track terminal facilities.
2. The design of the building shall result in a permanent civic architecture that contributes to its context. The design shall not only be a recognizable element of the truck Terminal, but also shall be clearly an integral part of the neighborhood and community. The external components must be aesthetic and shall display modern architecture and concepts.

Water Supply Structures

The Contractor shall provide adequate number of Water Storage and Supply Structures in the form of Over Head Water Storage and Under Ground Water Storage Tanks. These tanks shall be of adequate capacity to meet the peak hour requirements of the truck terminal and shall be designed and built as per relevant standards. Apart from meeting the user requirements, water storage shall be maintained for meeting the contingency requirements in case of fire or similar incidents. The water supply distribution network shall be laid exclusively for the Truck Terminal Facilities within the Truck Terminal complex. Separate water supply meters shall be installed for usage by Truck Terminal. The Contractor shall provide adequate number of Sanitation structures along with proper flushing and cleaning arrangement.

B.6. BOUNDARY WALL

The minimum Boundary wall length to be developed shall be approximately 12.5 KM, which is the entire perimeter of the site. The perimeter boundary wall includes the area of the all activity like residential, Commercial, Industrial area. The works shall include all the construction works to be carried out in the Boundary wall for its development to cater to the future requirements.

The scope of works covers the detailed design for project execution, detailed engineering and preparation of all related drawings concerned with the execution of the Boundary wall.

B.7. ENTRANCE GATE

IMC Khurpia shall have 3 accesses to the site: Access 1 from Kichha Bypass via a 60m RoW road; Access 2 shall be only for private vehicles and Intermediate Public Transport (IPT) from SH-44 via a 30m RoW road; and future Access 3 from SH-44 which shall be built in phase 2 of the project upon acquisition of land. Two Entrance gates shall be developed in phase 1: one at Access 1 from Kichha Bypass via a 60m RoW road and other at Access 2 shall be only for private vehicles and Intermediate Public Transport (IPT) from SH-44 via a 30m RoW road.

1. The scope of works covers the detailed design for project execution, detailed engineering and preparation of all related drawings concerned with the execution of the Entrance gate.
2. Provision of passenger amenities like Entry & Exit and security guard room etc.

- 3 Design and construct supporting infrastructure facilities related to Water Supply and Sanitary Installations, Communication System.
- 4 Co-ordination of different activities in terms of functional and spatial interrelationships.
- 5 Display Boards, Digital Displays and Variable Message Sign Boards
- 6 Security Guard Cabins are to be provided near the entrance gates.

SECTION-C (PROJECT FACILITIES)

(Refer Clause 9)

- i. Project Facilities for “Roads, Bridges, Culverts, Structures and Miscellaneous Works”
- ii. Project Facilities for “Wet-Utilities”
- iii. Project Facilities for “CETP and STP”
- iv. Project Facilities for “Truck Terminal”

C.1. ROADS

The Contractor shall design and construct the Project Facilities in accordance with the provisions of this Section C. Such Project Facilities shall include;

- (a) New Road network
- (b) Traffic Signage & Road markings.

1.1 Project Facilities

Each of the Project Facility is briefly described below;

1.1.1 New Road network: The proposed road network shall be as per the details furnished Section A

1.1.2 Road Markings & Traffic Signage

Road Side furniture and Road markings & signage shall be provided in accordance with the Section D.

Locations, Nos. and sizes of overhead traffic signs are given in Table C-1: Locations, Nos. and Sizes of Overhead Traffic Signs

S. No.	Road ID	Junction No.	Total Nos.	Width of each sign (m)
1	R1 Access-2	1	1	11.5

Table C-1: Locations, Nos. and Sizes of Overhead Traffic Signs

S. No.	Road ID	Junction No.	Total Nos.	Width of each sign (m)
1	R1 Access-2	1	1	11.5

1.1.3 Bus-Bays

Bus-bays shall be provided at following locations in accordance with the Standards and Specifications as referred in Section-D.

The following below are the locations identified preliminary and the contractor shall design in detail subjected to the satisfaction of Engineer-In-Charge/Authority

Table C-2: Bus-Bays Locations

Bus Bay location			
Sl.No.	Road Number	Chainage	Side
1	R1	0+600	Right
2	R1	0+720	Left
3	R1	1+170	Right
4	R1	1+450	Left
5	R1	1+670	Right
6	R1	1+820	Left

Bus Bay location			
Sl.No.	Road Number	Chainage	Side
7	R1	2+040	Right
8	R1	2+270	Left
9	R1	2+490	Right
10	R1	2+620	Left
11	R1	2+840	Right
12	R1	2+960	Left
13	R2	0+130	Right
14	R2	0+390	Left
15	R2	0+590	Right
16	R5	0+400	Left
17	R5	0+490	Right
18	R8	0+070	Right
19	R8	0+160	Left
20	R8	0+440	Left
21	R8	0+640	Right
22	R9	0+090	Left
23	R9	0+250	Right
24	R16	0+280	Right
25	R16	0+360	Left
26	R16	0+540	Right
27	R16	0+600	Left
28	R21	0+330	Left
29	R21	0+540	Right
30	R21	0+810	Left
31	R21	1+040	Right
32	R22	0+120	Right
33	R27	0+180	Left
34	R27	0+380	Right

C.2. WET-UTILITIES

1. Wet-Utilities

1.1. Industrial and Residential Pumping Stations

For supply of potable and recycled water to the entire Residential and Industrial zone, two pumping stations are proposed. The facilities to be provided in these pumping stations (but not limited to) shall be as follows:

- Pump House Building with toilets as per NBC requirements
- Electrical & SCADA Panel Building
- Chlorination Building
- Electrically Operated Travelling Crane (2T)
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Gate Valves / Check Valves / Pressure Gauge Transmitter / Gate Valve (actuated)
- Electromagnetic Flowmeters
- Ultrasonic Level Transmitters
- Chlorine Gas Feed System 1.0Kg/hr for Industrial potable and recycled water
- Chlorine Gas Feed System 0.5Kg/hr for Residential potable and recycled water
- Pressure Vessels for Potable and Recycled Pumping System
- Internal Lighting and Area Lighting
- Electrical Panel
- 300kVA 11KV / 433V outdoor off load tap changer type transformer for Industrial PS
- SCADA System with 750 tags for Industrial PS
- SCADA System with 500 tags for Residential PS
- 200KVA 160KW DG set for Industrial
- 62.5KVA 50KW DG set for Residential

1.2. Intermediate Effluent Pumping Station

The effluent collected by gravity on the western side of Paha canal is proposed to be collected and pumped to the first manhole on the eastern side of Paha Canal through an Intermediate Effluent Pumping Station. The facilities to be provided in this pumping station (but not limited to) shall be as follows:

- Electrical & SCADA Panel Building with toilet as per NBC
- Zib Crane for lifting pumps
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Gate Valves / Check Valves / Pressure Gauge Transmitter / Gate Valve (actuated)
- Electromagnetic Flowmeters
- Ultrasonic Level Transmitters
- Internal Lighting and Area Lighting
- Electrical Panel
- SCADA System with 500 tags for Residential PS
- 62.5KVA 50KW DG set
- Odor Control Devices (Preferably nature based)

1.3. Tube wells

For drawing potable water, 7 nos of tube wells have been proposed (5 shall be constructed in phase-1). The facilities to be provided in the tubewell premise (but not limited to) shall be as follows:

- Tubewell Building
- Chain Pulley arrangement for lifting the pump
- Boundary Wall with Gate
- Suitable internal drainage and driveway
- Sluice Valve
- Electromagnetic Flowmeters
- Non-Return Valve
- Pressure Transmitter
- Internal Lighting and Area Lighting
- Electrical Panel
- 40 KVA 30KW DG set

C.3. COMMON EFFLUENT TREATMENT PLANT (CETP) & SEWAGE TREATMENT PLANT (STP)

a) Common Effluent Treatment Plant (CETP)

The treatment process in CETP designed for automobile industries include pre-treatment, primary treatment, secondary treatment, and tertiary treatment so that the treated effluent can be reused. These treatment processes are briefed below:

- Pre-treatment: It involves physical process such as screening or grit chamber to remove floatable solids in raw effluent before they cause damage to pumps, and other equipment of the plant. It also consists of oil and grease trap to remove floatable oil and grease from automobile effluent.
- Primary Treatment: Pre-treated wastewater now enters primary tank which includes chemical process (which involves coagulation, flocculation, and neutralization). Here, heavy solids settle down to the bottom while oil, grease and other lighter solids float to the surface are skimmed off. The settled solids are called as primary sludge and the remaining liquid wastewater is subjected to next treatment level.
- Secondary Treatment: This treatment involves biological process and removes about 90% of BOD and COD. Biological process can be aerobic or anaerobic depending on the quality of the effluent. But most of the ETBs use aerated sludge process (aerobic process) for effective treatment of wastewater. It removes dissolved and suspended biological matter. However certain advanced treatment methods such as sequencing batch reactor (SBR), Dissolved air floatation (DAF), Fluidized bed reactor (FBR), Membrane Bio reactor (MBR), etc. may also be used to reduce the plant footprint while also eliminating the need for a separate primary treatment step. Further, the use of MBR could also eliminate the need for a separate tertiary treatment.
- Tertiary Treatment: Considering that the treated wastewater is to be reused for the purpose of horticulture and industrial process water it is essential to have a tertiary treatment process. This could include processes such as dual media filter (sand + activated carbon) and/or other membrane-based processes to achieve the desired treatment standard. A final disinfection of treated wastewater may be done by using chlorine, ozone, or UV light.

The selection of technology for CETP for handling effluent from automobile units is based on influent characteristics, effluent characteristics, land availability and techno-economic viability. During the treatment process, sludge will be generated which is hazardous in nature and need disposal at dedicated hazardous waste disposal facility. The nearest facility is Bharat Oil and Waste Management Ltd., Roorkee.

The major facilities/units proposed in the CETP include:

Civil Units	Electro-Mechanical units
Collection chamber	Air Grids in Equalization tank
Screen chamber (Coarse and fine)	

Oil and grease trap	Air Blower for Equalization tank and Filter backwash
Equalization tank	pH Correction dosing system
Float Settler Platform	Advanced Pipe flocculator for Primary Float settler
Advanced Oxidation Feed tank	Dosing system for Floatsettler
Bio feed tank (Advanced attached growth biological system)	Float Settler System
Bio tank	Sludge Transfer Pump
Secondary Float Settler Platform	Advanced Oxidation system
High-rate media filter feed tank	Pump house
RO feed tanks (1,2,3,4,5)	Feed Pumps
Treated water tank	Bio Feed pumps
Sludge Pit	Bio film
Additional Civil works	Air Blower for Bio tank
Other civil works - internal roads, compound wall, transformer room, security cabin, etc.	Nutrient dosing system
	Advanced Pipe flocculator for Secondary float settler
	Dosing system for Secondary Float settler
	Secondary Float Settler System
	Sludge Transfer Pump
	Filter Feed pumps
	Filter
	Filter Backwash pumps
	RO skids (1,2,3,4,5)
	Advanced Evaporation system
	Belt Press Feed pumps
	Belt Press
	De-water poly dosing system
	Interconnecting Piping
	MCC & Control panel
	Instruments
	Miscellaneous – DG set, cable trays, transformer, etc.

b) Sewage Treatment Plant (STP):

Domestic sewage generated from the residential areas, and from domestic activities in commercial, utilities/ public, and industrial land use areas are considered for the project. The domestic sewage which largely contains organic loads and microbes/ pathogens, is proposed to be treated through any aerobic biological treatment process followed by tertiary treatment for reuse. The sewage treatment process is designed keeping in view of the inlet parameters of the sewage generated from the facility. The proposed capacity of STP is 1 MLD. The treatment process for domestic sewage at STP include:

- Preliminary treatment: It involves physical process such as screening and/or grit chamber to remove floatable solids in raw sewage before they cause damage to pumps and other equipment of the plant. It may also consist of oil and grease trap to remove any floatable material.

- **Primary Treatment:** Pre-treated wastewater now enters primary tank which includes physical process of primary sedimentation. Here, heavy solids sludge settles down to the bottom which may be removed for further sludge treatment. The settled solids are called as primary sludge and the remaining liquid wastewater is subjected to next treatment level. The primary treatment removes about 30% of organic load (BOD).
- **Secondary Treatment:** This treatment involves biological process and removes about 90% of BOD and COD. Biological process can be aerobic or anaerobic depending on the quality of the effluent and process chosen. But most of the ETP's use the conventional aerated sludge process (aerobic process) for effective treatment of wastewater. It removes dissolved and suspended biological matter. However certain advanced treatment methods such as sequencing batch reactor (SBR), Dissolved air floatation (DAF), Fluidised bed reactor (FBR), Membrane Bio reactor (MBR), etc may also be used to reduce the plant footprint while also eliminating the need for a separate primary treatment step. Further, the use of MBR could also eliminate the need for a separate tertiary treatment.
- **Tertiary Treatment:** Considering that the treated wastewater is to be reused for the purpose of horticulture and industrial process water it is essential to have a tertiary treatment process. This could include processes such as dual media filter (sand + activated carbon) and/or other membrane-based processes to achieve the desired treatment standard. A final disinfection of treated wastewater is done by using chlorine, ozone, or UV light.

The major facilities/units proposed in the STP include:

Civil Units	Electro-Mechanical units
Collection chamber	Pump house
Screen chamber (Coarse and fine)	Feed Pumps
Grit removal system	ASBR internals (blowers)
ASBR tank	Chlorine dosing system
Chlorine contact tank	Screw press feed pump
Sludge collection pit	Screw press
Other civil works - internal roads, compound wall, transformer room, security cabin, etc.	Dewater poly dosing system
	Interconnecting Piping
	MCC & Control panel
	Instruments
	Miscellaneous – DG set, cable trays, transformer, etc.

C.4. TRUCK TERMINAL

v. The Truck terminal having the following facilities:

1. Truck Service & Repair shops,
2. Weigh Bridge,
3. Dormitory & Eating Places,
4. 2-3 Nos Toilet complexes,
5. 2-3 Nos Shops/ Eating Places and
6. Office building.
7. 7-meter-wide Road
8. Parking
9. Power and Water supply
10. Wastewater system
11. Storm water management
12. Firefighting system
13. CCTV system

SECTION–D (SPECIFICATIONS AND STANDARDS)

(Refer Clause 9)

1 Construction

The Contractor shall comply with the Specifications and Standards set forth in Annex-I of this Section-D for construction of the Project.

2 Specification and Standards

- i. Specifications and Standards for “Roads, Bridges, Culverts, Structures and Miscellaneous Works” are given in Section- D1
- ii. Specifications and Standards for “Wet-Utilities” are given in Section- D2
- iii. Specifications and Standards for “CETP and STP” are given in Section- D3
- iv. Specifications and Standards for “Power” are given in Section- D4
- v. Specifications and Standards for “Truck Terminal, Boundary Wall and Entrance Gate” are given in Section- D6

(Section-D)

Specifications and Standards for Construction

1. Specifications and Standards

Where the specification for a work is not given, Good Industry Practice shall be adopted to the satisfaction of the Independent Engineer.

2. Deviations from the Specifications and Standards

- 2.1 The terms “Concessionaire”, “Independent Engineer” and “Concession Agreement” used in the Manual shall be deemed to be substituted by the terms “Contractor”, “Independent Engineer” and “Contract Agreement” respectively.

Particular Technical Specifications

D.1. ROADS

ROADS, BRIDGES, CULVERTS, STRUCTURES AND MISCELLANEOUS WORKS

- 1.0** Specifications and Standards of roads, bridges, culverts, structures and miscellaneous works are given in this section;
- 1.1** The Codes, Standards and Technical Specifications applicable for the design and construction are as given under;
- i. Indian Roads Congress (IRC) Specifications, Standards, Design Codes
 - ii. IRC Special Publications
 - iii. Ministry of Surface Transport Publications (The terms 'Ministry of Surface Transport', 'Ministry of Shipping, Road Transport & Highways' and 'Ministry of Road Transport and Highways' or any successor or substitute thereof shall be considered as synonymous).
 - iv. Two lane, Four lane and Six Lane Manuals i.e. IRC: SP-73, IRC: SP-84, IRC: SP-87 as per the cross section of road
 - v. **Any supplement issued with the bid document**
- Latest version of the Codes, Standards, Specifications, etc., notified/published at least 60 days before the last date of bid submission shall be considered applicable.

1.2 Where the Contractor intends to use an alternative to these Standards/Guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

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

- I. American Association of State Highway and Transportation Officials (AASHTO)
- II. American Society for Testing of Materials (ASTM)
- III. Euro Codes
- IV. National Standards of any of the following countries: United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, Netherlands, Spain, Australia, New Zealand, Japan and South Africa

In case the Contractor intends to use any alternative material/technology/method, whether patented or otherwise, that is not specifically covered in the Indian or International Standards as listed above, but the use of which has been permitted on similar projects (similar in category of road, traffic and climatic conditions) as the Project Road, he would be permitted, its use on certification by the owners of such similar projects regarding the continued successful performance of such materials, technologies, methods, procedures or processes for at-least 5 years of the service life of the project. Such a certification shall be supported with details of critical performance parameters.

1.3 Standards and Specifications for Construction

The Contractor shall comply with the Standards and Specifications for Construction as given below;

All materials, works and construction operations shall conform to the "Specifications for Road and Bridge Works (Fifth Revision, April 2013)", issued by the Ministry of Road Transport & Highways (MoRT&H), Government of India and published by the Indian Roads Congress. Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

1.4 List of Standards

List of Standards are given in Table D-1

Table D-1: Roads, Bridges, Culverts, Structures and Miscellaneous Works

S. No.	Description	Code/Document No.
1.	Dimensions and weights of Road Design Vehicles	IRC:3-1983
2.	Recommended Practice for the Design and Layout of Cycle Tracks	IRC:11-2015
3.	Standard for vertical and horizontal clearances of Overhead electric power and telecommunication lines as related to roads	IRC:32-1969
4.	Code of Practice for Road Markings (with Paints) (First Revision)	IRC:35-2015
5.	Tentative Guidelines for the Design of Flexible Pavements	IRC:37 -2012
6.	Guidelines for the design of curves for Highways & Design tables (First Revision)	IRC:38-1988
7.	Lateral and Vertical Clearances at Underpasses for Vehicular Traffic	IRC:54-1974
8.	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)	IRC:56-2011
9.	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Third Revision)	IRC:58 -2011
10.	Recommended Practice for Traffic Rotaries	IRC:65-1976
11.	Code of Practice for Road Signs (Third Revision)	IRC:67-2012
12.	Space Standards for Roads in Urban Areas	IRC:69-1977
13.	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas	IRC:70-1977
14.	Guidelines for the Design of High Embankments	IRC:75-1979

S. No.	Description	Code/Document No.
15.	Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways	IRC:80-1981
16.	Geometric Design Standards for Urban Roads in Plains	IRC:86-1983
17.	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)	IRC:89 - 1997
18.	Guidelines for the Design of Interchanges in Urban Areas	IRC:92-1985
19.	Guidelines on Design and Installation of Road Traffic Signals	IRC: 93-1985
20.	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (Second Revision)	IRC:98-2011
21.	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads	IRC:99-1988
22.	Guidelines for Pedestrian Facilities	IRC:103-2012
23.	Guidelines for Capacity of Urban Roads in Plain Areas	IRC:106-1990
24.	Code of Practice for Concrete Road Bridges	IRC : 112 -2011
25.	Tentative Recommendations on the Provision of Parking Spaces for Urban Areas	IRC:SP:12-1973
26.	Vertical Curves for Highways	IRC:SP:23-1983
27.	New Traffic Signs	IRC:SP:31-1992
28.	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas	IRC:SP:41-1994
2.	Highway Safety Code	IRC:SP:44-1996
30.	Guidelines on Urban Drainage	IRC:SP:50-2013
31.	State-of-the-Art-Report: Lime-Soil Stabilization	HRB SR.No.1,2000
32.	State-of-the-Art-Report: Compaction of Earthwork and Subgrades	HRB SR No.3,1999
33.	State-of-the-Art-Report: High Embankments on Soft Ground, Part B – Ground Improvement	HRB SR No.14,1994

Annexure I (A) – Special Provisions to the "Specifications for Road and Bridge Works (5th Revision, April 2013)"

(Section-D)

Specifications and Standards

Special Provisions to the "Specifications for Road and Bridge Works (5th Revision, April 2013)", issued by the Ministry of Road Transport & Highways (MoRTH), Government of India and published by the Indian Roads Congress

1.0 Special Provisions

The Special Provisions are an amplification of the "Specifications for Road and Bridge Works (Fifth Revision, April 2013)", issued by the Ministry of Road Transport & Highways (MoRTH), Government of India and published by the Indian Roads Congress and contain provisions in respect of items of work not covered by or at variance with the Standard Specifications.

The Special Provisions contained herein shall be read in conjunction with the other Bidding Documents. These Provisions cover the items of civil and non-civil works coming under scope of this document. All work shall be carried out in conformity with the same. The works shall be executed in accordance with industry good practices followed for achieving high standards of workmanship, thus ensuring safety and durability of the construction. All codes and standards referred to in these specifications shall be the latest thereof, unless otherwise stated.

Where there is any ambiguity or discrepancy between the Special Provisions and the Standard Specifications, the requirements of Special Provisions shall prevail.

Clause numbers herein correspond with the numbers, if any, in the Standard Specifications. The numbering of new clauses is continuous with related clauses in the Standard Specifications.

The attention of the contractor is drawn to those clauses of codes which require supporting specification either by the Employer's Engineer or by 'Mutual agreement between the Contractor and the Employer's Engineer. In such cases, it is the responsibility of the Contractor to seek clarification on any uncertainty and obtain prior approval of the Employer's Engineer before taking up the supply/construction. In the absence of such prior clarification, the Employer's Engineer choice/design will be final and binding on the contractor without entitling the contractor for any additional payment.

1.1 Specification related to exposure condition shall be adopted Very Severe.

1.2 Defective Works

All defective works are liable to be demolished, rebuilt and defective materials replaced by the contractor at his own cost. In the event of such works being accepted by carrying out repairs etc., as specified by the Employer's Engineer, the cost of repairs will be borne by the contractor.

1.3 Site Information

The information given hereunder and provided elsewhere in these documents is given in good faith by the Employer but the Contractor shall satisfy himself regarding all aspects of site conditions and no claim will be entertained on the plea that the information supplied by the Employer is erroneous or insufficient.

1.4 SECTION 100: GENERAL

vi. Clause 105: Scope of Work - Shall be read as

Under this Agreement, the scope of the Work (the "Scope of the Project") shall mean and include:

- (a) Design and Construction of the Project components on the Site set forth in Section-A and as specified in Section-B together with provision of Project Facilities as specified in Section-C, and in conformity with the Specifications and Standards set forth in Section-D.
- (b) Maintenance of the Project components in accordance with the provisions of this Agreement and in conformity with the requirements set forth in Section-E; and

- (c) Performance and fulfilment of all other obligations of the Contractor in accordance with the provisions of this Agreement and matters incidental thereto or necessary for the performance of any or all of the obligations of the Contractor under this Agreement.

2.1 Clause 107: Contract Drawings Sub clause 107.1: Shall be read as

Design and Drawings shall be developed in conformity with the Specifications and Standards set forth in Section-D. In the event, the Contractor requires any relaxation in design standards due to restricted Right of Way in any section, the alternative design criteria for such section shall be provided for review of the Employer's Engineer.

2.2 Clause 108: Site Information

Sub-Clause 108.4: Clause added and shall be read as follows:

The Contractor shall identify quarries; borrow areas and other sources of materials required for the work. Contractor shall satisfy himself that the required materials are available in adequate quantities and complying with the requirements of specifications. No claims shall be entertained on account of non-availability of materials and increase in leads etc.

It is the sole responsibility of the Contractor to arrange the quarries, borrow areas etc., on license / lease basis or otherwise, and study in detail before tendering, the scope of taking the quarry on lease. Advance information must be collected by the contractor regarding the procedure laid down and the consequent delay in arranging the quarries on lease and must make alternative arrangement to procure the quarry products from lease holders. No separate payment will be made for arranging such quarries, borrow areas, etc."

2.3 Clause 109: Setting Out

Sub-Clause 109.7: Delete the 2nd paragraph last sentences

2.4 Clause 110: Encumbrances in Construction Area, Including Trees and Utilities Sub-Clause 110.7 Delete the Sub-clause 110.7 and shall be read as following:

The contractor may be required to carry out the removal or shifting of certain services/ utilities on specific orders from the Employer's Engineer. However for coordinating the work of cutting of trees and removal of encroachments etc. No separate payment to the contractor will be made and these will be incidental to the work.

2.5 Clause 113: General Rules for the Measurement of Works for Payment Clause 113: shall be read as follows:

All payments and measurements shall be as per Section H.

2.6 Clause 114: scope of rates for different items of work

Clause 114: shall be read as follows:

All payments and measurements shall be as per Section H.

2.7 SECTION 400: SUB BASES, BASES (NON BITUMINOUS) AND SHOULDERS

2.8 Clause 401: Granular Sub Base

Sub-Clause 401.2: Materials

Sub-clause 401.2.1: Para 1 of this clause shall be read as under:

"The material shall be free from organic or other deleterious constituents and conform to the Grading 1 given in Table 400- 1 with the percentage passing 0.075mm size restricted to 5%. The portion of the total aggregate passing 4.75 mm sieve shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS: 2720 (Part – 37)." *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*

Sub-Clause 401.2.2: Physical Requirements Add at the end of this clause as under:

“The Contractor shall, at least 21 working days before the commencement of the construction of the sub-base course, submit to the Employer’s Engineer, the sub-base material test results for approval of the laboratory testing on the physical properties defined above. The construction of the sub-base course shall be taken up only upon the Employer’s Engineer approval of the material.”

2.9 SECTION 500: BASE AND SURFACE COURSES (BITUMINOUS)

Sub-Clause 501.2: Materials

Sub-Clause 501.2.1: Binder

Replace the selection criteria for viscosity grade bitumen by adopted Viscosity-Grade shall be VG-30 as per IS: 73 – 2013 or latest revision.

2.10 Clause 505: Dense Graded Bituminous Macadam

Sub-Clause 505.2.1: Bitumen

Delete words “indicated in Table 500-10” and insert “grade of VG-30” in 3rd and 4th line.

Sub-Clause 505.2.5: Aggregates grading and binder content Add following between first and second sentence:

“Grading-I shall be used for compacted thickness of a layer of 75 mm and above while Grading-2 shall be used for compacted thickness of a layer of less than 75 mm thickness. The Contractor shall give job mix formula for the mix design indicating mix properties. The laying of mix shall be done after approval of the Employer’s Engineer.”

In Table: 500-10, the following may be substituted:

Grading	1	2
Layer Thickness	75mm to 100mm	50-75mm
Bitumen grade	VG-30	VG-30
Bitumen content % by mass of total mix	Min.4%	Min.4.5%

Sub Clause 505.3: Mixture Design

Sub-Clause 505.3.1: Requirement for the Mixture

Add the following requirements to the list of Table 500-11:

Water sensitivity (ASTM D1075): Retained stability (Ratio of Marshal Stability for 24 h Immersion and 30min Immersion in water at 60-degree centigrade temperature)

= not less than 75 %.

Stability to flow ratio = 205 to 410 Filler- Bitumen ratio = 0.6 to 1.2

Sub-Clause 505.3.3: Insert the following paragraph between the existing paragraphs 3 & 4:

Mixed design shall be carried out in accordance with the modified Marshal method described in Asphalt Institute Manual MS-2.”

Add the following at the end of clause:

The job-mix grading shall be within the limit stated in sub clause 507.2.5 and the bitumen content shall be determined by carrying out a series of Marshall Stability tests as per AASHTO: T 245 and durability test as per ASTM D 1075 and satisfying the following criteria:

- No. of blows each end =112
- Minimum stability (kN at 60°C) =18.0
- Minimum flow (mm) =3.0
- Marshall quotient (kN/mm) =6.0 min
- Air voids in total mix (%) =3-5
- Voids in mineral aggregate filled with bitumen (%) =65-75
- Loss of Marshall Stability by submerging Specimens in water at 60°C for 24 hrs.

as compared to stability measured after Submersion in water at 60°C for 30-40 minutes =25 percent max

- Air voids at refusal density (300 blows at each end of Marshall Specimen at Optimum Binder Content) =3% min.

2.11 Clause 510: Open-Graded Premix Surfacing

Sub-Clause 510.1.2.1: Delete the words “suitable grade as specified in contract or as directed by the Engineer” and insert “Viscosity Grade VG-30”

2.12 SECTION 800: TRAFFIC SIGNS, MARKINGS & OTHER ROAD APPURTENANCES

2.13 Clause 802: Overhead Signs

Sub-Clause 802.1: General Add at the end of the Clause:

“The locations of cantilever overhead and overhead signs (Gantry type) shall be decided by the Employer’s Engineer.”

Sub-Clause 802.4: Materials for Overhead Sign and Support Structures

Sub- Clause 802.4.2: The last line of this clause “they shall IS Specifications” shall read as

“They shall be thoroughly descaled, cleaned, primed along with all other components of signs, except reflective portion. They shall be painted with two coats of epoxy paint. The sign back side shall be painted with grey color and post shall be painted in black & white alternate bands. The post below ground shall be painted with three coats of red lead paint.”

Sub- Clause 802.4.3: Replace “1.5mm” with 2.0mm” in the fifth line.

2.14 Clause 803: Road Markings

Sub-Clause 803.2: Materials, this clause shall read as under:

“Road markings shall be hot applied thermoplastic compound and the materials shall meet the requirements as specified in Clause 803.4. The thermoplastic material shall be factory mixed, from a manufacturer approved by the Employer’s Engineer, and shall be of a tropical grade suitable for application, by the means proposed, to the specified road surfaces.

The road markings shall be laid in one layer with appropriate road marking machine approved by the Employer’s Engineer. Before the road-marking machine is used on the permanent works, the satisfactory working of the machine shall be demonstrated on a suitable site, which is not part of the permanent works. The rate of application shall be checked and adjusted as necessary before application on a large scale is commenced, and thereafter daily.”

Sub-Clause 803.3: Ordinary Road Marking Paint This Clause shall be deleted.

Sub-Clause 803.6: Application

Sub-Clause 803.6.4: Substitute 250gm by 350gms in the last line of this sub-clause

2.15 Clause 805: Distance Indicator Post

Sub-Clause 805.3: The first sentence of this clause shall be read as under:

“The hectometer/kilometer stones shall be made of concrete of grade as shown in the drawing.”

2.16 Clause 806 Road Delineators

Sub-Clause 806.2: This clause shall be substituted as follows:

The delineators shall conform to Recommended Practice for road Delineators, IRC: 79.

- a) Roadway Indicators shall be 1000mm high made with 100 mm dia. NB medium weight MS pipe. One reflector of high intensity grade retro reflective sheeting with encapsulated lens shall be provided on

top of the reflector. The white & red reflector shall be provided alternatively of 40mm width, so that total width of reflector shall be 120mm. A wire mesh cover of 150mm height shall be provided on top or as shown in the drawings.

- b) Rectangular hazard marker 600mm x 300mm made out of 2mm thick aluminium sheet, face to be fully covered by high intensity grade white retro reflective sheeting of encapsulated lens type. The background/ border/ symbols shall be made by screen-printing of desired colour as per sign details. The sign plate shall be fixed with 6mm dia. aluminium rivets on MS angle iron frame. The angle iron frame shall be made with angle of size 40mm x 40mm x 5mm. The sign shall be fixed to 80mm dia. (NB-MW) MS pipe or as shown in the drawings.
- c) Triangular Object Marker shall be 300mm side with four red reflectors, made out of 2mm thick aluminium sheet, face to be fully covered by high intensity grade white retro reflective sheeting of encapsulated lens type as per clause 801. The background/ border/ symbols shall be made by screen-printing of desired colour as per sign details. The sign plate shall be fixed with 6mm dia. aluminium rivets on MS angle iron frame. The angle iron frame shall be made with angle of size 40mmx40mmx5mm. The sign shall be fixed with nut-bolts & welding on MS pipe 50mm dia. (NB-MW) and 500mm high or as shown in the drawings. All components of signs & supports shall be thoroughly descaled, cleaned, primed and painted with two coats of epoxy paint. The sign backside shall be with grey colour and post shall be white colour/ alternate white & black bands. The post below ground shall be painted with three coats of red lead.

2.17 SECTION 1600: STEEL REINFORCEMENT (UN-TENSIONED)

2.18 Clause 1602: General

Paragraph 2 of Clause 1602 shall read as follows:

“Reinforcements shall be Thermo Mechanically Treated (TMT) deformed bars of grade Fe 500 conforming to IS: 1786. Only epoxy coated steel shall be used as reinforcement unless specified”.

2.19 7.0 SECTION 2100: Open Foundations

Sub-Clause 2104.3: ii) Substitute M10 by M15 of this sub-clause.

D.2. WET-UTILITIES

2. Earth Work

2.1. General

The conditions/specifications laid down hereunder will hold good whether the excavation is to be carried out over areas for levelling, foundations of structures, trenches for pipes or cables or any other type of work which involves earth work like levelling or forming/embankments etc. as per CPWD specifications/ Uttarakhand PWD specifications.

- i. Earthwork in excavation includes site-clearing activities like removal of shrubs, loose stones, and rubbish of all kinds, interfering with the works and with complete removal of roots.
- ii. The products of the above clearing operations shall be removed from the site, dumped, stacked at a place or places, burnt or otherwise disposed of as directed by the Engineer with in the compound.
- iii. A permanent base line and cross lines shall be established to serve as reference grid using MS plates, pegs, pins set in concrete or brick masonry pillars where they will be free from disturbances.
- iv. A permanent bench mark or marks as required necessary for the works connected to the nearest GTS benchmark shall be established for reference.
- v. Excavation shall be carried out in all types of soil like top soil, silt, sand, gravel, soft murram, clay, kanker, hard materials like disintegrated rock shale which can be removed by picks, crow bars and showels. Soil/earths may contain boulders. Loosening of rocks include the other methods of excavation other than blasting such as chiselling, wedging line drilling to avoid shattering of rock. The

Engineer shall decide what method shall be adopted for removal of the hard rock (*50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures*).

- vi. All excavation shall be strictly done true to line, level, grade or slope as the case may be for the respective structure as shown in the drawings/directed by the Engineer.
- vii. Sides and bottoms of excavation shall be cut sharp and true. Under cutting shall not be permitted. Earth sides of excavation shall not be used in lieu of formwork for placement of concrete unless authorised in special cases, by the Engineer where limitation of space for larger excavation necessitates such decision.
- viii. Excavation, whose sides are required to be maintained at a steeper slope than the stable slopes, will be required to be properly stored and strutted failing which the Contractor will be required to execute the work by open cutting by the approval of Engineer.
- ix. Negligence on account of this leading to any mishap will be entirely the responsibility of the Contractor.
- x. All surplus soil/earth shall be transported and disposed off as directed by the Engineer. The rates quoted by the Contractor shall be deemed to be inclusive of all such works.

2.2. Drainage in the vicinity of Excavation

- i. The Contractor shall control the drainage in the vicinity of all Excavation so that the surface of the ground will be properly sloped to prevent surface water running into excavated areas during construction. Arrangements shall be made for preventing rain and other extraneous liquids entering the excavated parts. Seepage water shall be directed to flow away from the trenches by gravity. If any pumping is required to keep the trench and the exposed areas dry for further work the same shall be done by the Contractor at his own expenses.
- ii. The rates quoted by the Contractor shall be deemed to be inclusive of all the above costs or charges for stipulations stated above.
- iii. Excavated material shall not be deposited within 0.6 meters from the top edge of the excavation.
- iv. The Contractor shall remove the excavated material to spoil heaps on the site transport the same to a place as directed by the Engineer.
- v. If the bottom of the excavation is left exposed by the Contractor and in the opinion of the Engineer, it has become deleteriously affected by atmospheric changes or affected by water then the Contractor shall remove at his own cost such portions of the affected foundations and shall make good by filling with lean concrete or with compacted sand as directed by the Engineer.
- vi. Where Excavation is made in excess of the depths required as shown in the drawings or as directed by the Engineer the Contractor shall at his own expense fill up to the required level with lean concrete or well compacted sand as decided by the Engineer (*50:50 ratio of River sand and crusher/Robo Sand is proposed*).
- vii. Loose, soft or bad soil encountered in Excavation at the required depth on Engineer's directions shall be excavated to the firm bed and the difference of levels between the required level and the firm bed shall be filled up or dealt with as directed by the Engineer.
- viii. Any obstacle encountered during excavation shall be reported immediately to the Engineer and shall be dealt with as instructed by him. Same shall be applicable for any antiques/treasure found during Excavation.
- ix. Any public utility services/facilities like water supply lines, sewers, telephone/electric cables poles etc., met with during Excavation shall not be damaged and no disruption is caused to the utility service on account of damages caused by the Contractor. Such facilities shall be properly supported in their original positions by giving slings, suspension beams etc. at Contractors own expenses.
- x. The Contractor shall undertake any concreting or construction work of any nature on the excavated surfaces in the presence of Engineer.
- xi. The Contractor shall be solely responsible for the protection of adjoining properties from damages that may be on account of excavation close to the properties whether the property belongs to government or to a private party.

- xii. The Contractor shall make all arrangements for proper warnings like providing fences, danger flags, barricading, night warning lights, watch and ward etc., to caution the public as well as the labourers engaged by him about the dangers that may be involved by excavation of trenches, pits, foundations etc. Safety code for excavation work IS: 3764-1966 shall be rigidly followed unless instructed otherwise by the Engineer.
- xiii. Any useful material obtained during Excavation shall be stacked as directed by the Engineer and will be the property of the department. The decision of the Engineer in this regard shall be final and binding on the Contractor.
- xiv. Any material used by the Contractor out of the excavated stuff in lieu of his own materials shall be charged to the Contractor at the market rates as decided by Engineer.
- xv. The rates quoted shall include back filling of excavated material & disposal of surplus earth as directed by the Engineer.

2.3. Excavation in Trenches

- i. Excavation as required for manholes, other overflow structures, cross drainage works, extra depths for joints of pipes shall be carried out as shown in the drawings/directed by the Engineer.
- ii. For deep foundations, necessary shoring and strutting shall be executed as directed by the Engineer. If additional slopes are to be provided where vertical cuts are not possible the same shall be executed without any additional cost. The rates quoted shall be deemed to be inclusive of all such extra work.
- iii. The trench shall be kept perfectly dry by preventing the extraneous water entering the pits and also wherever necessary by pumping at the cost of the Contractor. No additional cost of dewatering shall be payable.
- iv. The trenches after laying, jointing and testing of pipes/cables are to be back filled. The trenches shall be filled with the excavated material as directed by the Engineer.
- v. All surplus soil/earth shall be transported and disposed of as directed by the Engineer. The back filling shall be done very carefully so as not to damage the pipe/cables or disturb the alignments/levels of the pipe / cables. The back filling shall be done in layers on both sides of the pipes, watered, and consolidated by ramming to a dense layer. The thickness of each layer shall not be more than 15 cm. Special care shall be taken to avoid unequal pressures and not to disturb the pipe.
- vi. In case the excavated material falls short of requirement the backfill soil/earth shall be taken from borrow pits approved by the Engineer. The rates quoted by the Contractor shall be deemed to be inclusive of all such works.
- vii. Sight rails and boning rods are to be used at regular intervals as directed by the Engineer to excavate the trenches true to line and grade.

2.4. Back Filling / Earth Filling

- i. Back filling of earth around liquid retaining structures and pipes shall be done only after the water-tightness test is done to the satisfaction of the Engineer. Chosen earth out of the excavated earth shall be used for backfilling/embankments.
- ii. Care shall be taken to see that unsuitable soil/earth does not get mixed up with the material proposed to be used for filling.
- iii. The soil/earth to be used for back-filling shall have the prior approval of the Engineer.
- iv. Backfill shall be placed in successive horizontal layers of loose material not more than 15 cm thick. The material shall be brought to within + or -2% of the optimum moisture content as described in IS:2720 (part VIII) after adjusting the moisture content, the layers shall be thoroughly compacted with such equipment as may be required to obtain a density equal to or greater than 95% of Procter density.
- v. Successive layers of filling shall not be placed until the layer under construction has been thoroughly compacted to satisfy the requirements laid down in the requirements.

2.5. Filling and Embankment

- i. The area where filling or embankment is to be carried out shall be cleared from loose material and the virgin soil shall be exposed. All shrubs and vegetation with roots are cleared. All soft patches shall be removed and filled with selected soil/earth and consolidated. Exposed soil/earth shall be consolidated properly to obtain 95% of maximum laboratory dry density of the soil.

- ii. Approved filling material shall be uniformly spread in layers not exceeding 15 cm in loose depth. All clods, lumps, etc. shall be broken before consolidation.
- iii. Successive layers of filling shall not be placed until the layer under construction has been thoroughly compacted to satisfy the requirements laid down in these specifications.
- iv. The Contractor shall give the samples of the earth he proposes to use for back filling for testing, if required or directed by the Engineer along with the following characteristics of the soil/earth.
- v. Soil/earth having laboratory maximum dry density of less than 1500 kg per cubic meter shall not be used.
- vi. If the layer fails to meet the required density it shall be reworked or the materials shall be replaced and method of compaction altered as directed by the Engineer to obtain the required density.
- vii. If any test indicates less than the specified degree of compaction, the Engineer may require all the fill placed subsequent to the latest successfully tests to be removed and compacted and compaction procedure to be done once again to obtain satisfactory density.
- viii. The Contractor shall perform all necessary tests to determine optimum moisture content and the degree of compaction. He shall furnish the results to the Engineer.
- ix. Prior to rolling the moisture content of the material shall be brought to within + or - 2% of the optimum moisture content as described in IS: 2720 (part VIII). The moisture content shall preferably be on the wet side for potentially expansive soil/earth. After adjusting the moisture content as described in this clause, the layers shall be thoroughly compacted by means of rollers till 95% of Procter Density.
- x. If the layer fails to meet the required density it shall be reworked or the materials shall be replaced and method of compaction altered as directed by the Engineer to obtain the required density.
- xi. The embankment shall be finished to the alignment levels and grades, cross sections, dimensions shown in the drawings or as directed.
- xii. If sand filling is specified in the tender for filling the trenches, plinth or foundations the sand used shall be hard, free from inorganic materials and deleterious materials and approved by the Engineer. Filling shall be carried out in layers not exceeding 15 cm in loose depth and flooded and tamped till it meets the approval of the Engineer. *(50:50 ratio of River sand and crusher/Robo Sand is proposed)*
- xiii. The Contractor shall perform all necessary tests to determine optimum moisture content and the degree of compaction. He shall furnish the results to the Engineer.

2.6. Shoring / Strutting / Timbering

- i. When the depth of foundation or pipe trench is deep and the soil/earth is soft and generally for depths more than 1.5 m. stepping, sloping and or paneling and strutting of sides shall be done as directed by the Engineer. The decisions regarding the positions and depths at which and what type of precautions are to be provided shall be decided by the Engineer.
- ii. It shall be the responsibility of the Contractor to take all necessary precautions or steps to prevent the sides of trenches from collapse. The Contractor shall be responsible to make good any losses or damages caused to execute works, life and property due to his negligence.
- iii. Deep Excavation shall be inspected after every rain, storm, or other hazards and if necessary the precautions required shall be augmented.
- iv. Planking and strutting shall be either "Close" or "Open" type depending upon the nature of the soil/earth surcharge and depth of excavation etc.
- v. The timbering shall be of sufficient strength to resist earth pressure and ensure safety to the adjoining property and to persons. Where the Excavation is subjected to vibrations due to machinery, vehicles, rail traffic, blasting and other sources, additional bracings shall be provided.
- vi. Generally, the specifications and sizes and spacing of sheeting, Waters and struts used for timbering of different depths shall be as given in the IS:3764- 1965 Safety code for excavation work unless otherwise specified in the tender elsewhere. Shoring shall extend 30 cm above the vertical sides.
- vii. Withdrawal of timbering shall be done very carefully to prevent collapse of the sides of Excavation and any damage to the work executed.
- viii. Timbering will be provided in the trenches as per CPWD specifications.

2.7. Measurements

- i. Wherever possible, the excavation, back filling and timbering works shall be done for piping and manhole works with reference to the existing ground level. This shall be done before filling for the road works. The filling above the existing ground level shall be considered under road works
- ii. Measurement for excavation of pipe trenches shall be made per cum. For all class of soil. No extra payment shall be made for consolidation, disposal of extra earth within a lead of 200m, stepping (excavation in steps), pumping and bailing out water in saturated soil, pumping out surface water from rain falls or broken pipes etc.

3. Potable and Recycled Water Supply Network

3.1. General Requirements

Specifications for additional specialized items shall be adopted as stipulated in this section. For items that are not covered in the following sections, the relevant standards issued by BIS, PWD Uttarakhand, CPWD, International standards and good engineering practices shall be referred. The Technical Standards consist of Technical Specification to be followed during Construction of Sewerage Network / Water Supply and other ancillary/ allied works for all Civil and Mechanical required to be executed under this Contract. Notwithstanding the said Specifications, the Contractor shall adopt and follow necessary standards and approved Codes /specification wherever required for fulfilment of all the works under this contract.

Following general guidelines shall be followed by the selected Contractor:

- i. All materials shall be new of the best quality conforming to specifications and subject to the approval of the Engineer.
- ii. All lines shall be laid to the required gradients and profiles.
- iii. All works shall be done in accordance with the local bye laws and CPWD standards.
- iv. Location of all manholes, valve chambers catch basins etc., shall be got confirmed by the Contractor from the Engineer before the actual execution of work at site.
- v. All works shall be executed as directed by Engineer.
- vi. Setting up of suitably equipped/manned field offices for supervision of the works for the Contractor's staff and the Employer.
- vii. Development of suitable storage spaces for construction material and equipment to be received for the works.
- viii. Identification of suitable quarries/sources for construction material and get them approved from the Employer.
- ix. Setting up laboratory and deploying qualified engineers/ technicians.
- x. Setting up suitable labour camps with all water and sanitation arrangements and other facilities required under the relevant labour laws.
- xi. Implementation of all the environmental and relevant social mitigation measures as required.
- xii. Making arrangements for equipment and material required for maintaining safety of the sites and the workmen on site (helmets, boots, jackets, safety belts, gloves, scaffolding, barricading, etc.)
- xiii. Submission of initial work program and updating the same every month for approval by the Employer.
- xiv. Disposal of surplus soil as directed by Employer, construction of civil components of all the units, and maintaining the construction site in orderly manner.
- xv. Manufacturing, shop testing, pre-dispatch inspection, packaging, transportation to site, providing transit insurance, storage, handling at site, installation, sectional testing, pre-commissioning testing, trial runs and commissioning of all components of the system including the pipes, fittings, hydraulic and mechanical equipment.
- xvi. Providing spares, tools and tackles.
- xvii. Approval of all sources of materials and equipments shall be obtained in writing from the Engineer before their use on the project.
- xviii. All the safety precautions will be taken to avoid any damage/incident.

- xix. Electric poles, telephone cables, trees etc. should be protected with due care. The Contractor will be responsible for any damage to Electric Pole & Wires Telephone cables etc. any payment on this account, will be borne by him.
- xx. Suitable arrangement must be made for street drainage.
- xxi. There should be approach for existing buildings/facilities.
- xxii. Specification may have to be changed as per site conditions for which nothing extra will be paid.
- xxiii. All the sewer lines will be got tested by Contractor before filling. If there is any leakage or damage during execution or after commissioning, the same will be rectified by the Contractor at his own cost, loss or damage what so ever may be shall be borne by the Contractor.
- xxiv. Material defect, execution defect or other defect such as gradient etc if any on the part of the Contractor, found at later stage which could not be traced while execution due to hidden work and are not part of maintenance, will remain the responsibility of the Contractor to set right the same at his own cost though he may have taken his all dues.
- xxv. Cross-Sections of Excavation: The cross-section of excavations adopted in Estimate is not standard. Hence depending upon the nature of soil, depth of excavation and spring level, the required slope should be approved by the concerned Engineer and paid accordingly.
- xxvi. Offset in Excavation: Since, the excavation is not too deep and suitable side slope have been is proposed. Hence there is no need of providing offset in the excavation (as in such cases, sub-soil water level very near to the ground level), pumping sets can be provided at ground level. Payment should be restricted accordingly.
- xxvii. All the RCC/ DWC/ HDPE/ DI Pipes to be utilized in the work should be procured from and approved manufacturer (who has the manufacturing unit as per the laid down IS standard i.e. has the requisite BIS Certificate). Before procuring these pipes should be got tested as per the relevant IS Code.
- xxviii. Level & Gradients. While execution of the work it should be ensure that sewers have been laid as per Design Statement (approved) i.e. at proper levels and gradients.
- xxix. Execution of work. The work of laying pipeline should commence from the downstream and no gap should be maintained while laying the pipe lines.
- xxx. Commissioning of Pipes. Before commissioning the pipe line, they should be tested to confirm there is no leakage and requisite water flows in the concerned pipe line.
- xxxi. Moreover, in case of any discrepancy between specifications laid down in this document and CPWD specifications/ Uttarakhand PWD specifications/relevant IS code, the decision of the Engineer will be final & applicable.
- xxxii. Wherever reference is made to Indian Standard Specifications, the latest amendments shall be applicable.
- xxxiii. Miscellaneous
 - a) Road cutting
 - b) Road cutting of any type viz. Brick flooring, CC flooring, metal led road will be done wherever required before laying the storm water / Water Supply/sewerage lines.
 - c) Shifting of Electric and Telephone poles
 - d) Electric and telephones poles coming in the alignment of sewerage lines and causing any hindrance in the execution of the work will be got shifted by the agency from the concerned department at his level. Payment if any made to the concerned department will be reimbursed to the agency on actual receipt of the department.

xxxiv. As-built Drawings

After construction and commissioning of all civil works mentioned above, the Contractor shall submit the five complete sets of As-built Drawings along with editable soft copy. The As-built Drawings are the Detailed Engineering Drawings showing the actual details on which the Construction/Fabrication/Erection has been carried out. The Contractor shall have to obtain approval of the As-built Drawings from the Engineer.

Activity Bar Chart

The successful bidder shall submit Activity Bar Chart, giving Time Section for each activity according to priorities of Engineer. The construction activities shall be based on this Bar Chart. Whenever there is a deviation from the approved Bar chart, a revised Bar chart shall be submitted by the Contractor. During the construction duration, the updated Bar Chart shall be submitted to the Engineer from time to time.

3.2. Required Analysis of Ground Water

The contractor has to perform the following analysis of ground water upon boring on each borewell as per IS 10500 : 2012.

Sl. No.	Parameters	Unit
1	Temperature	°C
2	Colour	Hazen
3	Turbidity	NTU
4	pH	--
5	Conductivity	µS/cm
6	Total Suspended Solids	mg/l
7	Total Dissolve Solids	mg/l
8	Alkalinity as CaCO ₃	mg/l
9	Total Hardness as CaCO ₃	mg/l
10	Calcium as Ca	mg/l
11	Magnesium as Mg	mg/l
12	Sodium	mg/l
13	Potassium	mg/l
14	Bicarbonate	mg/l
15	Chloride as Cl	mg/l
16	Sulphate as SO ₄	mg/l
17	Nitrate as NO ₃	mg/l
18	Fluoride as F	mg/l
19	Phenolic compound as C ₆ H ₅ OH	mg/l
20	Cyanide	mg/l
21	Aluminum	mg/l
22	Arsenic	mg/l
23	Cadmium	mg/l
24	Chromium as Cr+6	mg/l
25	Iron	mg/l
26	Copper	mg/l
27	Lead	mg/l
28	Manganese	mg/l
29	Mercury	mg/l
30	Zinc	mg/l
31	Silica	mg/l
32	Selenium	mg/l
33	Boron	mg/l
34	Barium	mg/l
35	Nickel	mg/l
36	Molybdenum	mg/l
37	Silver	mg/l
38	Sulphide	mg/l
39	Total Phosphorus	mg/l
40	Total Nitrogen	mg/l
41	Ammonia-N	mg/l
42	Phosphate	mg/l
43	Total Coliform	MPN/100 ml

3.3. Measurements

- i. All HDPE/ RCC/ DI pipes shall be measured net when fixed correct to a centimeter including all fittings along its lengths. No allowance shall be made for the portion of pipe lengths entering the sockets of the adjacent pipes or fittings. No extra payment is made for any clamp, hanger, slotted angle, channel, nuts, and bolts.

3.4. List of Standards and Specifications

Key standards to be followed in potable and recycled water network have been listed below.

- CPHEEO Manual for Water Supply & Treatment, 1999
- SP 7 (2016): National Building Code of India, 2016
- Urban and Regional Development Plans Formulation and Implementation Guidelines, 2014
- SP-35: Handbook on Water Supply, Plumbing & Drainage, 1987
- Manual on norms and standards for environment clearance of large construction projects, MoEF
- IS 1172: Code of Basic requirements for water supply, drainage and sanitation
- IS 8329: Centrifugally Cast (spun) Ductile Iron Pressure Pipes for Water, Gas and Sewage — Specification Volume II: Technical Specifications
- IS 12288: Code of practice for laying of ductile iron
- IS 9523: Ductile iron fittings for pressure pipes for water, gas and sewerage
- IS 4984: High Density Polyethylene Pipes for Water Supply.
- The road surface box shall conform to IS 3950.
- Duck foot bend, shall conform to IS 1538 heavy duty type.
- The flange riser shall conform to IS 7181. The length of the pipe shall be as required.

3.5. HDPE Pipes

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

3.5.1. Applicable Codes

The manufacturing, testing, supplying, laying, jointing and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In Particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to.

IS:4984	High Density Polyethylene Pipes for Water Supply
IS:2530	Methods of test for polyethylene moulding materials and polyethylene compounds
IS:5382	Rubber sealing rings for gas mains, water mains and sewers. Methods for random sampling
IS: 7328	High density polyethylene materials for moulding and extrusion
IS: 7634	Laying & Jointing of Polyethylene (HDPE) Pipes
IS:9845	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with foodstuffs
IS: 10141	Positive lists of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
IS: 10146	Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water

IS 4905 1968	Methods for random sampling
IS 8360 (part- 1): 1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies-General Requirements"
IS 8360 (part- II) :1977	"Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies-Specific Requirements for 90 Deg. Tee"
IS 8360 (part-III) :1977	Specification for Fabricated High Density Polyethylene Fittings for Potable Water Supplies-Specific Requirements for 90 Deg. Bends"
IS 8008 (part-1): 2003	"Injection Moulded / Machine High Density Polyethylene (HDPE) Fittings for Potable Water Supplies -Specification-General Requirements for fittings"

3.5.2. Designation

Pipes shall be designated as per IS 4984, according to the grade of material, followed by pressure rating and nominal diameter, for example, PE 100 PN 8 DN 200 indicates a pipe pertaining to material grade 100 having a pressure rating 0.8 MPa and outside nominal diameter 200 mm

3.5.3. Colour

For the purpose of identification of the pipes, each pipe shall contain minimum three equispaced longitudinal strips of width 3mm (min) in blue colour, these strips shall be coextruded during pipe manufacturing and shall not be more than 0.2 mm in depth. The material of the strip shall be of the same type of resin.

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

3.5.4. Materials

The material used for the manufacturer of pipes should not constitute toxicity hazard, should not support microbial growth, should not give rise to unpleasant taste or odor, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any internationally reputed organization as per the satisfaction of the engineer in charge.

3.5.5. Raw Material

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

- The resin should have been certified by an independent laboratory of international repute for having passed 10,000-hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10MPa. Internal certificate of any resin manufacturer will not be acceptable.
- Certificate for having passed the full scale rapid crack propagation test as per ISO 13478. High density Polyethylene (HDPE) used for the manufacture of pipes shall conform to designation PEEWA-45-T-006 of IS 7328. HDPE conforming to designation PEEWA-45- T-012 of IS 7328 may also be used with the exception that melt flow rate (MFR) shall not exceed 1.10 g/10 min. In addition, the material shall also conform to clause 5.6.2 of IS 7328.
- The specified base density shall be between 941.0kg/ m³ and 946.0kg/ m³ (both inclusive) according to procedure prescribed in IS7328 The value of the density shall also not differ from the nominal value by more than 3 kg/ m³ as per 5.2.1.1 of IS 7328. The MFR of the material shall be between 0.41 and

1.10 (both inclusive) when tested at 19 deg C with nominal load of 5 kgf as determined by method prescribed in IS 2530. The MFR of the material shall also be within ± 20 percent of the value declared by the manufacturer.

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

3.5.6. Anti-oxidant

The percentage of anti-oxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harmless and shall be selected from the list given in IS 1014135.8 Reworked Material

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

3.5.7. Effect of nature of soil on pipe performance

The bidder shall provide certified information, as per IS code of practice about the performance of HDPE pipes, if laid in corrosive soils, below water table or under saturated conditions or rocky strata, etc. The necessary precautions, as per IS code of practice, to be taken like painting or bitumen coating or providing special bedding or crossing any feature under hanging, etc to encounter such conditions shall be mentioned and accounted for in the bid cost by the bidder

3.5.8. Maximum Ovality of Pipe

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

3.5.9. Wall Thickness

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

3.5.10. Length of Straight Pipe

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

3.5.11. Coiling

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

3.5.12. Workmanship / Appearance

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

3.5.13. Marking of Pipes

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

- i. The manufacturers name and trade mark,
- ii. Outside diameter,
- iii. IS classification,
- iv. Stiffness class
- v. Lot number I Batch number

3.5.14. Handling, Transportation Storage and Lowering of pipes

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

- i. Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60°C.
- ii. Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- iii. Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.
- iv. PE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- v. Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks be used on PE pipes.
- vi. Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so permitted by the Employer before installation.
- vii. During coiling care should be taken to maintain the coil diameter at or above the specified minimum to prevent kinks. Coiling shall be done when the pipe attains the ambient temperature from the extruder. In uncoiling or recoiling care should be taken that sharp objects do not scour the pipe.
- viii. When releasing coils, it must be remembered that the coil is under tension and must be released in a controlled manner. The end of the coil should be retained at all times, then the straps released steadily, one at a time. If the coil has bands at different layers of the coil, then they should be released sequentially starting from the outer layers. The amount of the energy locked up in the coil will depend on the size of the pipe, the SDR of the pipe, and the size of the coil.
- ix. Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set
- x. Bare coils shall be wrapped with hessian cloth for long distance (> 300Kms) transportation. The truck used for transportation of the PE pipes shall be exclusively used of PE pipes only with no other material loaded - especially no metallic, glass and wooden items. The truck shall not have sharp edges that can damage the Pipe
- xi. Pipes manufactured at factory are to be carried to the site of work directly or stacked suitably and neatly along the alignment/road side/elsewhere near by the work site or as directed by the Engineer.
- xii. Damages during transit, handling, storage will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost as directed by the Engineer.

3.5.15. Lowering, Laying of Pipes

Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Engineer shall be laid. While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same as backfill material. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M15, 15 cm or 20cm thick sand bed as approved by the Engineer may be provided(*50:50 ratio of River sand and crusher/Robo Sand is proposed*).

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

Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day). For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom. The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.

The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD (outer diameter) of the pipe.

The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.

Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint.

PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done. When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern. However, weights by way of concrete blocks (anchors) are to be provided so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away.

Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% of Procter Density.

3.5.16. Jointing of Pipes

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

- i. All joints shall be made as per relevant IS code, in practice, and manufacturer's installation manual or instructions. All joints shall be tested for their performance as per provisions made in relevant IS codes. Joints that show leakage will not be accepted. After backfilling and inspection, if groundwater

infiltration is observed through joints into the laid water line, then such joints shall be sealed by the bidder at no extra cost to the owner.

- ii. Pipe surfaces to be joined must be free of dust, dirt, oil, moisture and other foreign material. If required, use of chemical such as dichloro-methane, methyl ethyl-ketone or mechanical cleaner may be carried out.
- iii. Jointing of pipes and fittings shall be done by Electro fusion/ Butt fusion welding to joint two ends of HDPE pipes. ISO 12176-1:1998 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems - Part 1: Butt fusion and ISO 12176-2:2000 Plastics pipes and fittings - Equipment for fusion jointing polyethylene systems- Part 2: Electro-fusion shall be followed for the same.
- iv. However to join HDPE with other pipe/valves flanges/ mechanical joint compression fittings shall be used conforming to ISO 14236:2000 Plastics pipes and fittings - Mechanical-joint compression fittings for use with polyethylene pressure pipes in water supply systems

3.5.17. Road Crossing

Where HDPE pipes are to be laid crossing the road, the same shall be laid with RCC NP4 sleeve of dia minimum 100mm more than the outer dia of HDPE pipe.

3.5.18. HDPE Fittings & Specials

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

- i. Part I. Bends
- ii. HDPE bends shall be conforming to IS: 8008 Part II Specifications. Tees
- iii. HDPE Tees shall be conforming to IS: 8008 Part III Specifications. Reducers
- iv. HDPE Reducers shall be conforming to IS: 8008 Part IV Specifications. Flanged HDPE Pipe Ends
- v. HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VI Specifications. Stub ends will be welded on the pipe. Flange will be of slip on flange type as described below:

3.5.19. Slip-On Flanges

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

3.5.20. Welding Procedure

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

3.5.21. Tests to Establish Portability of Work

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

- i. Smell of the extract
- ii. Clarity of the colour of the extract
- iii. Acidity and alkalinity
- iv. Global migration UV absorbing material Heavy metals
- v. Un-reacted monomers (styrene) and Biological tests

3.5.22. Push-On Joints

For Push-on joints the rubber ring will be inserted through the chamfered spigot end of the pipe. The two pipes shall be aligned properly in the trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot.

After insertion, the correct position of the socket has to be tested with a feeler blade. A penetration gauge shall be used to check each joint after assembly, to ensure that the rubber ring is properly seated.

When it is desired to deflect push-on joint pipe in order to form a long-radius curve, the amount of deflection shall be as per the instructions of the manufacturer and approved by the Engineer. It is important that in making the joint the pipes are maintained in a straight line and the deflection introduced after the joint has been assembled. However, it is preferable that such deflection will not exceed 75% of the permissible deflection at a single joint as stipulated by the manufacturer of the pipe.

3.5.23. Mechanical Joints

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

3.5.24. Flanged Joints

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

Slip-on flanges shall be double welded to the pipe with a strength weld jointing the flange hub to the pipe and sealfillet weld inside the flanges at the pipe end. All flanges of the same diameter shall be compatible.

3.5.25. Tolerance

The tolerance on the pipe body shall be + 0.75% for all sizes of pipes. The tolerance on specified wall thickness shall be - 2% /+ 10%

Straightness - Finished pipe shall not deviate from straightness by more than 0.2% of the total length. Checking shall be carried out using a taut string or wire from end to end along the side of the pipe to measure the greatest deviation.

Length- Straight pipe shall not vary from the specified overall length by +10 mm or -10 mm for length up to and including 6 m.

3.5.26. Inside / Outside Coatings

The coating of the pipes shall be smooth, dense and hard. The coating shall be free from excessive surface irregularities. Projection exceeding 3 mm. measured from the general surface shall be removed. For inside coating of epoxy paint, the inside surface of the pipe should be sand or shot blasted. The surface should be thoroughly rubbed down with rough sand paper or wire brush so that

surface will be uniformly rough. Mixed paint should be used within 3 to 4 hours of mixing and fresh mixing is taken for every new application.

Zinc rich epoxy primer and epoxy paint of approved quality shall be used for external and internal painting. No primer shall be applied without prior approval of the owner. The mix of zinc rich epoxy primer shall be prepared at works site not earlier than 15 min. before applying the same on pipes and special surfaces. One coat of zinc rich epoxy primer shall be applied along with 2 coats of epoxy paint. No thinner shall be added to ready mix paints without previous approval of the owner and the finishing coats on top of the primer coat shall only be applied after allowing the film to cure for at-least 48 hours.

After application of zinc rich epoxy primer, the surface should be cleaned by duster and inspected. If during inspection any portion is found rusting the same shall be removed by emery paper and coated with zinc rich epoxy primer.

3.5.27. Steel Flanges

The flanges and their dimensions of drilling, wherever not specified, shall be in accordance with 18:6392 -1971 or its latest revision. The flanges shall be slip on boss type of 1N/mm² pressure rating. Prior to welding flange, the contractor shall have to obtain approval of Engineer for all sizes and types of flange drawings.

3.5.28. Warning Tape

The HDPE pipes shall have a warning tape placed 400mm above the top of pipe buried to protect the pipe against damage when dug up later on. The specifications of the warning tape is as follows:

Sr no	Test property	Unit	Test Value	Test Reference/ Remarks
01	Visual appearance	--	Surface shall be smooth. No visual defects like crack, roughness, waviness & free from blisters, shrinks, holes, etc.	
a	Colour of Mat	--	Blue	As per client requirement/demand.
b	Text legend	--	Black	As per client requirement/demand. Non-deletable & high Abrasion Resistant.
c	Identification & Marking	--	--	Warning message in English & Local language at defined interval. Mfr's brand name:
d	Packing	--	Roll Packing	100 mtr $\pm$ 2 mtr of each Roll, packed in plastic woven sack parcel
02	Dimension & Tolerance			
	Width	mm	300 mm $\pm$ 5 mm	
	Thickness	mm	0.5 mm $\pm$ 10 %	
	Roll Length	mtr	100 mtr $\pm$ 2 mtr	
03	Adhesive tape test	--	Not more than 10% of the area shall be removed.	Marking shall not be removed
04	Tensile strength at break	Kg/cm ²	Min. 150	ASTM D 882
05	Elongation at break	%	Min. 150	

3.6. Ductile Iron Pipes

- Specification of Double Flanged D.I. Pipes ISI marked centrifugally cast DI pressure pipes with flanged ends should be confirming to IS 8329 (latest edition) with up to date amendments. The flanges should be class PN 16 and the barrel shall be K-9. The rubber gaskets shall confirm to IS 638.
- ISI marked centrifugally cast (spun) Ductile iron pressure pipes with socket/spigot ends confirming to IS8329 in standard working length of 4.00m, 5.00m, 5.50m and 6.00m for class K-7 suitable for push on joint (Rubber Gasket Jointing) with inside cement mortar lining.
- ISI marked SBR quality Tyton Rubber Gaskets (Push on joint type) as per IS5382& IS12820 suitable for jointing of DI spun Tyton pipes.
- The bidder shall supply attested photocopies of license granted by BIS authority to the manufacturer for marking the pipes & rubber rings with ISI certification mark before inspection of material.
- At the time of supply, the bidder shall supply a certificate of manufacturer at the time of inspection of material that each and every pipe has been tested for "WORKS HYDRAULIC PRESSURE TIGHTNESS TEST" as per relevant IS code.
- The bidder shall supply attested photocopies of license granted by BIS authority for making the DI Detachable joints & rubber rings with ISI certification mark before inspection of material.

3.6.1. Applicable codes

IS 9523	Ductile iron fittings for pressure pipes for water, gas and sewage –
IS 5382	Rubber sealing rings for gas mains, water mains and sewers
IS 638	Specification for Sheet Rubber Jointing and Rubber Insertion Jointing
IS 12288	Code of practice for use and laying of Ductile Iron pipes
IS 5330	Anchor or thrust blocks
IS 12820	Rubber gaskets
IS 2685	Selection, installation & O & M of SV

IS1363 Part I & III	Nut & Bolts
IS 14846	Sluice valve for water works purpose (50 to 1200mm size)
ISO 2531	Ductile iron pipes, fittings, accessories and their joints for water applications
ISO 4179	Ductile iron pipes and fittings for pressure and non-pressure Pipelines -- Cement mortar lining
ISO 4633	Rubber seals -- Joint rings for water supply, drainage and sewerage pipelines - Specification for materials
ISO 8179	Ductile iron pipes -- External zinc based coating -- Part 1: Metallic zinc with finishing layer
ISO 8179	Ductile iron pipes -- External zinc coating -- Part 2: Zinc rich paint with finishing layer
ISO 8180	Ductile iron pipelines - - Polyethylene sleeving for site application
ISO 10802	Ductile iron pipelines - - Hydrostatic testing after installation
ISO 10803	Design method for ductile iron pipes
ISO 16132	Ductile iron pipes and fittings - - Seal coats for cement mortar linings
AWWA M 41	Ductile - Iron pipe and fittings (guideline code for design, manufacturing, testing, jointing, laying & installation etc.)
BSEN 545	Ductile iron pipes, fittings, accessories and their joints for water pipelines
IS 1387	General requirements for supply of metallurgical materials
IS 1500	Methods for Brinell hardness test for metallic materials
IS 1608	Mechanical testing of metals - tensile testing

3.6.2. Design Requirements

i. Classification

The class of DI pipes to be provided shall be as specified in the data sheet attached with this sub section. The external diameter and wall thickness of socket and spigot pipes for the specified Class shall be as per IS 8329 or equivalent international standard.

Pressure class and thickness class of pipe flanges shall be as specified in the data sheet attached with this sub section and shall conform to the requirements of IS 8329 or equivalent international standard.

ii. Length

Socket and Spigot pipes shall be supplied in standard working lengths of 5.5m or 6m and flanged pipes in lengths of 4m / 5m / 5.5m as per requirements.

iii. Tolerances

Tolerances on External diameter, ovality, thickness and length of pipes etc. shall conform to the provisions of IS 8329 or equivalent international standard.

iv. Material Requirements

The metal used for manufacturing the pipes shall be of good quality, commensurate with the mechanical requirements laid down in IS 8329 or equivalent international standard.

v. Manufacturing Requirements

Pipes supplied shall be centrifugally cast (spun) Ductile Iron pipes conforming to IS 8329 or equivalent international standard. The pipes shall be stripped with all precautions to avoid warping or shrinkage defects, detrimental to their good quality. The pipes shall be sound and free from surface or other defects.

vi. External Layer

The DI pipes supplied shall be provided with external protection of metallic zinc coating with finishing layer of bituminous paint as per IS 8329 or equivalent international standard.

vii. Internal Lining

The pipes shall be provided with suitable cement mortar internal lining as per IS 8329 or equivalent international standard.

viii. Joints

Push on flexible joints shall be provided for pipe to pipe connection as per IS 8329 or equivalent. Wherever, flange joints are required e.g. at terminal points, valves, over ground and underground pipe connection etc., Welded on flanges shall be used.

ix. Rubber Gaskets & Sealing Rings

Rubber gasket used with push on flexible joints shall conform to the requirements of IS 5382, IS: 12820 or equivalent. Rubber gaskets for use with flanged joints shall conform to IS 638 or approved equivalent.

3.6.3. QA Requirements for DI Pipes, Fittings and Specials

Following tests / inspections to be carried out on the finished pipes, Joints, Gaskets, DI Fittings & specials as per relevant IS/ISO standard.

- i. Pipes produced are subject to following checks
 - a) Visual Inspection for workmanship, marking, visual defect etc.
 - b) Mechanical Properties as per relevant governing Standard
 - c) Dimension
 - Inside Diameter
 - Outside Diameter
 - Wall Thickness
 - Ovality of Pipes
 - Length of Pipes
 - Straightness
- ii. Hydrostatic Leak Tightness to be carried out as per relevant standard.
- iii. Zn coating & Bituminous painting on external layer DI pipes shall be carried out as per relevant standard / Technical Specifications.
- iv. Identification – Manufacturer Logo, Nominal Diameter, Class, length indication for cutting of pipe at site, ISI certification mark, pipe no.
 - a) Internal lining of suitable cement mortar shall be done as per relevant standard / Technical Specifications.
 - b) Rubber gaskets shall confirm to the requirement of relevant standard / Technical Specifications.
 - c) Joints for pipe, DI Fittings & specials shall be as per relevant standard / Technical Specifications.

3.6.4. Data Sheet for DI Pipes, Fittings & Specials

S. No.	Description	Parameters
1.	Pipe Material	Ductile Iron (DI) pipe internally cement mortar lined and externally coated with metallic zinc & finishing layer of bituminous paint
2.	Applicable standards	IS / ISO / AWWA / BS as listed in technical specification
3.	Hazen & William's constant	130
4.	Pipe Class	K7/K9 based on approved design as per IS 8329 or equivalent
5.	Pipe Joint type	Push on flexible joints as per IS 8329
6.	Pipe Joint type at valves, pumps and other piping	Flange Joints as per IS8329 & IS 9523
7.	Welded on Flange (as applicable) Pressure Class	PN 16
8.	DI fittings class	K12 as per IS 9523 or equivalent
9.	DI fittings flange (as applicable) class	PN 16 / as per approved design
10.	Restrain mechanism at bends, specials etc.	Thrust Blocks
11.	Other Requirements	As per technical specification

3.6.5. Quality Assurance Protocol (DI Pipes) Quality Assurance Steps to be taken at Site

DI Pipes IS 8329:2000 and Amendments

i. Check of Documentation

As and when, the truck with the consignment reports to the Work Site, the Executive on ground from the Agencies should obtain the Certificate to the effect that the pipes have been manufactured strictly as per IS Code 8329:2000. This documentation will include Manufacturer's Certificate and the Test Reports. Normally, the driver of the consignment should be in possession of the said Certificate.

ii. stacking

vii. Three types of stacking are recommended (*Figure D-1*):

- Square Stacking: suitable for pipes up to and including DN400
- Parallel Stacking Using 2 no timber between each layer: Suitable for pipes of all sizes
- Pyramid Stacking: suitable for pipes of all sizes



Table D-2: Stacking Heights of DI Pipes

Diameter (mm)	No. of Layers
100	16
150	14
200	12
250	10
300	8
350 and 400	7
450 and 500	6
600	4
700	3
750 and above	2

The hooks should be wide as possible and padded with rubber to minimize damage to cement linings. Smaller sizes up to DN400, may be lifted with wide fabric sling. Wire ropes or chain slings should not be used.

iii. Marking on the Pipes

Conduct a check to ensure that each pipe shall have as cast or stamped or legibly and indelibly painted on it with the following appropriate marks (Clause: 18.1 & 18.2 of IS 8329:2000)

- Indication of the source of manufacture;
- The nominal diameter;
- Class reference;
- The last two digits of the year of manufacture;
- The non-standard length of the pipe if specially ordered;
- Where applicable, an indication of length over which the pipe is suitable for cutting on site; and
- A short white line at the spigot end of each pipe with push-on joint in sizes DN 700 and above, to indicate the major axis of the spigot.
- BIS Certification Marking
- The above marking should be on all pipes.

iv. Jointing System

- Joints:** Jointing of DI pipes and fittings shall be done as per IS: 12288 and manufacturer's recommendations. After jointing, extraneous material, if any, shall be removed from the inside of the pipe. Rubber sealing rings / gaskets used for jointing shall conform to IS: 638, IS: 12820 and IS:5382.
- Push-on-Joint:** In case of push-on flexible joints, the spigot ends shall be suitably chamfered or rounded off to facilitate smooth entry of pipe in the socket fitted with the rubber gasket (Clause 6.1, 6.1.1 & 6.1.2 of IS 8329:2000 and IS 12288).
- Flanged Joint:** In case of flanged joints, refer clause 6.2 & its sub-clauses of IS 8329:2000 and IS 12288 (latest edition).

v. Physical Characteristics

- A check of the following physical characteristics will be carried-out of samples as mentioned above:
 - Sampling (Table in Clause 9.2)
 - Dimensions & Ovality (Clause 13, Table 2, Tolerances: Clause 15, Table 7&8 of IS 8329:2000)
- Dimensions tests will be conducted at storage site

vi. Manufacturer Tests

- Sampling for Mechanical Acceptance Tests

The mechanical acceptance tests shall be carried out on samples of ductile iron pipes which shall be grouped in following batch sizes (Clause 9.2)

DN (mm)	Maximum Batch Size
200 Pipes	80 250
300- 600	100 Pipes
700 - 1000	60 Pipes
1100 - 1400	40 Pipes
1600 - 2000	30 Pipes

In order to check compliance with the requirements specified in 10, a sample ring or bar shall be taken from the spigot end of pipe. (Clause 9.3 of IS 8329:2000)

vii. Mechanical Tests (Clause 10 of of IS 8329:2000)

Mechanical tests shall be carried out during manufacture. One test shall be conducted for every batch of production. The number of pipes for each batch shall be as laid down in clause 9.2 of IS 8329:2000. The results obtained shall be taken to represent all the pipes of that batch. (Clause 10.1 of of IS 8329:2000)

viii. Zinc Coating (Clause 16.2 Annex A of of IS 8329:2000)

The mean dry film thickness of the finishing layer shall not be less than 70 µm with nowhere less than 50 µm.

ix. Bituminous Coating (Clause 16.2 Annex C)

The mean thickness of the coating shall be not less than 70 µm and the local.

x. Cement Mortar Lining (Clause 16.3 Annex B)

viii. Thickness of the Lining (Clause B-5 Table 15)

xi. Hydrostatic Site Test Pressures and Hydraulic Working Pressure

ix. Annex E Table 1 Amendment

xii. Tests to be conducted for DI Pipe and Fittings at Two Laboratories

x. The following tests for DI Pipe and Fittings (as per IS 9523:2000) suitable for pushon flexible joints are to be got conducted:

- Tensile Test (Clause 10.1.1 as per IS 8329:2000)
- Brinell Hardness Test (Clause 10.2 as per IS 8329:2000)
- Hydrostatic Test (Clause 11 as per IS 8329:2000)
- Sizes (Clause 12 as per IS 8329:2000)
- Dimensions (Clause 13 as per IS 8329:2000)
- Tolerances (Clause 15 as per IS 8329:2000)
- Quality Assurance (Clause 17 as per IS 8329:2000)
- Cement Mortar Lining (Clause 16.3 Annex B as per IS 8329:2000)
- Bituminous Coating (Clause 16.2 Annex C as per IS 8329:2000)

xiii. Rubber Gasket

xi. The following test is to be got conducted from NABL accredited laboratories as per BIS, as agreed with the Employer:

- The test is to be got conducted as per IS 5382 (1985): Rubber Sealing Rings for Gas Mains, Water Mains and Sewers [PCD 13: Rubber and Rubber Products] suitable for push-on flexible joints.

3.6.6. DI Fittings & Specials

i. General

- The manufacturing unit should have ISO 9001 certification.

- b) The company should have fully equipped laboratory with in-house microscope to check modularity and to check chemical composition along with tensile, hardness & elongation by universal testing machine. The laboratory of the manufacturer should be accredited by NABL.
- c) Since the socket design is not given in the standard the min. socket thickness of fittings at any point must not be lesser than minimum body thickness given in the standard.

ii. Design Requirements

- a) The class of DI fittings to be provided shall be as specified in the data sheet attached with this sub section. The external diameter and wall thickness of fittings for Push on joints for the specified Class shall be as per IS 9523 or equivalent.
- b) The Pressure class of flanged fittings shall be as specified in the data sheet attached with this sub section and shall conform to the requirements of IS 9523 or equivalent.

iii. Permissible Deviations on Length of Fittings

- xii. The permissible deviations on the length of fittings shall be as per IS 9523 or equivalent.**

iv. Tolerances

- xiii. Tolerances on external diameter, raised face height, thickness and Flange drilling of fittings etc. shall conform to the provisions of IS 9523 or to the provisions of international equivalent standard to which they are supplied.**

v. Material Requirements

- xiv. The metal used for manufacturing the fittings shall conform to the appropriate grade as specified in IS 1865, in commensurate with the requirements of IS 9523 or equivalent.**

vi. Manufacturing Requirements

- a) The fittings shall be stripped with all precautions to avoid warping or shrinkage defects, detrimental to their good quality. The fittings shall be sound and free from surface or other defects.
- b) Linings and Coatings for Ductile Iron Fittings
- c) The DI Fittings are to be lined with Cement Mortar Linings with a sand cement mixture and the lining thickness should be as per Table 33 (Annex B) of IS 9523. The Coatings to DI fittings shall be similar in line with the provisions of DI pipes. All fittings must be painted with Zinc rich paint as per Annexure A of IS 9523. Bitumen being used for External coating should be approved by WRAS or similar approval authority. However, in soil conditions where soil resistivity is less than 1000 ohm-cm with or without water table, fusion bonded epoxy lined and coated DI fittings to be used in place of other type of lined and coated fittings. *(50:50 ratio of River sand and crusher/Robo Sand is proposed)*
- d) Fittings with Flexible Push-on joint:

Flexible joints shall be of spigot and socket “push-on” type suitable for angular deflection in any direction and capable of axial movement to compensate for thermal expansion or contraction and ground movement.
- e) Fittings with Flanged joint

Fittings with Flanged joints will be with raised face and they shall be supplied complete with approved gaskets, hot dipped galvanized or cadmium plated bolts, nuts.
- f) Fittings with Mechanical joint
- g) Where Fittings with mechanical type joints are specified, proposed and approved they shall be supplied complete with approved gaskets, glands, hot dipped galvanized or cadmium plated bolts, nuts and all other necessary accessories.

h) Fittings with Restrained Joints

- i) DI fittings with restrained joints shall be utilized in underground application where pipelines have to cross roads through existing ducts or in areas with restricted accessibility where the use of concrete anchor blocks is prohibited, or as directed by the Engineer. The Contractor shall submit with his bid with full details of the type of restrained joint he proposes to use.
- j) Whenever in the course of work the Contractor intends to utilize restrained joints he shall obtain prior approval from the Engineer.
- k) Calculation of the number of pipe lengths with restrained joints required on both sides of the fitting shall follow the manufacturer's recommendation and shall be subject to the Engineer's approval.
- l) Restrained joints shall be designed in accordance with ISO 10804-1. The permissible angular deflection will be as declared by the manufacturer. The performance Type test of this Joint in line with ISO 10804-1/EN545 has to be established by the manufacturer by getting it witnessed by a NABCB (National Accreditation Board for Certification Bodies) or IAF (International Accreditation Forum) or EA (European Cooperation for Accreditation) accredited institution / certification agency. The certificate must be produced with the technical bid.
- m) Rubber ring for joints shall be of a type that will not deteriorate when stored under manufacturer's guidelines or during operation. The rubber gasket shall be of EPDM elastomer in accordance with IS5382 suitable for water supply.

vii. Joints Between Pipe and Fittings

- a) Push on flexible joints shall be provided for pipe to fitting connection as per IS 9523 or equivalent. Flange joints, wherever required, shall conform to the requirements of IS 9523 or equivalent.
- b) Rubber gaskets
- c) Rubber gasket used shall conform to IS: 53821985 or amended up to date. Other requirements of gaskets are as per clause-7 of IS 952:32000. Rubber Gaskets to be ISI marked EPDM quality.

viii. Type Tests

- a) The contractor / manufacturer shall carry out the type tests as listed in this specification on the pipes to be supplied under this contract. The bidder shall indicate the charges for each of these type tests separately in the relevant Section and the same shall be considered for the evaluation of the bids. The type tests charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the Employer.
- b) The type tests shall be carried out in the presence of the Employer, for which minimum 15 days' notice shall be given by the Contractor. The Contractor shall obtain the Employer's approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set-up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.
- c) In case the Contractor / manufacturer has already conducted such specified type test(s), he may submit the type test reports to the Employer during detailed engineering for consideration of waiver of conductance of such type test(s) or otherwise as deemed fit by Employer. Such test(s) should have been either conducted at an independent laboratory or duly approved by accredited third party agency. The Employer reserves the right to waive conducting of any or all the specified type test(s) under this contract.
- d) The type test shall be performed whenever a significant change is made in the design, material or process of manufacture or a new size or size range of the product is being supplied by the manufacturer.

ix. Joint Leak Tightness Test

- a) Tests for joints (push on flexible joints) shall be conducted as per the guidelines of ISO 2531 to establish adequate joint performance with respect to internal pressure, external pressure and vacuum pressure under both normal alignment of joints and deflected alignment of joints as dictated in ISO 2531.
- b) Tests for Leak tightness and mechanical resistance of flanged joints shall be conducted as per ISO 2531.
- c) Cement Lining Smoothness Type Test
- d) The contractor / manufacturer should have carried out Cement Lining Smoothness test to establish C value (Hazen & William's constant) of the offered DI pipe as 130. The necessary certificate for the same shall be furnished to the Employer.
- e) In case the contractor / manufacturer has not carried out the test, the same shall be carried out by the contractor / manufacturer within the scope of this contract.
- f) Ring bend test
- g) Ring bend test for 3% deflection with respect to external diameter of DI pipe offered shall be conducted by contractor / manufacturer to prove that internal cement mortar lining does not come off the substrate surface of Ductile Iron on random basis for each manufacturing lot.
- h) If the contractor / manufacturer of pipes does not have the facility for this type test at his own works, the same can be arranged by him to conduct and demonstrate the test.

x. Marking

xv. Each Pipe shall have as cast or stamped or legibly and indelibly painted on it with the following marks:

- a) The Manufacturer's name or trademark on each pipe
- b) The nominal diameter of pipes and batch number.
- c) Class of Pipes and fittings
- d) A white ring line showing length of insertion at spigot end
- e) Standard ISI certification mark for the pipes conforming to IS or international standard mark to which they are supplied.
- f) The last two digits of the year of manufacture
- g) Any important information that the manufacturer deems fit to be inscribed on pipe.

3.6.7. Laying and Jointing of DI Pipes

i. Laying Underground

- a) Pipes shall be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250 mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes suitable mechanical equipment shall be used.
- b) All construction debris shall be cleared from the inside of the pipe either before or just after a joint is made. All persons shall vacate any section of trench into which the pipe is being lowered.
- c) The assembly for the pipes shall be made as recommended by the pipe manufacturer and using the suitable tools.
- d) The socket and spigot ends of the pipes shall be brushed and cleaned. The chamfered surface and the end of the spigot end have to be coated with a suitable lubricant recommended by the manufacturer of the pipes. Oil, petroleum bound oils, grease or other material, which may damage the rubber gasket, shall not be used as lubricant. The rubber gasket shall be inserted into the cleaned groove of the socket. It shall be checked for correct positioning.

- e) The two pipes shall be aligned properly in the pipe trench and the spigot end shall be pushed axially into the socket either manually or with a suitable tool specially designed for the assembly of pipes and as recommended by the manufacturer. The spigot has to be inserted up to the insertion mark on the pipe spigot. After insertion, the correct position of the socket has to be tested with a feeler blade.
- f) Deflection of the pipes, if any, shall be made only after they have fully been assembled. The deflection shall not exceed 75% of the values indicated by manufacturer.
- g) On gradients of 1 in 115 or steeper, precautions shall be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe shall be held firmly in position while the trench is back filled over the barrel of the pipe. The backfill shall be well compacted.
- h) Special provisions in trench shall be made for accommodating socket (Bell) of each pipe, as applicable so that barrel is uniformly rested on even trench bed surface, which is well compacted as recommended in codes / standards.
- i) At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt, water or other foreign matter by means of approved plugs or end caps.

ii. Laying above Ground

- a) The following is applicable only when no additional bending moments except that those due to self-weight of pipe and its content are present. If any additional moments are present, piping contractor has to suitably support the pipe in consultation with manufacturer and Employer.
- b) Socket and spigot pipes
- c) Socket (Bell) and spigot pipes shall be provided with one support (usually pedestal or steel pipe support) per pipe. The supports shall be positioned behind the socket of each pipe.
- d) Pipes shall be fixed to the supports with mild steel straps so that axial movement due to expansion and contraction resulting from temperature fluctuations is taken up at individual joints in the pipeline. Joints shall be assembled with the spigot end withdrawn 5 to 10 mm from the bottom of the socket to accommodate thermal movements.
- e) The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.
- f) Where a pipeline crosses a watercourse, the design and method of construction shall take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc., which affect the design and laying of pipeline.
- g) Flanged pipes
- h) The maximum unsupported span for flanged pipes shall not be more than 8 m. The supports shall be located at the centre of every second pipe.
- i) The maximum unsupported span at water course shall also be not more than 8 m. The relative position of pipe joints and pipe supports shall be as per IS 12288 or equivalent.
- j) The supports of all flanged pipe work spans shall be stable and unyielding due to movements in the pipeline.
- k) The straps shall prevent any lateral movement or lifting of the pipelines but not restrict expansions and contractions caused by temperature fluctuations.

iii. Cutting of Pipes

- a) The cutting of pipe, if required, for inserting valves, fittings etc. shall be done in a neat and workman

like manner without damage to the pipe or lining so as to leave a smooth end at right angles to the axis of the pipe. Cutting of pipes shall be reduced to a minimum required.

- b) Cutting has to be made with suitable tools as per IS 12288 or equivalent and according to the recommendations of the manufacturer. The spigot end has to be chamfered again at the same angle as the original chamfered end. If there is no mark for the insertion depth on the spigot ends of the (cut) pipe it shall be marked again according to the instructions of the manufacturer.

iv. Pipeline Anchorage

- a) Pipeline shall be securely anchored at dead ends, tees, bends, tapers and valves to resist thrust arising from internal pressure. Suitable thrust blocks made of concrete shall be designed and cast- in-situ.
- b) All specials like bends, tees etc. and appurtenances like valves etc. shall be laid in synchronization with the pipes. The Contractor has to ensure that the specials and accessories are available at site ready to be installed together with the pipes.

v. External Protection

- a) The Contractor shall carry out soil resistivity survey along the RoW of the pipeline using Winner's 4 pin method in the presence of the Employer.
- b) On completion of all fieldwork, a report incorporating resistivity (on semi log graph sheets) data shall be prepared by the Contractor and submitted to the Employer.
- c) In case of highly corrosive soil (soil resistivity less than 1000-ohm cm), polyethylene sleeving shall be provided for encasement of the pipes, fittings and joints against corrosion. This encasement shall be so designed to prevent the contact of pipe, fittings and joints with the surrounding backfill and bedding material. It shall conform to the requirements of IS 8329 & IS 12288 or equivalent international standards.

3.7. CI Double Flanged Sluice Valves

- i. Sluice Valves for water supply shall be ISI marked in accordance with IS 14846 and as per list of approved makes by the Employer. CI Flanged type of nominal sizes 80 to 600mm and pressure PN-16
- ii. The components/parts of Sluice Valves shall be manufactured from preferred material mentioned in table-1 of IS 14846 except for body seat ring, Wedge facing ring and bushes which shall be made of stainless steel. The Body Length over Flanges shall be as given under Column 3 i.e. PD in table 3 of IS14846.
- iii. Each valve shall be hydrostatically tested as per clause 10 of IS14846 for closed end Test as well as open End Test. The Valves shall be suitable for application in horizontal, position as well as for use in pipeline in unsupported and terminal position rigidly held at one end only.
- iv. The CI double flanged sluice valves shall be supplied either with Cap or with Hand wheel.
- v. The bidder shall supply attested photocopies of license granted by BIS authority to the manufactures for marking the CI, Double Flanged Sluice Valves with ISI certification mark before inspection of materials.

3.7.1. Indicating Plate for Sluice Valves

- i. Enameled indicating plates made of 16-gauge Mild Steel sheet with ground colour Prussian blue and letters in white enamel. The indicating plates should have 4 No. holes of 4 mm dia meter for screws, on the corners. The size of the plate shall be 150mm x 150mm with back side also black enameled to protect it from rust.

3.8. Air Valve

- i. Air valves shall be installed on top of air valve tees. It should conform to IS 14845:2000.
- ii. Air valves are to be used for evacuation of accumulation of air in water mains under pressure, for the exhaust of air when such mains are being charged with water and for inlet of air when they are emptied of water.

- iii. There are two types of air valves generally use. Single air valves with single ball and double air valve with double ball. The single ball type can have either large orifice or small orifice, the former being only suitable for emptying and filling of pipe line and latter for discharging small quantities of entrained air in the pipe.
- iv. Double air valves are commonly available which are suitable for dual purpose with a large orifice and a small orifice in one unit, with a common connection with the main. For large aqueduct pipe line, a triple orifice air valve is available with two large orifices and one small orifice.
- v. For high pressure, stainless steel floats are used instead of vulcanite-covered balls. In case of high velocity air discharge, special design of air valves is also available. Under such situation if usual type of air valves is used there is danger that the ball might be carried to its seat by the air stream before the accumulated air has been completely exhausted.
- vi. Single air valves of small sizes are provided with stop cock with the inlet of the air valve, whereas double air valves are provided with a standard sluice valve fixed, with inlet flange of the air valve or with integral valve, Regular maintenance at least on annual basis is necessary to ensure that the balls are free to move and that the seat do not leak. In very cold weather it is necessary to drain the chamber of valves to avoid any damage due to frost.
- vii. Construction of watertight chamber around the air valve when fixed in street is necessary to avoid the admission of any polluted water

3.9. Field Level Smart Instruments

3.9.1. Control Actuators

- i. For control and on/off valves and penstocks, electric actuators shall be used.
- ii. Each control valve/penstock actuator shall include an inductive position transmitter with 4 – 20 mA output signal. This transmitter shall be protected from mechanical damage by a friction clutch.
- iii. The output signal shall be 4-20 mA with LoRaWAN superimposed.
- iv. Electric actuator enclosures with position transmitters and limit switches shall be provided with space heaters (if required) to maintain the inside temperature above dew point.
- v. A hand wheel shall be provided for manual operation. Movement from motor operation to hand wheel operation shall be accomplished by a positive declutching knob, or lever, which will disengage the motor and motor gearing mechanically but not electrically. Provision of locking device for manual operation to prevent unauthorized operation of actuator shall be provided.
- vi. Actuators with servomotors shall have a self-locking characteristic in order to maintain its last position in case of switching off the motor or power failure against 120 % counter force/torque. If the motor is not fitted with a brake for these purposes, a gear box with a self-locking characteristic may be used.
- vii. All power gearing and rotary thrust conversion shall be oil or grease lubricated with an approved lubricant, which is suitable for at least four years' operation under the given ambient conditions.
- viii. All actuators for above ground service shall be of ingress protection class IP 65 and for the below ground service the ingress protection class shall be IP68.
- ix. All actuators are to be equipped with mechanical stops adjustable to the used travel range in order to prevent the actuator and the associated equipment from travelling past its normal range in the event that the limit switches fail to operate.
- x. If the actuator design requires a switching off in the end positions, the actuator shall be equipped with a travel limit switch mechanism. If the actuator with these cut-off switches is proposed then a minimum of two switches, one for the closed position and one for the opened position shall be provided.
- xi. The electrical motor operated valve actuators shall be suitable for power supply at 415V $\pm$ 10%, 50 Hz $\pm$ 3%, 3 phase, unless specified otherwise in the data sheet.
- xii. Safety factor shall be 1.5% and 200% for general purpose and shutdown application respectively.
- xiii. In case pneumatic control valves shall be used, they shall be supplied with spring return actuator, positioner and other accessories.
- xiv.

3.9.2. Electromagnetic Flow Meters

- i. The flow meter shall comprise of a flow sensor and a transmitter unit. The transmitter shall be integral to the flow tube for above ground installations and separate from the flow tube for below ground installations such as chambers. The flow meter shall be of the electromagnetic type utilizing pulsed DC excitation and shall be microprocessor based. Each unit shall be of stand-alone type.
- ii. Electromagnetic flow meters shall operate on electromagnetic induction principles and shall consist of a detector head and signal converter system which shall comply with BS EN ISO 6817 and Traceability Group A1 of BS ISO 11631. The flow metering system shall provide pulse and analogue current outputs proportional to volume and rate of flow respectively.
- iii. The flow meter shall feature on-site field validation for sensor, transmitter and interconnecting cable. The flow meter shall be calibrated at the factory to its actual flow range in m³/hr. A factory calibration certificate shall be provided with the meters.
- iv. The flow sensor shall be manufactured from AISI 304 stainless steel metering tube with a non-conductive hard rubber liner to withstand process temperatures as per the data sheet. The liner material shall be abrasive resistant and approved for potable water use by WRC-UK or equivalent internationally recognized authority
- v. There shall be 2 nos. of measuring electrodes with built in reference electrode and empty pipe detection electrode as a standard item. The reference electrode shall ensure potential equalization between the sensor and the fluid and proper grounding of the installation. Electrode material shall be SS 316L or Hastelloy.
- vi. Detector heads shall be flanged to BS EN 1092. The flanges shall be compatible with those specified for the associated pipe work. Detector heads shall be fitted with an anti-roll system to prevent damage during storage. The flow meter shall have an empty pipe detection facility. The input impedance shall be 1015 ohms or greater so that electrode fouling does not affect signal and electrode seal integrity. The sensor data shall be stored in a built-in EPROM module.
- vii. Automatic cleaning of electrodes shall be possible through the transmitters.
- viii. Power and signal cables to the detector head shall be factory sealed only, potting _on Site shall not be acceptable.
- ix. The electrical connections for cable entry for sensors with remote transmitters shall be ½" NPT with appropriate cable glands.
- x. A minimum of ten (10) metres of interconnecting cable between sensor and the remote transmitter unit shall be included in the scope of supply. The interconnecting special cable shall be supplied from the manufacturer of the flow meter.
- xi. The transmitter unit shall be either integral with the flow sensor or remotely mounted to suit the application requirements.
- xii. The transmitter unit shall be microprocessor based, of modular design and shall be easily configurable through integral keypads. The electronics shall be of modular construction for ease of maintenance and future expandability.
- xiii. The transmitter shall be provided with at least three (3) lines illuminated display for rate of flow and totalized flow indication. The data storage shall be on EEPROM to preserve data on power failure without battery backup. The unit shall have high electromagnetic compatibility according to IEC 801 recommendations.
- xiv. The transmitter shall be housed in a robust die-cast aluminium enclosure with IP65 protection for both compact and remote versions and shall be IP68 for submerged application.
- xv. The unit shall be provided with extensive self-diagnostics for operational security with resulting error messages enunciated at the alarm output.
- xvi. The transmitter will be powered from a 230 VAC or 24 VDC supply. All inputs and outputs shall be galvanically isolated from the power supply, the measuring circuit and each other.
- xvii. The following outputs shall be available and configurable by the user:
 - Analogue, 4-20 mA. Analogue signal proportional to flow rate.

- Active / Passive (open collector) selectable to Pulse/Frequency output.
 - Status configurable for limit values, end value switching, empty pipe detection, flow direction over ranging or instrument fault.
- xviii. The output signal shall be 4-20 mA with LoRaWAN superimposed.
- xix. The transmitter unit shall be provided with two (2) no's. of suitable cable glands for power supply and signal cables.
- xx. Accuracy shall be better than + 0.25% of reading (actual flow rate) at flow velocity > 1 m/s with repeatability within + 0.1% of flow rate. The measurement shall be insensitive to entrained solid particles.
- xxi. The transmitter unit shall be suitable for operation in an ambient temperature range of 0 to 50°C

3.9.3. Pressure Transmitters

- i. Pressure transmitters shall be of the direct sensing type with the sensing element as per manufacturer's standard. The diaphragm shall be hermetically welded to the measuring element assembly
- ii. The transmitter shall be of a smart type. The measuring element shall be able to withstand a temporary/permanent overpressure to at least 30% of the specified range limits without calibration
- iii. All wetted parts and the diaphragm shall be compatible with the process fluid and shall be of minimum AISI 316 SS/ceramic. The measuring assembly fill fluid shall be silicon oil, unless otherwise specified.
- iv. PTFE gaskets shall be applied as a standard, unless otherwise specified. The bolts and nuts shall be high tensile stainless steel.
- v. The transmitter cover material shall be low copper aluminum. Enclosure class shall be according to IP 65 of IEC 60529, as a minimum.
- vi. The process connection shall be 1/2" NPT (M) and the electrical signal cable entry connection shall be 1/2" NPT unless otherwise specified in the data sheet. Unused electrical connections shall be plugged off with a recessed head screw in compliance with the specified electrical safety requirements. The screw material shall be of stainless steel for stainless steel enclosures. The signal cable termination points shall be of the screw type.
- vii. The transmitter output signal shall be 4-20 mA with LoRaWAN superimposed.
- viii. The transmitter power supply voltage shall be 24 VDC, for two-wire transmission system with a minimum power supply voltage of 12.5 VDC.
- ix. The transmitter electronics shall be microprocessor based.
- x. The electronics system shall be provided with a reverse polarity protection circuit.
- xi. Zero and span shall be non-interacting, easily and continuously accessible. The external adjustment(s) should be provided with an environmental protection cover. Pressure gauges and transmitters shall have primary isolating valves, 2 or 3-way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.
- xii. The transmitter shall be provided with integral digital indicator with scale identical to the calibrated range as indicated in the instrument data sheet.
- xiii. The performance of the transmitter shall be as follows:
 - The transmitter accuracy including combined effect of linearity, hysteresis and repeatability shall be equal to or better than $\pm 0.25\%$ of calibrated span

3.9.4. Residual Chlorine Sensors & Transmitters

- i. Measurement of total free chlorine residual is important to allow chlorine dosing to be controlled to ensure that water supply is adequately dosed to ensure satisfactory disinfection but not excessively dosed which is wasteful of chemicals. Total free chlorine monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- ii. The transducer assembly shall comprise the sensor and any mounting hardware required. The system shall not require chemical reagents to make measurements. The sensor shall measure the concentration of free chlorine by amperometric principles. Total free chlorine shall be in the form of hypochlorous acid contained in the medium, which shall diffuse through the sensor membrane. Once

inside the sensor, the hypochlorous acid is reduced to chloride ions (Cl-) at the cathode, whilst at the anode, silver is oxidized to silver chloride. A current flow results from the electron release at the cathode and electron acceptance at the anode. The current flow is proportional to the total free chlorine concentration in the medium under constant conditions. The concentration of hypochlorous acid in the medium depends on the pH value. Accordingly, the sensor shall incorporate a pH sensor and the transmitter shall adjust the free chlorine measurement to compensate for pH. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure

- iii. The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate free chlorine residual and provide the option of displaying pH if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- iv. Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- v. The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.
- vi. Ingress protection shall be IP65 as minimum.
- vii. The transmitter output signal shall be 4-20 mA with LoRaWAN superimposed.

3.10. Valve Chambers, Thrust Blocks, Anchor Blocks, Pipe Supports, Pipe Ducts, Pipe Encasing etc.,

The Contractor shall build Pipe Supports, Pipe Ducts and such other miscellaneous structures that may be required at the locations shown by the Project Manager and as shown in the drawings or as may be otherwise specified or directed. The specifications of these ancillary structures shall be as per requirement, unless otherwise specified in this Section or advised by the Project Manager based on the site conditions.

The various structures shall be built as the pipe laying progresses and the Project Manager at his discretion, may stop work entirely on the laying of pipe or construction of other structures, until the construction of the structures already approved by the Project Manager are completed by the Contractor.

3.10.1. Pipe encasing

Where pipes are laid below storm water drains, at road crossings and where the depth of cover is less than 1.0m, the pipeline shall be encased & bedded as per the construction drawing.

3.10.2. Thrust Blocks and Anchor Blocks

Thrust blocks shall be provided for both horizontal and vertical bends for DI pipes wherever required in the pipeline to effectively transfer the hydrostatic thrust developed to the surrounding ground. They shall be constructed at the locations shown in the construction drawings and are of the respective dimensions shown therein depending on the angle of the bends, and the pressures developed in the main. Anchor blocks shall be provided for gradients steeper than 16%. All the thrust blocks and anchor blocks are of M20 grade concrete. The surrounding virgin land of the thrust blocks shall not be disturbed, to effectively transfer the thrust developed in the main. The Contractor should make his own

arrangement for any dewatering or bailing out of water. The contractor has to submit the design and drawing for the approval of the Project Manager before execution of the item.

3.10.3. Valve chambers

RCC valve chambers with precast /cast in-situ RCC slabs shall be provided for all Air valves, Scour valves and Sluice Valves of various sizes and all field level smart instruments. The locations and dimensions of valve chambers shall be as per the approved construction drawings. The construction of valve chamber includes earthwork, dewatering wherever necessary until completion of chamber, concreting, centering, shuttering, steel reinforcement etc. with necessary finishing's required to complete the work as shown in drawings and as directed by the Project Manager. The contractor has to submit the design and drawing for the approval of the Project Manager before execution of the item. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

3.10.4. Pipe Supports

Pipe supports shall be of saddle type. Pipe supports shall also be provided for the stretches of the pipe, where the pipe is to be gradually brought above the ground for crossing any obstructions as shown in the drawings. Pipe supports shall be placed at 2.5/5.0m center-to-center depending upon the pipe material and length of pipe available.

The dimension of pipe supports for pipelines of various diameters shall be as per approved drawing and shall have sufficient height above ground to be able to support the pipe. MS clamps of 8 mm thickness, 50 mm width, conforming to IS: 2062 shall be provided all-round the pipe and fixed to the pipe supports using appropriate means as shown in the drawings or as directed by the Project Manager. The clamps shall be provided with one coat of Zinc coating.

There shall be no joints at the location of the pipe supports. The joints shall be located on any one side of the support, at a minimum distance of 200 mm from the face of the support. The contractor has to submit the design and drawing for the approval of the Project Manager before execution of the item.

4. Sewerage & Storm Water Drainage Network

4.1. General

- i. For sewerage infrastructure, only Sulphur Resistant Cement shall be used

4.2. RCC Pipes

4.2.1. Quality Assurance steps to be taken at site

Precast Concrete Pipes (with Reinforcement) Socket and Spigot NP4 as per IS 458:2003

4.2.2. Check of Documentation

The Executive at site should obtain the following documents from the Agency and Agency should obtain the same from the Supplier of pipes:

- i. Certificate to the effect that the Precast Concrete Pipes (with Reinforcement) Socket and Spigot NP3 pipes have been manufactured strictly as per IS code IS 458: 2003. This Certificate would include Manufacturer's Test Certificate and Test Reports
- ii. Conduct a check to ensure that each pipe is clearly and indelibly marked in ink/paint or embossed on white base as under. The following markings should be on all procured pipes/collars:
 - Identification of the source of Manufacture
 - Class and size of S&S pipe
 - The words 'SPUN PIPE' or 'VERTICAL CAST (REINFORCED)' as may be applicable, for pipes

- Date of manufacture
 - BIS Certification Marking
 - Any other marking which would be prescribed by the Employer.
- iii. The above information shall be clearly marked on outside for pipes up to 300 mm internal diameter, and both outside and inside for pipes above 350 mm internal diameter.
- iv. Obtain from the manufacturer a Certificate indicating the details relating to quality, quantity and dispersion of steel in the pipes as well as the clear cover to the steel provided in the pipes. (Clause 6.2.3 of IS 458:2003).

4.2.3. Classification

Table D-3: Classifications of RCC Pipes

Class	Description	Conditions Where Normally Used
NP3	Reinforced (in case of pipes manufactured by vibrated casing process) concrete, medium-duty, non-pressure pipes	For drainage and irrigation use, for cross drains/culverts carrying medium traffic
NP4	Reinforced and also Non-reinforced (in case of pipes manufactured by vibrated casting process) concrete, heavy-duty, non- pressure pipes.	For drainage and irrigation use, for cross drains /culvert carrying heavy traffic

4.2.4. Sampling for Physical Characteristics

i. Scale of Sampling (as per IS 458:2003)

Table D-4: Sampling of RCC pipes

Nos of pipes in the Lot	For requirement under Clause 8 & 9		Sample size for Test under Clause 10.2 (Excluding Ultimate load test)
	Sample Size	Permissible Nos of Defects	
Up to 50	8	0	2
51 to 100	13	1	3
101 to 300	20	2	5
301 to 500	32	3	7
501 and above	50	5	10

- ii. Dimensions, Workmanship and Finish (Clause 8 & 9 of IS 458:2003)
- iii. Hydrostatic test, Three-edge bearing test and Permeability test (Clause 10.2 of IS 458:2003)
- iv. In any consignment, all the pipes of same class, same size and belonging to the same mix of concrete shall be grouped together to constitute a lot.
- v. For ascertaining the conformity of the material to the requirements of this specification, samples shall be tested from each lot separately.
- vi. A pipe failing to satisfy one or more of these requirements shall be considered as defective.
- vii. The lot shall be declared as conforming to these requirements if the number of defectives found in the sample does not exceed the number of defectives given in Column 3.
- viii. To ascertain reinforcement, pipes may be broken from different locations.

4.2.5. Dimensions (Clause 8 of IS 458:2003)

A check of the following physical characteristics will be carried out of samples as listed above:

- i. All the pipes selected shall be inspected for dimensional requirements, finish and deviation from straight.
- ii. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

4.2.6. Workmanship and Finish (Clause 9 of IS 458:2003)

- i. Pipes shall be straight and free from crack except that craze cracks may be acceptable.
- ii. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench, no opening between ends in contact shall exceed 3 mm in pipes up to 600 mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.
- iii. The outside and inside surfaces of the pipes shall be dense and hard and shall not be coated with cement wash or other preparation.
- iv. The inside surface of the pipe shall be smooth.
- v. For better bond, inner surface of the collar may have rough finish.
- vi. The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.
- vii. Pipes shall be free from local dents or bulges greater than 3.0 mm in depth and extending over a length in any direction greater than twice the barrel wall thickness.
- viii. Pipes may be repaired, if necessary, because of accidental injury during manufacture or handling and shall be accepted if in the opinion of the Engineer, the repairs are sound and appropriately finished and cured, and the repaired pipe conforms to the requirements of this specification.

4.2.7. Deviation from Straight

The deviation from straight in any pipe throughout its effective length, tested by means of a rigid straight edge as described in IS 3597 shall not exceed, for all diameters, 3 mm for every metre run.

4.2.8. Tests to be conducted at two Laboratories

The following tests are to be got conducted from an authorised and reputed NAB approved labs:

- i. The specimens of pipes selected in accordance with 10.1 of IS 458:2003 shall be subjected to the following tests in accordance with IS 3597:1998
 - Permeability Test
 - Hydrostatic Test
 - Three-Edge Bearing Test
 - Split Tensile Tests of concrete cylinder (5.5.2 of IS 458:2003) made from the concrete used for the pipes.
 - Absorption Test
- ii. Rubber Ring chords used in pipe joints shall conform to Type-2 of IS 5382.:1985

4.3. Precast concrete box section

4.3.1. Scope

These guidelines cover the requirements related to Precast Concrete Segmental Box Culverts / Storm water conveyance. These guidelines deal with the construction methodologies for single-cell (or) multi-cell precast reinforced concrete box sections cast monolithically (or) partly and proposed for use in the construction of culverts and for the conveyance of storm water.

4.3.2. Specifications

- The precast concrete box culvert / drain shall be strong, durable and manufactured in a controlled environment to ensure accuracy of dimensions and quality of the product. Precast production eliminates traditional on-site construction problems caused by substandard materials, uncertified craftsmanship, improper curing and bad weather, honeycombing in concrete, untimely and improper finish of the components.
- The concrete mix properties and cover for precast segmental box section shall be minimum M25 (placed over a compacted PCC 1:3:6 base)
- The precast concrete box culvert shall be strong, durable and manufactured in a controlled environment to ensure accuracy of dimensions and quality of the product. Precast production eliminates traditional on-site construction problems caused by substandard materials, uncertified

craftsmanship, improper curing and bad weather, honeycombing in concrete, untimely and improper finish of the components.

- The concrete mix properties and cover for precast segmental box section (placed over a compacted PCC 1:3:6 base) shall be selected depending on whether it is placed under footpath or below the carriageway.
- When ordering box culverts to casting yard or a separate manufacturing unit, specifications to be followed shall be given in writing and shall include:
 - Specifications for the PCBC
 - Name and location of the project
 - Box size, laying length and the bury depth
 - Design live load
 - Type of joint of two units
 - List of fittings
 - Material test requirements
 - Joint material and quantity

4.3.3. Bed Protection

For other structures, the precast box shall be placed on plain cement concrete (PCC) of M10 bed of adequate thickness so as to contain the bearing pressure within safe / allowable bearing capacity of the soil below the structure. However, the PCC bed thickness shall not be less than 75 mm.

4.3.4. Structural Design

Designs shall depend on project requirements and applications. The precast concrete segments shall also be designed for handling and erection stresses based on the method of construction or site conditions. Box culverts can be designed to any standard or custom size and strength, including capability for withstanding anticipated loads. The precast concrete segmental box culvert shall be designed for the required forces. The dimensions of top slab, bottom slab and web shall be finalized on the basis of designs and project requirements.

4.3.5. Foundation

Box culverts are most suitable, where safe bearing capacity of soil is less than 10t/m². Where there are purely clayey strata, the top 900 mm below box should have granular material, like, sandy murum or stone dust. Where there is murum and mixed soil having Φ more than 15°, there is no need of providing sandy layer. Foundation requirement shall be as per the design, loading and site conditions. Segmental Precast Concrete Box cell can also be placed on the prepared concrete bed of required strength. *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*

The techniques for handling precast units should aim for successful fabrication, delivery and installation without causing structural damage, detrimental cracking, architectural impairment or permanent distortion

The aggregates shall be sized, proportioned and mixed with such proportions of cementitious materials and water as will produce a thoroughly-mixed concrete of such quality that the box will conform to design requirements. All concrete shall have a water – cementitious material ratio not exceeding 0.45 by weight.

The box sections shall be cured for a sufficient length of time so that the concrete will develop a specified compressive strength in 28 days or less. The concrete box shall be cured by steam curing or water curing or membrane curing.

The base, sub-base and sub-grade shall also be as per the intended usage of box culvert, traffic over it and invert level.

4.3.6. Construction Methodology

4.3.6.1. Types of Manufacturing Methods

There are two main methods of casting of PCBC. These are

- i) Dry cast (Machine Made)
- ii) Wet Cast

4.3.6.2. Dry Cast Method

In this method precast segments are cast using mechanized equipment. Form vibrators consolidate zero-slump concrete between core and jacket. Hole formers can be incorporated, or sometimes coring is resorted to as may be needed. The Precast Concrete segment is immediately stripped and the form is reused. Segments are typically cured in a curing tank, or moisture curing is used.

4.3.6.3. Wet Cast Method

In this method, the precast concrete segments are typically cast on using an inner and outer form. Forms shall be cleaned of concrete build-up after each use. Block outs/hole formers can easily be incorporated before concreting. The segments are cast using conventional concrete or self-consolidating concrete.. Precautions shall be taken to ensure that the reinforcement does not move significantly during the casting operations. The segments are cured in the form.

IS:15916:2010 gives various accepted methods of manufacture of precast units. These have been broadly classified as:

- a) The 'Stand Method' where the moulds remain stationary at places, when the various processes involved are carried out in a cyclic order at the same place, and
- b) The 'Flow Method' where the precast unit under consideration is in movement according to the various processes involved in the work which are carried out in an assembly-line method.

Any method which is suitable to the project and site requirements shall be adopted.

4.3.6.4. Curing methods

Moist/wet curing, steam curing or Membrane curing shall be adopted as per IRC:112

4.3.6.5. Identification and Marking

All precast units shall bear an indelible identification, location and orientation marks as and where necessary. The date of manufacture shall also be marked on the segments. The identification markings on the drawings shall be shown in a table on the setting Section together with the length, type, size of the unit and the sizes and arrangement of all reinforcement for easy identification of the segment.

Dimensions of the precast segmental box unit shall conform to the design requirements. The transportation/shifting of the pre-cast elements shall be carried out only after achievement of minimum strength of 20 MPa or 0.7 times the compressive strength of concrete. The strength of concrete shall be tested as per IS:516.

The delivery and off loading of precast concrete box culverts segments should be well planned. A suitable hard access that can be used safely by standard delivery vehicles and a suitable crane of adequate capacity shall be provided in the casting yard. The pre-cast concrete segments shall be properly cured to ensure achievement of appropriate strength.

4.3.7. Handling

Products shall be stored, handled shipped and unloaded in a manner to minimize damage. The handling process encompasses the demoulding of the precast units, their loading and transportation to storage areas, offloading and storage, transfer to site and site erection. To avoid excessive stresses and possible damage, all precast units should be handled in the manner as envisaged in their design by means of approved devices, identified in the production and erection drawings.

4.3.8. Lifting Equipment, Accessories, Storage, Transportation and Installation

Lifting holes or inserts shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose. Lifting equipment such as mobile crane, gantry crane, forklift etc. must be carefully selected to ensure that lifting of precast units is carried out within the rated capacity of the equipment. The support for the lifting equipment must be checked to ensure that adequate supporting capacity is provided. Lifting accessories may comprise combinations of lifting beams or frames, slings or cables, hooks or shackles. The selection of each of these components should be predetermined to take account of the forces exerted on them due to various aspects of the lifting operations.

A person suitably qualified in accordance with the relevant regulations must regularly inspect all lifting equipment prior to and after use. Results of such inspections must be properly recorded and be available for subsequent inspection. The location of lifting points should be clearly indicated on the drawings. Lifting methods may differ from different manufacturers and the same shall be agreed upon. Verticality or otherwise of the lifting ropes shall be as per the design requirements. During operation of lifting and unloading the precast concrete box culvert segment shall be protected from damage particularly the joining surfaces. Also, due care shall be taken for safety of the crew during this operation.

4.3.9. Factory/Casting Yard and Site Storage

Storage areas must be large enough so that the precast units can be stored safely, with adequate room for lifting equipment and transporting vehicles to manoeuvre. The ground of the storage area must be hard, level, clean and well drained to permit organised storage. Precast segments can be damaged by incorrect stacking and storage. Where the locations of support points for a precast unit are critical, the locations for the supports should be noted on the shop drawings.

Supports must be arranged to avoid twisting or distorting of the precast segments and must be adequate to transfer the weight of the stacked units to the ground without excessive settlement.

The stored and stacked units should be protected to prevent accidental damage and discolouration and the support material should be non-staining. Lifting points should also be well protected and kept accessible while the units are in storage. Precast segments must be stored safely with adequate supports such that it would not endanger any workers moving in the vicinity.

4.3.10. Transportation

Commonly precasting yards are at a distance from the project site where in these segments are to be used. Hence, it is necessary to transport them from casting yard to the construction site.

Transportation requirements will need to be met and permits, where applicable, obtained. Transportation must comply with the appropriate regulations. The precast units should have gained sufficient strength before being loaded for transportation.

4.3.11. Loading and Storage on Transporters

Precast units must be loaded carefully on to delivery vehicles to prevent damage. To protect the edges throughout their journey, proper devices should be used to support, secure and wedge the precast units. The units should be adequately secured and supported to prevent them from overturning, shifting or being damaged during transportation. Adequate non-staining cushioning should be provided between the unit and any securing chains, cables or ropes to prevent localised damage.

Precautions should also be taken to ensure that no undesirable stresses will be transmitted to the precast unit due to any flexing of truck or trailer.

4.3.12. Erection Preparation

Consideration should be given to the following items to ensure safe and efficient installation of the precast elements in accordance with the design intent. For designing erection of precast concrete segments, provisions of Sub clause 11.10 of IS:15916:2010 shall apply.

4.3.12.1. Propping and temporary support details

If the sequence of erection is critical to the structural stability of the structure, or for access to connections at certain locations, it should be noted on the drawings. The erection drawings, which should include all relevant information, should be prepared prior to the commencement of any erection during Erection Safety.

Safety during the handling and erection of precast concrete elements is of paramount importance and compliance with the relevant current regulations is required.

All equipment used for the handling and erection of a precast element must be maintained to a high standard, load tested as necessary, and be suited to the intended use. Consideration should also be given to the site environment particularly with regard to built up areas and implications this may have on erection safety.

4.3.12.2. Erection sequence

Precast segments should be erected in accordance with a pre-planned sequence as detailed in the erection drawings. This sequence of erection should be such that the multiple handling of elements is minimised. A trial erection operation should be considered to identify any unforeseen erection difficulties.

4.3.12.3. Missing or Damaged Lifting Inserts

If missing, faulty or incorrectly located lifting inserts are identified, the designer should be contacted immediately to assess the problem and decide on an alternative lifting system. It should be verified, where permanent fixings or connections are temporarily used during construction, that the fixings are suitable for the temporary use and their long-term performance will not be compromised

4.3.13. Bedding Details

Bedding details for box segments shall be as designed and specified. Proper support for a box culvert consists of specified bedding material having uniform flat surface as low or high points could create stress concentrations in the box after installation. The box segment, once installed, will not normally settle; it cannot be forced down to grade. Coarse bedding materials are not beneficial due to their irregular shape and sharp angles; instead medium to fine granular material should be used if concrete bedding is not used. A bedding thickness shall not be less than 75 mm. The width of the bedding material should equal the width of the box (span plus twice the wall thickness) and the length of the bedding material should equal the length of the box. In the event that the levelling course consists of layers with the upper layer being clean, uncompacted sand, that layer shall be a maximum thickness of 50 mm to prevent non-uniform settlement from personnel and equipment during the installation process. If rock strata or boulders are encountered under the box section, the same shall be removed and replaced with additional levelling course material. A concrete slab is not considered as an appropriate leveling course *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*.

The box will tend to pull some bedding material toward the connection as it is aligned with the previous box segment. Excess bedding material trapped in the joint will prevent a proper alignment and connection and hence should be prevented. Therefore, at the connection end, a small trench should be dug. This allows for the bedding material to fall into the trench instead of the joint when the box is pulled into place. All bedding material characteristics should correspond to code and

designer's plans for the specific project. Correct installation requires that the box culvert be installed on properly graded bedding. Any discrepancies in the installation of the culvert regarding bedding or grade should be addressed with the designer for remedial action

4.3.14. Box Alignment during Installation

It is critical that the first box segment should be installed correctly as it will determine the line and grade of the following boxes/segments. If these are not correct, future connections may be affected. The trench/bed shall be checked for line and gradient.

4.3.14.1. Box Placement

A box culvert line shall be usually laid from downstream end and suitable joint sealing arrangement should be made. Placement of boxes should start at the outlet end of the line of box sections. The bell end should point upstream and the spigot or tongue should point downstream. Unless otherwise approved by the owner, loads from construction equipment transferred to a box section before, during, or after fill placement, either directly or through the fill, should not be greater than the loads assumed in the design. Using excavating machinery for the purpose of pushing boxes into place should be avoided, since this could cause cracking, requiring on-site repairing.

Also, dropping or dragging the section over gravel or rock shall be avoided. A proper foundation for construction equipment should be available on site in order to ensure that no damage is caused to the levelling course and the sidewalls of the excavation area. PCBC shall be placed properly on the constructed base. The base shall be firm to avoid settlement of the units after loading. Bedding shall be properly designed. Improper bedding could prevent the tongue of the box from being properly inserted into the groove. It is very important that time be spent to ensure the box culvert bedding preparation is done correctly.

4.3.14.2. Joints Sealing

Many methods for jointing and sealing are available. The joints and sealing of units shall be as per the design or project requirements. The design of joints shall be made in the light of their assessment with respect to feasibility, practicability, serviceability considerations as per IS: 15916:2010

Normal joint is socket and spigot joint and same is generally used in culvert construction. Jointing is important in reducing the migration of soil fines and water between box sections and their surroundings. Depending on the use of the box culvert, various materials and methods may be used for sealing the joints. Box culverts specified for a soil-tight joint can be sealed between the joint with a bituminous mastic sealant. Either liquid butyl (bulk mastic) or non-shrink grout can be added to the outside top slab and applied down the sidewall 300 mm as well as applied to the inside bottom slab and inside sidewalls; or butyl sealant 25 mm thick and placed on the inside bottom and halfway up the sides of the bell end (approximately 13 mm from edge) and placed on the outside top and halfway down the sides of the spigot end (approximately 13 mm) from edge can be used to seal a soil-tight joint. In cold weather it may be necessary to heat the butyl sealant with a hot water bath, bottle gas torch, or both. Placing this joint material in a sunny location, just prior to use, will allow heat absorption and make it more workable. Different grades of joint material are available for different temperatures.

Another joint commonly used is an extruded sealant which is placed between the joints. The extruded sealant can be applied in the same manner as the bituminous sealant, applied to the bell and spigot end of the sections being joined. In some areas, rubber gasket box joints may be available. Pre-made foam gaskets can also be used to seal joints. However these forms of sealant will have to be manually attached to the bottom of the spigot end of the box to prevent sagging. If the seal is insufficient then an added layer of adhesive joint wrap (butyl rubber laminated to polyethylene vapour retarder) can be used on the outside of the box to prevent infiltration.

Backfilling should commence as soon as possible after the Precast Concrete Segmental box culverts have been placed by filling the trench evenly on both sides with a drainage layer of min 600 mm thickness and rest by using approved materials in layers not exceeding 200 mm. Backfill should be placed in uniform layers along the sides of the boxes and over the top of the box sections wherever required. The backfill material should not contain debris, organic matter, or large stones with a diameter greater than 1/2 the thickness of the compacted layers being placed. When vibratory compactors are used to compact the backfill material, care should be taken to avoid damage to the Box cell. In sections in cutting where space is a constraint, the back filling shall be done with granular material like coarse sand/gavel. Lift holes shall be properly sealed and plugged *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*.

Construction machinery shall not be used over the box culvert without proper protection. Care must be taken since site traffic and construction equipment over shallow fill depths can impose loadings greater than those for which the finished box culvert has been designed. If construction equipment is going to travel over installed box sections, a temporary compacted backfill should be placed to a minimum of 1 m over the top of the box section unless the box has been specifically designed for the anticipated construction loads. The loads applied to the box section should not exceed those specified by the designer. In an embankment installation, the minimum amount of backfill should extend one box section span or 1 m, whichever is larger, in each direction to prevent lateral displacement.

Made up of separate segments that are assembled in the field to make the final structure, segmental box sections are being used in building culverts for underground conveyance of storm water. In addition, culverts can also function as pedestrian tunnels as well as wildlife passage areas under heavily travelled highways.

Equipment used- Equipment used for precast concrete segments shall satisfy the requirements stipulated in IS: 15916:2010

4.4. Precast RCC Manholes

It is proposed to provide circular and rectangular manholes as per the standard drawings. The general construction of the manhole shall be RCC Precast manholes as per the approved drawings. The contractor will be responsible for ensuring the procurement and placement of the precast elements in position without any damage. The jointing of the various elements will be made so as to achieve the required water tightness. RCC pre-cast and RCC cast in situ elements shall be tested in accordance with the provisions of IS456:2000.

The manholes shall generally conform to I.S. 4111.RCC works shall generally conform to IS.456-2000. The location of manholes shall be as per the approved drawing or layout given by the Employer or as directed by the Engineer. The Manhole dimensions and other details shall be as per the approved drawings. The Contractor, while constructing the manholes, shall suitably provide PVC-U pipe connection lines for the house sewer connection to prevent the undue breaking of man hole or road in future, as directed by the Engineer.

Pre-cast RCC M – 40 manhole & sewer chambers shall be procured / constructed simultaneously with the laying of sewers as per approved drawing and detailed specification.

RCC precast manholes shall be constructed as per approved drawings.

In case of Pre-cast RCC manholes, design mix concrete of grade M-40 shall only be used for the precast manhole elements as per approved drawings.

The Contractor shall provide steel reinforcement as per design requirement in each Pre- Cast M-40 Grade Circular Rings including Starter Base Wall at the bottom of the manhole chamber, subject to a minimum of nominal reinforcement as per Code of “Practice of Plain and Reinforced Concrete” IS:456

2000. No extra payment shall be made to the contractor on this part. The Contractor should therefore take provisions accordingly.

The Contractor shall study the design, drawings and specifications carefully and if felt necessary, may increase the sectional thickness, reinforcement or the grade of concrete suitably. No extra payment shall be made to the Contractor over the rates quoted by the Contractor for any modifications / changes proposed by him. The Contractor shall be fully responsible for the structural safety of the pre-cast manhole elements/components.

Any data or information received by the Contractor, from the Employer or otherwise, shall not relieve the Contractor from his responsibility for the design and execution and structural stability of the pre-cast elements.

All manholes shall be provided with cement concrete benching in 1:2:4 nominal mix. (1 cement: 2 coarse sand: 4 stone aggregate 20 mm nominal size). The benching shall have a slope of 1:6 towards the channel. The depth of the channel shall be full diameter of the pipe. Benching shall be finished with a floating coat of neat cement *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*.

The safety steps in the Manhole shall be of Plastic Encapsulated Steel reinforced.

4.4.1. Manhole Frame and Cover

Steel Fibre Reinforced Concrete (SFRC) frame and cover shall be used for covering the manhole.

The selection of samples per lot for testing, failure percentage, no. of test, Concrete mix curing, etc shall be as per IS 12592 (part-I) for Pre-Cast Concrete Manhole Cover. The load of class AA shall be as per IRC guidelines.

The Manhole cover shall be heavy duty and shall confirm to IS 12592 (Part I & II). The inspection and testing for these shall be done by Third Party agency also in the presence of Engineer. The load test shall be done in accordance with Table 1 of IS 12592 (Part – I). The cover & frame shall be manufactured as per standard specifications.

4.5. House Service Connections/ Property Connections

House service connections shall be provided to collect sewage / effluent from individual plots.

The pipeline shall be laid from the property boundary / inside of property boundary to the nearest manhole. The Contractor has to do the survey for house service connections from the Nearest Manhole to the property boundary / inside the property boundary. This shall be done along with the sewer alignment survey and to be submitted for approval of Project Manager at least 4 weeks prior to the commencement of work. All the property connections shall be done simultaneously while sewer lines are laid in a particular road/area.

The uPVC Pipes of 160 mm dia shall be confirming to IS 15328:2003. The Nominal Ring Stiffness (SN) for these pipes should be 8 kN/m² and Standard Dimension ratio (SOR) should be 34. The jointing should be with Elastomeric Rubber Rings (Ring Stiffness ≥ 8) with socket and spigot fittings. The rings shall be in accordance with one of the type (Type 1 to 6 as per IS 5382). The manufacturer however will specify the type of ring. The providing plot service connection work is also including earthwork excavation in all types of soil, road cutting in all types of soil, refilling, disposal of unserviceable materials, restoration road work as required etc complete.

These pipes are proposed to be used for laying the house sewer connection from the man hole to the boundary of premise of the consumer and will be done under this. Contract. The pipes are to be laid generally to serve one consumers with size of 160 mm with slopes not less than 1 in 50. The

consumer end will be provided with inspection chamber and the consumers are expected to connect their plot outlet to the inspection chamber.

4.6. Double Walled Corrugated (DWC) Pipes

Class SN 8 Structured Double Wall (Non-Smooth External Annular Corrugated wall & Smooth Internal wall) Polyethylene Piping System for non-pressure underground Sewerage & Drainage Applications

4.6.1. Scope

This specification covers the requirements for manufacturing, supplying, transportation, handling, stacking, installation, jointing, and testing of Class SN-8 Structured Double Wall (Non-Smooth External Annular Corrugated wall & Smooth Internal wall) Polyethylene Piping System for non-pressure underground Sewerage & Drainage Applications herein after called the DWC PE Piping System.

4.6.2. Applicable Codes

The manufacturing, testing at factory, supplying, transportation, handling, stacking, installation, jointing, and testing at sites shall comply with all currently applicable statutes, manuals, regulation, standards & codes. In particular, in addition to all relevant National Standards, following International standards with latest revisions shall be referred. If requirements of these specifications are at variance with any other standards, this particular document shall govern the proceedings.

EN 13476-1	Plastics piping Systems for non-pressure underground drainage and sewerage- Structured-wall piping systems of Polyethylene (PE) Part 1 : General requirements and performance characteristics
EN 13476-3	Plastics piping Systems for non-pressure underground drainage and sewerage- Structured-wall piping systems of Polyethylene (PE) Part 3 : Specifications for pipes and fittings with smooth internal and profiled external surface and the system, Type B

Other International Codes/ Standards (EN/ ISO) which are integral part of above two standards as normative references form a significant portion of this specification document.

4.6.3. Manufacturing

The DWC PE Piping System of stiffness class designation SN 8 shall confirm to the European Union standards as mentioned above. Each pipe shall be coupler (on-line or off-line) and spigot type along with rubber sealing ring (as designated under above international specifications).

4.6.4. Transportation

The arrangement of loading the pipes in a telescopic manner is advised, i.e. smaller diameters inserted into the next higher sizes of pipes. While loading the pipes onto the truck, care should be taken that the coupler- end should be arranged alternatively in the corresponding layers so as to avoid the damage to the coupling/ socket ends

4.6.5. Handling

Following Recommendations shall be followed while handling the pipes:

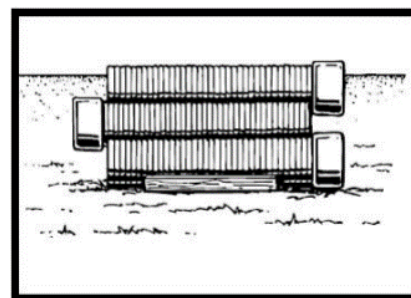
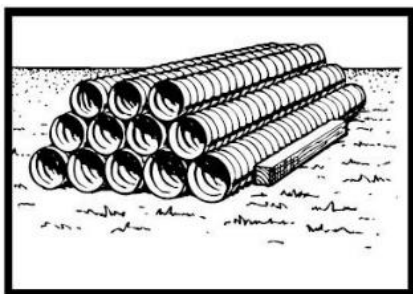
- i. Adherence to National Safety requirements
- ii. Pipes to be smoothly lowered to the ground
- iii. Pipes should not be dragged against the ground to avoid the damages to the Coupler/pipes.
- iv. 800mm and larger diameter pipes are carried with Slings at two points spaced approximately at 3 Meters apart

- v. For smaller diameters (400mm 800mm) one lift point shall be sufficient & can be handled either manually or mechanically
- vi. Do not use a loading Boom or Fork Lift directly on or inside pipe.

4.6.6. Pipe Storage at Site

- i. Stockpiling shall be done temporarily on a Flat Clear Area as per **Error! Reference source not found..**
- ii. For avoiding collapse of Stacks, use Wooden Posts or Blocks
- iii. Stacking shall not be higher than 2.5 Meters
- iv. While stacking, alternate the socket/coupler ends at each row of stacked pipes as per **Error! Reference source not found.**

Figure D-2: Pipe storage of DWC pipes



4.6.7. Lowering, Laying & jointing of Pipes

The width of a Sewer Trench depends on the soil condition, type of side protection needed and the working space required at the bottom of Trench for smooth installations. Increase in width over required minimum would unduly increase the load on pipe and cost of road restoration. Considering all above factors, the Minimum Trench Width is specified as per Table below

Table D-5: Indicative Minimum Trench Widths for DWC Pipes

Pipe Diameter (mm)	Trench Width (m)
75-170	0.6
250	0.7
400	0.9
600	1.2
800	1.3
1000	1.8

****In actual practice the trench width can be as narrow as possible but adequate to allow the workmen to execute the job satisfactorily.**

The pipe segment between two manholes shall be laid approximately in straight line without any vertical undulations. However, on the strength of its flexibility, the DWC PE Piping system can be laid in very smooth curve if found necessary. The piping system shall rest on the carefully prepared bedding portion of the Backfill Envelope and at appropriate jointing locations the trenches shall be excavated deeper to accommodate the bulges of coupler-spigot joints. However, special care shall be ensured as mentioned below:

- i. Excavation of trenches shall be carried out in accordance with the drawing & specifications and as directed by the field engineer as well.
- ii. The piping system shall be laid and jointed in true to gradient with the help of sight rails and boning rods as detailed in CPHEEO, MoUD, GoI Manual on Sewerage and sewerage treatment. The levels need be checked with calibrated modern Levelling Instrument. Specific care shall be taken to prevent entry of sand / mud /slush/ any other foreign material etc into the system during the installation operation.

The structural property of the system suggests that a minimum cover of 300 mm adequate even for maximum quantum of superimposed (live) load. In case of wider trenches than required (above table),

the permission of the competent authority shall be necessary.

The bedding area is an essential portion of Back fill Envelope and shall be constructed with proper bedding material as computed in accordance with appropriate international code of practice for structural bedding design mentioned in the list of normative references under EN 13476. The bedding shall be laid to specified thickness and gradient with proper manual compaction of the aggregate.

The moulded on-line coupler (or separate coupler integrated to the pipe in case of lower sizes) will have a suitable internal surface for push-fitting the said end over the spigot end of the next pipe. On first valley of the corrugation of said spigot end (destined to receive the pushed coupler) the sealing rubber ring of standard (EN 13476) quality shall be placed so that the coupler end of the pipe smoothly but tightly slides over the sealing ring for making an absolute watertight joint. Similar system is also used for fabricated accessories or moulded fittings required such as Tee, Bends, Elbows, Reducer end caps for the purpose of installation of the system related to drainage/sewerage.

4.6.8. Jointing

For quality connections following steps are to be ensured, failing which the performance aspects are to be severely compromised:

- i. The non-coupler (socket) end needs to be thoroughly cleared and shall be free from any foreign material
- ii. Clean and lubricate the coupler end of the pipe, if required. Lubricate the exposed Gasket in the same manner, if required.
- iii. Keep the non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised.
- iv. Push the coupler into non-coupler and align properly. Always push coupler end into non-coupler end.
- v. For smaller diameter pipes simple manual insertion shall be sufficient. It should be ensured that the coupler end is adequately "homed" with non-coupler end to ensure installation and tight joining seal. Therefore prior to insertion always place a "Homing Mark" on appropriate corrugation of the "Non Coupler End"

4.6.9. Construction of backfill envelope and final backfilling of the trenches

DWC PE Piping System with well compacted Backfill Envelope along with the bottom and sides of trench (native soil) work together to support soil overburden and superimposed (traffic) loads. The carefully constructed Backfill Envelope has three distinct but non-isolated stages (Ref. enclosed C/S Drawing III, Annexure I). The construction need to be done stage by stage as per the sequence stated below:

- i. Bedding portion
- ii. Up to Haunch level
- iii. Remaining portion

The material for backfill envelope shall be in accordance with the structural design of flexible buried conduit as per relevant international codes mentioned in the list of Standards as normative references of EN 13476 /1 & 3. It can be the same material that were removed in the course of excavation or it can be fine sand/course sand/gravel / moram /other form of course / fine aggregates depending on the effected Design Load [Overburden + Superimposed (Live) load]. However, in no circumstances, the flexible pipe should not be embedded in cement concrete (un- reinforced or reinforced) which invariably induces undesired rigidity in the system (*50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures*).

- i. The remaining portion of backfilling which do not contribute to the structural integrity of the system may be the materials that were removed in the course of excavation or any other foreign material as may be required to suit the particular site condition. These materials shall consist of at least clean

earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.

- ii. After completion of lying of pipes, etc, first the Backfill Envelope shall be constructed as per design around the pipe. Voids must be eliminated by knifing under and around pipe or by some other indigenous tools.
- iii. The compaction, by hand rammers or compactors with necessary watering to a possible maximum level of proctor density shall be ensured.
- iv. Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open.
- v. Precautions shall be taken against floatation (if at all necessary) as per the specified methodology and the minimum required cover.

4.6.10. Continuity Test /Hydraulic Testing

Continuity of the pipe segments in between two manholes is required to be ensured in the same modality as practiced for non-pressure RCC pipeline. Hydraulic testing of pipes shall be done, if specifically asked for by the client for any specific stretch. The procedure for hydraulic testing shall be similar to that for non-pressure RCC pipes.

4.7. Un-plasticized Non-Pressure Polyvinyl Chloride (PVC-U) Pipes and Fittings

4.7.1. Quality Assurance Protocol for PVC-U Pipes

PVC-U SN8 Non-Pressure Pipes as per IS 15328: 2003

4.7.2. Check of Documentation

As and when, the truck with the consignment reports to the Work Site, the Contractor on ground from the Supplier/Manufacturer should obtain the Certificate to the effect that the pipes have been manufactured strictly as per IS Code 15328:2003. This documentation will include Manufacturer's Certificate and the Test Reports. Normally, the driver of the consignment should be in possession of the said Certificate.

4.7.3. Sampling for Physical Characteristics Visual Appearance and Dimensional Requirements

Samples Required for Dimensional requirements as per IS 15328:2003

- i. If no Failure: Minimum 13 Nos and maximum 50 Nos
- ii. If Failure: Maximum 100 Nos
- iii. As per Table 13 Clause F-1.4.1 and F-1.4.3 of IS 15328:2003

4.7.4. Marking on the Pipes

Conduct a check to ensure that each pipe is clearly and indelibly marked in ink/paint or hot embossed on white base at intervals of not more than 3m as under

- Manufacturer's name/Trade-mark
- Outside diameter
- Stiffness class (SN8)
- Batch or Lot Number and Period of Manufacture
- BIS Certification Marking
- Any other marking which would be prescribed by the ULB

The above marking should be on all pipes.

4.7.5. Physical Characteristics

A check of the following physical characteristics will be carried-out of samples as mentioned above as per IS Code 15328:

i. Dimensions

Clause 6.1.1 to 6.1.4.1 of IS 15328:2003 (Dimensions tests will be conducted at storage site)

ii. Appearance

- Confirming to Clause 7.1 of IS 15328:2003
- The internal and external surface of the pipes should be smooth, clean and free from grooving, blistering and any other surface irregularity, which is likely to prevent conformance of the pipe with the standard.
- Slight shallow longitudinal grooves or irregularities in the pipe are permissible, provided the wall thickness remains within permissible limits.
- The pipe wall does not contain impurities or pores.
- The pipe ends should be clearly cut and reasonably square to the axis of pipe.

iii. Colour

- Confirming to Clause 7.2 of IS 15328:2003
- The colour of the pipe should be dark (any shade of brown)
- The pipe shall have uniform colour throughout the entire wall
- Slight variations in the appearance of the colour are permitted.
- Check for Cracks: Pipes shall be checked to ensure that during transportation they have not cracked and care shall be taken during unloading at site.
- Storage: Pipes shall be stored under shade and on already prepared levelled ground.

Notes:

- The samples for the lab tests would be signed and sealed by all concerned. This will ensure that no change can be made during transportation of samples. The samples required for lab tests will be as per (Table 14 Clause F-1.5.2 and F- 1.6.2 and Table 15 Clause F-1.7.2 of IS 15328:2003 (Three samples of one meter each are required for Resistance to Internal Hydrostatic Pressure Acceptance test (1 hr/27°C)

4.7.6. Tests required to be conducted at Laboratories

The following tests are required to be conducted at relevant laboratories as per relevant BIS:

- Vicat Softening Point (VSP)
- Longitudinal Reversion
- Resistance to External Blow at 0°C
- Ring Stiffness
- Resistance to Internal Hydrostatic Pressure
- Acceptance Test (1 hr/27°C)
- Type Test (1000 hrs/60°C)
- Internal Hydrostatic Pressure Test for Elastomeric Sealing Ring joints, Solvent Cement Joints. (applicable only for Pipe Joints)
- Internal negative Hydrostatic Pressure for Elastomeric Sealing ring joints. Solvent cement joints. (applicable only for Pipe Joints)

4.8. Field Level Smart Instruments

4.8.1. Overflow Sensors & Transmitters

- Ultrasonic level detectors shall be used for most situations where a continuous level measurement is required. The ultrasonic level detector system shall comprise a transducer, a separate transmitter unit and an interconnecting cable, operating on the time-of-flight principle.
- The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build-up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).

- iii. The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- iv. The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC with LoRaWAN superimposed and shall be proportional to the measured value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.
- v. The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall give a measurement of $\pm 0.5\%$ of the measurement span.
- vi. Ultrasonic Level Transmitter with two sensors and two analogue (4-20mA) LoRAWAN superimposed outputs.
- vii. Ultrasonic level transmitter with two separate sensors shall be used where a continuous differential level measurement is required. The ultrasonic level detector system shall comprise a separate two transducers, one transmitter unit with two analogue outputs and two numbers interconnecting cable
- viii. The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The
- ix. transducer shall not be affected by the measured liquid and shall be insensitive to dirt build-up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).
- x. The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. The transmitter shall have simple push button to alternate between readings of two sensors. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- xi. The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC, LoRaWAN superimposed and shall be proportional to the differential level. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

4.8.2. Dissolved Oxygen Sensors & Transmitters

- i. Dissolved oxygen monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- ii. The transducer assembly shall comprise the sensor and mounting hardware. Mounting hardware shall be provided for either rigid wall mounting, freely swinging suspended wall mounting or a floating installation with the float suitably anchored to a fixed location, as required by the application. The sensor shall be membrane covered amperometric type suitable for constant immersion, giving high O₂ selectivity and minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- iii. Also the sensor can be an optical sensor working on the fluorescence quenching principle suitable for constant immersion giving minimum maintenance and maximum availability. The sensor shall compensate for fluid temperature and air pressure. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- iv. The transmitter shall be microprocessor based and shall include an integral display and a simple
- v. push button user interface. The display shall indicate oxygen content and provide the option of

- vi. displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- vii. Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user **specified** curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- viii. The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.
- ix. Ingress protection shall be IP65 as minimum.
- x. The transmitter output signal shall be 4-20 mA with LoRaWAN superimposed.

4.8.3. Power supply to Field Instruments like Control valves, Pressure Transmitters, Level Transmitters, RTUs and online Analysers

- i. Power supply requirement for all control valves, RTU'S, field devices and accessories for Potable, Recycled and Sewerage network will be sourced from nearest feeder pillars.
- ii. Dedicated Power DB shall be provided for feeding power to field instruments. The power cables will be terminated to respective control valves, RTU'S, field devices and accessories of Potable, Recycled, and Sewerage network from RCC cable trenches through Double Wall Corrugated HDPE Ducts.

5. Water Pumping Stations and Intermediate Sewage Pumping Station

5.1. Induction Motors for Pumps

5.1.1. General

The motors for all the pumps shall be of suitable HP, 1450 RPM synchronous speed, TEFC, IP: 55 protection, squirrel cage induction motors continuous rated with "F" class insulation conforming to IS: 12615-2018 with latest amendments. The motors shall be suitable for operation on 3 Phase 50 Hz AC supply indoor application with variations as listed and shall be suitable for installation at an altitude as per site condition and 50o C design temperature.

Motors for VT pumps shall be of hollow shaft type vertically mounted so as to have direct coupling of pump shaft to the motor shaft. The total load of rotating parts shall be on top thrust bearing placed on top of the motors. Irrespective of where it spelled all the Motors shall be IE3 only, except for Submersible pumps and submersible mixers.

5.1.2. Codes and Standards

The design, manufacture and performance of the motor shall comply with all currently applicable statutes, regulations and safety codes in the area where the motors will be installed.

Unless otherwise specified the motors shall conform to the latest applicable Indian Standards as below:

IS :12615-2018 Induction Motors

IS : 4691 Degrees of protection provided by enclosures for rotating electrical machinery.

IS : 4029 Measurement and evaluation of vibration of rotating electrical machines. Guide for testing 3 phase induction motors.

IS : 900 Code of practice for installation and maintenance of induction motors.

IS : 1231 Dimension of 3 phase foot mounted induction motors

5.1.3. Performance

The motors shall be suitable for neutral connected FCMA soft starter. All six terminals shall be brought for this purpose. A separate terminal box shall be provided for the starter. Motor shall

also be suitable for direct on line starting and the starting current shall be limited to 5xI_r. Terminal shall be suitable for 25 KA fault level. Pull out torque of motor shall not be less than 2.1 times the rated torque. Starting torque shall be more than 0.80 times the rated torque.

The starting equipment offered shall be of proven design and shall be robust and can withstand number of starts in day. All the control equipment for selection of pumps to be started, and all interlock, indication and alarm and annunciation circuits shall be included in the scope of supply. All the protection and control circuits of starting equipment shall be incorporated in the system.

The motors shall be designed to allow the required number of consecutive starts.

The details to be furnished shall include efficiency and P.F. at no load, 50%, 75% and full load.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following cases of supply conditions.

Variation of supply voltage from the rated voltage $\pm 10\%$

Variation in supply frequency from the rated frequency $\pm 5\%$

Combined Voltage and frequency variation $\pm 10\%$ absolute

Motors shall be capable of starting and accelerating the load with the applicable method of starting without exceeding acceptable winding temperature when the supply voltage is 85% of the rated voltage. The locked rotor current of squirrel cage motors shall not exceed 600% rated current.

5.1.4. Features of Construction:

Terminal box shall be suitable for top and bottom entry of cables. Further it shall be capable of being turned through 360° in steps of 90°.

Motors shall have grease lubricated ball or roller bearings. Bearings shall be adequate to absorb axial thrust from the driven load together with any thrust produced by the motor itself.

Bearings shall be capable of grease injection from outside without removal of covers with motor in running condition. The bearing boxes shall be provided with labyrinth seal to prevent loss of grease or entry of dust.

The degree of protection of TEFC motors shall be to IP: 55.

The motors shall be complete with all other standard fittings.

Two earth terminals shall be provided for each motor. These shall be located outside the terminal box. These terminals shall preferably be on diametrically opposite points. A separate earth terminal shall be provided inside the terminal box.

The motor shall be provided with roller bearings at bottom and 2 Nos. of angular contact bearing at top to take care of the thrust due to self-weight of the rotor and provided with labyrinth ring seal in the bearing housing to prevent the entry of dust or water as per IS: 4691 standards. The rotor shall be dynamically balanced.

5.1.5. Testing:

The motors shall be subject to testing as per IS: 12615-2018.

5.1.6. Name Plate:

All motors shall have a stainless steel nameplate on the body.

5.1.7. Protections

The motors shall be provided with suitable protections including protection against reverse rotation, dry run protection, phase sequence change indicators, single phase preventor, RTD's, temperature rise protections etc.

5.1.8. Panting:

External parts shall be finished and painted to produce a neat and durable surface, which will prevent rusting and corrosion. The surface shall be degreased and all rust, sharp edges, scales be removed and treated with two coats of primer and finished with two coats of epoxy based final paint. Unless otherwise agreed the motors shall be painted with shade 631 of IS: 5.

5.2. Variable Speed Hydropneumatic System, With Vertical Inline Pumps:

5.2.1. Scope (Item Description)

The item includes the Pumps (Vertical/Horizontal centrifugal type), Pressure vessels, pressure switches, gauges, pressure transmitter on delivery manifold, pump suction & delivery piping, manifolds & valves, flexible bellows, Fixed speed/ variable frequency drive, control panels, Microprocessor based operation) and all accessories including installation, testing & commissioning.

5.2.2. Pump-Motor Set

5.2.2.1. Design & Construction Features

Inline vertical type centrifugal pump shall be provided. Variable frequency drive shall be provided with each of them

The pump motor set shall be suitable for 3 Ph., 415 V, 50 Hz. AC power supply and having 1500 / 3000 RPM speed. The pump shall be installed with isolation valve, non return valve, etc. The detailed specification for pump & motor is as below:

- The design and manufacture of the pump shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- The pump shall be capable of developing required total head at rated capacity. Impeller shall be closed type and shall be dynamically balanced. The pump shall have non overloading characteristics.
- The casing shall be of rigid construction and shall have side suction and side delivery in case of vertical multistage pump and side suction and central delivery in case of horizontal centrifugal pump.
- The pump shall have very small length suction and delivery pipe connections which will result in minimum friction loss.
- Impeller shall be of one piece and shall be of SS CF8 / SS 304
- The shaft shall be of S.S. and its surface shall be properly finished. Shaft sleeves shall be provided to protect shaft from any damage.
- Bearing shall be ball or roller type.
- Mechanical seal shall be provided to avoid any leakage.
- Pump shall be mounted on a concrete foundation, projecting at least 15 CM above finished floor level. The pumps base shall be set on an anti vibration pad.
- All the parts of the pumps that are in contact with water e.g. shaft, impeller etc. shall be hot dip galvanized or of stainless steel construction.
- Pumps shall be so selected that the design duty point is within 5% of the maximum efficiency point. Shut off head shall be 120% of duty point head.

- All pumps and motors shall be of minimum vibration and noise level during operation. Vibration isolators shall be provided for all pump sets.
- Facilities shall be provided to prevent starting of pumps when the water tank is at low water level. An indicator for this low water level alarm shall be provided.
- Facilities to select which pump to be duty pump and standby pump shall be provided and be interchangeable.
- Leakage from pump gland shall be drained to the nearest floor waste.
- Pump shall be driven by directly coupled squirrel cage induction motor having TEFC enclosure, IP 55 protection & shall be of Class F insulation.
- Pump motors above 7.5 kW shall be equipped with a spacer coupling which allows changing of shaft seals without removing the motor.

5.2.2.2. Inspection & Testing

The pump shall be offered for visual inspection before dispatch.

Material test certificates for the various pump components shall be furnished for purchaser's approval.

5.2.3. System Description

The system operation will be such that the initial small water demand shall be met by the charged diaphragm pressure vessel. When the water demand continues the system pressure will dip to a preset pump cut-in point when the lead pump starts to operate at reduced speed through the variable speed drive. However, if the system pressure is still below the pre-set value, the controller continuously increases pump speed to meet the system demand. When the lead pump is not able to meet the system pressure at full speed, the second pump also starts to operate.

At peak demand all the pumps operate, similarly, if there is a drop in water demand the duty pump speed starts to reduce, then standby pumps cut-off, followed by stopping of the duty pump.

The closed diaphragm pressure vessel shall be of polyethylene material with a pressure gauge and isolating valve. The interior shall be of non-toxic lining suitable for use with potable water. The vessel shall be manufactured to conform to ASME pressure vessel code/ standards.

The system shall be under the control of a microprocessor based control panel.

A pressure transmitter shall detect the pressure at the delivery manifold and feedback to the microprocessor control panel via control circuit.

The system shall incorporate a frequency converter or frequency converter motors on the pumps and the pressure transmitter shall register the actual pressure on the discharge side.

The variable frequency drive pumping system shall maintain a constant pressure regardless of the system demand. If there is a drop in pressure outside the preset point, the Variable Frequency Drive (VFD) pump shall start to run until the pressure increases to the preset limit, or it will continue to increase the pump speeds to the upper limit of the frequency. If the water system demand still cannot be met, the second pump shall be called in to run, the VFD will then alter the pump speed to meet the preset pressure point. If the set point is still unable to be met, the third pump is then activated to run (in case of 3 pumps units).

This shall be achieved by continuously varying the motor speed of the duty pump according to the demand up to a maximum designed capacity.

Under decreasing hydraulic demand the reverse sequence to the above description shall apply. Alternatively pumping system shall be with fixed speed drive motor. By getting the signal from

microprocessor based control panel through pressure transmitter, pumps will operate in sequence & vice versa.

The frequency converter shall be linked to the motor of the duty pump for continuous speed adjustment and ultimately the water delivery shall be maintained at constant pressure at the pre-set value.

5.2.4. Control Panel

The motor control panel shall be equipped with all the necessary electrical components including a microprocessor control unit and a frequency drive. The control panel and the microprocessor shall cover the followings functions.

Flexibility and simplicity in allowing the necessary re-adjustment of the pumping system pre-set delivery pressure to operate the pumps within the specified maximum and minimum delivery ranges.

Automatic changeover of the pumps to be controlled by the microprocessor which dictates the duty and standby pumps.

When the system has not been operated for more than 24 hours, it shall automatically start the pumps for a few seconds/ day to ensure the pumps readiness at all times. The standby pumps shall be activated upon failure of duty pump(s).

In event of control failure, the pumps shall be able to be start/ stopped manually at the local panel by means of pressure switches.

The microprocessor control panel shall be able to cut-off the pumping system when excess pressure is registered in the discharge common manifold.

The system shall have the capability of receiving input signal concerning reduced water level in suction tanks and shall have control mechanisms to prevent the pumps from running dry.

Automatically starting the pumps when the water level is back to normal.

In case of pump failure due to motor overload, the standby pump is switched on automatically. Alarm signal is displayed on the LCD Display unit and alarm lights are activated.

Functions to limit the no. of start/ stop of pumps per hour. The system control panel shall incorporate LCD Display.

5.2.4.1. Operation of Control Panel

Auto mode

- The desired delivery pressure within the range specified, shall be set at the control panel. The pressure transmitter shall detect the delivery pressure continuously and give feedback to the microprocessor which will control the variable speed drive frequency converter for speed control of the duty pump. When demand increases, the subsequent pumps in the system will be activated to boost up the pressure. Ultimately the duty pump set shall be operated fully automatically to maintain the delivery pressure constantly at the desired set value.

Manual Mode

- The on/ off function of the pumps shall be manually adjusted at the microprocessor located at the local control panel.

Frequency Control By-pass Mode

- All the pump sets shall be started/ stopped automatically with the pump output at fixed maximum rotational speed. All the control and protection functions shall remain active. The cut in/ cut out pressure shall be internally calculated by the microprocessor for each pump.

5.2.5. Electrical Component

All circuit breakers, thermal overloads and contactors shall be of reputable make acceptable to the employer. Electrical supply to the pump controller shall be protected using an isolating circuit breaker.

5.2.5.1. Method of Starting

The panel shall be built to start the pumps in suitable starting modes, i.e. D.O.L., Star/ Delta, or using Soft Starters.

5.2.6. Pump Pressure Vessel

Diaphragm type pressure vessels shall be provided. They shall be incorporated into the system so that during normal operation the pump shall not need to be start within 30 seconds of it switching off in order to prevent the pump hunting.

The pressure vessel shall be of adequate capacity to accommodate a considerable fluctuation in water demand by the system with minimum start/ stop cycles of the pumps. The vessel shall be constructed of steel plate built to ASME Standards for Unfired Pressure Vessel. A rubber diaphragm shall be provided in the vessel for separating the water and pre-charge nitrogen. The pre-charge pressure shall be adjustable and charging port with non-return device shall be provided. The adjustable cut-in and cut-off pressure unit for the pumps shall be built-in at the vessel to suit the system.

5.2.7. Accessories

The system shall be provided with all accessories such as base plate, mounting pads, foundation bolts, foot valves, pressure gauge, pressure switches, pressure transmitter, level indicator, isolation valve for pressure vessel, etc. all accessories required for proper and safe operation shall be furnished with the pumps.

5.2.7.1. Suction and Delivery Pipe, Fittings, Flanges & Valves

All suction, delivery and header pipe shall be GI & shall conform to IS: 1239, medium/ heavy duty. Fittings shall be as per the pipe thickness. All pipes shall have flanges connection & pipe shall conform to BS 10, Table - D. All hardware shall be zinc plated. The system shall be equipped with suction & delivery valves flanged valves. On suction side ball/gate valve shall be provided while on delivery side ball/ butterfly valves shall be provided. Also, spring operated dual plate check valves shall be provided on delivery side of each pump & on delivery header. In case of negative suction foot valve shall be provided for each pump suction or suction header as specified in data sheet. Flexible bellows shall be provided on suction & delivery side of each pump.

5.2.8. Testing

Hydrostatic test shall be carried out at 1.5 times the maximum discharge pressure.

For electrical accessories, necessary tests shall be performed or factory test certificate shall be furnished.

5.3. Submersible Pumps

5.3.1. General

- i. The total head capacity curve shall be continuously rising towards the shut off with highest at shut off. Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistance and shall be designed to handle solid sizes of up to 50 mm. The pumps shall run smooth without undue noise and vibration and shall be suitable for starting with discharge valve open and / or closed. The pump set shall be capable of withstanding the accidental rotation in reverse direction.
- ii. Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the specifications without surging, cavitations or excessive vibration to the limits specified.

The pump shall meet maximum allowable shut off head. The pumps shall not overload the motors at any point on the maximum pump speed performance characteristic curve and the pump operating range within the limits of stable pump operation. The total head capacity curve shall be continuously rising towards the shut off as flow decreases throughout the entire curve from run out to shut off head with the highest at shut off. Its total head capacity curve shall be continuously rising towards shut off with the highest at shut off, and its capacity shall be meet to handle sludge volume.

- iii. Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
- iv. Pumps and motors shall run smooth without undue noise and vibration, cavitations, oil or water leaks over the range of operation. To ensure vibration free operation, all rotative components of pump shall be statically and dynamically balanced to BS 6861 as per zones A&B of ISO 10816- 1.
- v. Vibration levels shall not exceed the levels given in BS 4675. Abnormal sound and noise from pump set and or motor will not be acceptable.
- vi. The pump set shall be suitable for starting with discharge valve open and/or closed.
- vii. The pump set shall be capable of withstanding the accidental rotation in reverse direction.

5.3.2. Features of Construction

- viii. Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, and single stage type.
- ix. Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.
- x. Double Mechanical seals (back to back) shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Seals must be capable of withstanding rotation in either direction. A detector shall indicate when moisture is leaking past the first seal.
- xi. Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials.
- xii. The critical speed of the rotor shall be at least 30% above the operating speed. The pump shut off head shall be minimum 110% and maximum 130% of the rated pump head.
- xiii. Pump-sets shall have double bearings. Bearings shall be of the anti-friction type. Bearings shall be capable of taking the static weight of the rotating parts and any thrust generated by the operation of the pump. The bearing life shall be minimum 100,000 hrs of operation.
- xiv. Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering. Each pump shall be provided with a SS 316 lifting chain conforming to BS 1663 and BS 4942.
- xv. Each pump shall be provided with an automatic coupling device for attaching to the duck foot bend base at low level by using lifting chain SS 316 and guide rail SS 316, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple from the duck foot bend base and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.
- xvi. The materials of construction for submersible pumps shall be as follows:

SL. No.	Component	Material
1.	Impeller	Stainless Steel : CF8M/SS316
2.	Pump and Motor Casing	CI : IS 210, FG 200 with 1.5 to 2.0% Nickel
3.	Shaft	Stainless Steel : SS 410
4.	Guide Pipe and Lifting Chain	Stainless Steel : SS 304
5.	Fasteners, Anchors bolts, Foundation Bolts etc.	Stainless Steel : SS 316

SL. No.	Component	Material
6.	Lifting Bracket	Stainless Steel : SS 316
7.	Bearings	Pre-lubricated heavy duty ball bearings
8.	Auto coupling system	Stainless Steel : SS 316

Note:

- i. Material test certificates shall be submitted for all the parts.
- ii. The material of construction for all the other parts shall be suitable for use in adverse environmental conditions of sludge / chemical water.

5.3.3. Testing:

The pumps shall be tested over the range covering from shut off head to maximum flow. The duration of test shall be minimum one hour. Minimum 5 readings approximately equidistant shall be taken for plotting the performance curve.

5.3.4. Rejection:

If on shop testing, the guaranteed efficiency considering the zero percent negative tolerance is not met, the pump shall stand rejected.

5.3.5. Induction Motor

5.3.5.1. Performance and Characteristics

The submersible motor shall confirm to IS: 9283 and submersible cable shall conform Clause No: 4.4 of IS: 9283.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions.

- i. Variation in supply voltage from rated motor voltage $\pm 10\%$
- ii. Variation in supply frequency from rated frequency $\pm 5\%$
- iii. Combined voltage and frequency variation $\pm 10\%$

The starting current of motor shall not exceed 200% of rated full load current for star / delta starting and 600% of rated full load current for DOL starting under any circumstances. Motors shall be suitable for full voltage DOL starting or star / delta starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage to maximum permissible voltage.

The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerance as per the applicable standard) unless otherwise specified. Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment. Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283.

Protection against increase in stator winding temperature (150°C), bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors in series are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of water into the oil housing is above 30% concentration. Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The power rating of the motor shall be larger of the following:

115% of the power input to the pump at duty point at a speed corresponding to the frequency of 50 Hz.

Maximum power input while operating single pump corresponding to the speed of 50 Hz.

5.3.5.2. Submersible Cable

The power cable shall be PVC insulated, flexible, 3.5 core and flat type. The cable shall be sheathed in suitable material to withstand adverse environmental conditions of sludge / chemical water. The size of the conductor shall be adequate for continuous use under water and air. The half core shall be used for earthing.

The control cable shall also be PVC insulated, flexible, flat type and shall be adequate for continuous use under adverse environmental conditions of sludge / chemical water. The control cable for stator winding temperature sensor (thermistors) 3 core x 2.5 sq.mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq.mm copper conductor shall be provided.

The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3.0% of the rated voltage.

5.3.5.3. Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

5.3.5.4. Insulation

Any joints in the motor insulation such as at coil connections or between slot and end winding sections shall have strength equivalent to that of the slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

The stator winding shall be made from high conductivity annealed copper conductor, PVC insulated winding wires conforming to IS: 8783 for wet type motors. The stator winding shall be of high conductivity annealed copper enameled insulated wires conforming to IS: 4800 for dry type motors.

5.3.5.5. Temperature Rise

The temperature rise test of the motor shall be taken with the motor coupled to the suitable pump to give the full load output of the motor. When the various temperatures are stabilized, the set is stopped and the temperature rise of the stator winding by the resistance method shall not exceed 35 °C. During the test, the temperature of the cooling water may not exceed 35 °C. As the cable resistance will also be substantial it is necessary that while calculating the temperature rise by resistance method, due care is taken to account for the correct hot and cold resistance of windings.

5.3.5.6. Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not by providing either external or internal cooling arrangement.

5.3.5.7. Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and dust. The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

5.3.6. Submersible Pump Lifting arrangements

Suitable Guide rail mechanism in SS304 shall be provided for lifting of Submersible pumps and along with jib crane of 1.5times the minimum submersible pump capacity shall be provided

5.4. Submersible Sump Drainage Pumps

Sump pumps shall be of the open-impeller centrifugal-type, vertically-mounted and close coupled to their fully-submersible electric motors. Sump pumps of 1.5 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably-fused three-phase or single-phase low-voltage supply and with supply isolation at the supply point.

Sump pumps over 1.5 kW shall be controlled and started from the supply point. Control shall be by means of adjustable float level switches mounted near the pump.

Pumps shall be supplied with all necessary pipe work to discharge to surface drainage. Each pump shall be provided with delivery reflux and isolating valves, and suitable lifting gear for lowering and lifting the pump from the sump. Pumps weighing 40 kg or more shall be lowered into the sump on guide rails and be located to their respective discharge pipe work with an angle flange connection and self-locating clamps. Pump impellers shall be designed to pass solids of the sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 50 mm diameter.

The material of construction for different components of the pumps shall be as specified below;

Sl. No.	Component	Material
1	Impeller	Stainless Steel
2	Casing	Cast Iron IS: 210 GR FG 260
3	Shaft	Stainless Steel: BS: 970 GR 304
4	All fasteners including nuts, bolts, washers, anchor bolts, foundation bolts etc. both in wet and dry areas	Stainless Steel : 316

5.5. EOT Crane

5.5.1. General:

The intake pumping station, treated water pumping station and booster pumping stations shall be provided with suitable capacity electrically operated transverse crane for the required span, height and long travel length including all the accessories, electrically operated hoist, travelling trolley, lifting chain, hook etc. complete for electrically hoisting and lowering of pumps, motors and other equipment etc.

The scope of work includes designing, providing, erecting and commissioning the crane suitable for electrically operation of designed capacity traversing gantry crane as specified. Test load for EOT cranes shall be minimum 1.50 times safe working load.

5.5.2. Codes and Standards

The design, manufacture and performance of the crane and its allied equipment and material shall comply with all currently applicable statutes regulations and safety codes in the locality where the crane will be installed.

The equipment shall also conform to IS: 3177 and IS: 807 and relevant international standards.

5.5.3. Features of Construction

The feature of construction shall generally conform to the specifications.

The crane shall be of best quality equipped with given capacity standard travelling trolley, chain pulley block etc.

The chain block shall be of machine cut gears, tested for 50 % over load capacity and shall have sturdy forged hooks, special alloy load chains, chain for hand operation all for smooth working without any shocks, all complete.

Chain block shall be fitted or hinged on cross traversing trolley.

A traversing cross trolley shall be designed and assembled using standard size RS girders adequate to withstand to travel in any direction on load with all mechanism complete. It shall be provided with wheels and trade over two girders. There shall be adequate room dimensions.

The gantry girders shall be designed and manufactured with two girders frame, travelling wheel on both ends of the span and shall have an arrangement to operate with sprocket wheel and chain, suitable for operations from ground level of the pump house. The steel used for the same shall conform to IS 2062.

Two girders shall be adequately braced at equal spacing using MS channels or MS standard section and shall have bolting arrangement to have perfect rigidity and performance.

MS girders of standard sizes are to be designed and aligned on concrete corbels provided in civil structure of pump house to cover the entire straight or peripheral length needed for operation of a crane. Such arrangement shall be provided on peripheral to cover the entire length.

These girders are to be fitted over corbels using MS plates of adequate capacity and shall be rigidly fixed in corbels. Girders are to be welded to MS plates. Expansion allowance for lengthwise girders shall be kept.

Welding quality for the entire unit shall be maintained using standard make welding rods for duty purpose. All lengthwise girders and frame used for traversing shall be designed for 150% of the design load, considering the spans, in both direction, lengthwise and width wise where the crane is to be operated.

On the entire length of girder, both sides, adequate size MS square or standard rail section shall be designed and used. It shall be welded on both sides of the section to have homogeneous section. Welding shall be carried out using standard welding rods for the purpose and it shall be carried out by experienced trained welder having sufficient experience of this type of work. All excessive welding shall be removed and then to be ground to requirements.

The entire structure shall have good stability with or without load.

Suitable arrangements at both the ends shall be provided to restrict the travel of the crane beyond decided limits.

5.5.4. Performance

The unit shall be capable of satisfactory operation and shall be available for duty as required in the pump house for maintenance and repairs of pumping machinery, motor and allied equipment provided in the pump house for functioning as a pumping station.

5.5.5. Painting

All the parts of the unit shall have good and smooth finish. It shall be painted to produce a neat and durable surface which will prevent rusting and corrosion. The equipment shall be degreased cleared of all rust, sharp edges, scales to be removed before painting. The Crane structure shall be painted with two coats of red-oxide metal primer and two coats of enamel paint of approved colour. The electric hoist and LT - drive units shall be painted with enamel paint approved by Engineer-in-Charge.

5.5.6. Tests

All routine tests shall be conducted in manufacture's works and test certificates shall be produced.

The unit shall be tested for 150% of designed load.

Load chain certificate, forged load hook certificate shall be provided along with the test certificate of chain pulley block provided on the unit.

5.5.7. Documents

As a part of proposal, the Tenderer's shall furnish relevant descriptive and illustrative literature on the components proposed to be provided for the gantry arrangement.

General arrangement drawing showing details of all parts and accessories of EOT crane.

Detailed methodology and note for erection and testing.

Test certificates of chain pulley block and other components.

5.5.8. Bearing

Plain or roller type bearings shall be used. Roller bearing shall conform to IS: 5669. Plain bearing shall be of cast iron or bronze.

5.5.9. Frame

The frame shall be designed for proper strength and it shall maintain alignment under all service conditions. The material shall be high tensile, weldable structural steel.

5.5.10. Lubrication

The block shall be provided with adequate facility for lubrication unless materials with inherent lubricating properties are used.

5.5.11. Anchorages

The load chain anchorages associated fittings and framework at the slack end shall be at least equal in strength to 2.5 times the maximum tension in the load chain when working load is being lifted.

5.5.12. Gears

Gears shall be provided for proper strength and for surface durability such as to afford efficient operation during the guarantee period and there after. Material of construction shall be carbon steel of conforming to IS 1875 and 4367, or equivalent international Standard.

5.5.13. Load Brakes

Chain pulley block shall be provided with an automatic mechanical load brake which will prevent self lowering of the load. It will arrest and sustain the load in any position within the working limit. Brake should allow smooth lowering of the load.

5.5.14. Inspection

The representative of employer shall have access to the works of the manufacturer for inspecting the material, tests etc.

5.5.15. Design Tests

Test certificate shall be produced for design test, which should be carried on tensile testing machine to at least 4 times the working load limit without any distortion.

5.5.16. Operational Proof Tests

Each chain pulley block shall be subjected by the manufacturer to a proof load of 1.5 times the working load limit through a length of lift which will ensure that every part of the block mechanism and each tools of gear comes under load.

5.6. Electric Hoist

The electric hoist shall consist of load chain, bottom block, gears, load chain wheel, electrical control panel, bottom block, main body and operating pendent. Test load for electric hoist shall be minimum 1.50 times safe working load. The hoist shall have overload slipping clutch for safety. The body shall be compact, light weight, precision engineered and shall be made of aluminium cast alloy material. The finishing at top shall be anticorrosive powder coated. The load chain shall be strong, wear resistant and shall be made of grade 80 surface hardened materials confirming to IS: 3109. The chain shall be of welded construction with a factor of safety not less than 5. The swivelling bottom block shall provide free rotation handling of loads. Gears shall be made of precision machined case hardened alloy steel and shall confirm to IS: 4460. Lifting speed shall be maximum 4 MPM and travelling speed shall be maximum 15 MPM. The motor shall be squirrel cage type with TEFC IP: 55 enclosure, Class F insulation and temperature rise limited to Class B.

5.7. Electrical Specification

5.7.1. General

These are general technical specifications. The contractor shall read this in conjunction with SLD and other drawings.

5.7.2. Regulations and Standards

The installation shall conform in all respects to Indian Standard code of practice for electrical wiring installation IS: 732 (1963) and IS: 2274 (1963). It shall also be in conformity with the current Indian Electricity Rules and Regulations and the requirements of the local electric supply authority in so far as these become applicable to the installation. Wherever this specification calls for higher standard materials and / or workmanship than those required by any of the above regulations, this specification shall take precedence over the said regulations and standards. In general the materials, equipment and workmanship not covered by the above shall conform to the latest relevant Indian Standards unless otherwise called for.

5.7.3. Inspection and Approval of the work by Local Authority

On completion of the work the Contractor shall obtain and deliver to the PRED the certificates and approval by the Electrical Inspectorate of local administration. Necessary drawings for submission to the electrical inspectorate shall be prepared by the Contractor. The PRED representative shall have access to the manufacturer's premises for inspection of any item of the tender.

5.7.4. Sub-Contractor

The works shall be carried out by a licensed electrical Sub-Contractor possessing a valid Electrical Contractor's license of required category in the state, employing licensed supervisors and skilled workers having valid permits as per the regulations of Indian Electricity Rules and local Electrical Inspector's requirements.

5.7.5. Power Distribution Transformer

5.7.5.1. Scope

This specification is for design, manufacture, inspection and testing at vendor's works and erection and commissioning of oil filled power / distribution transformer, along with necessary accessories.

5.7.5.2. Codes and Standards

The design, manufacture, testing and performance of transformer and all accessories shall comply in all respects with the currently applicable IS specifications and codes of practice and other statutory regulations prevailing in the region where the equipment is intended to be installed.

Some of the applicable IS specifications are;

IS: 2026 & 1180 Transformers

IS: 335 - Transformer Oil

5.7.5.3. General Constructional Features

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 without distortion or deterioration.

Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanised.

Exposed parts shall not leave pockets where water can collect. Tank covers shall be sloped so as not to retain rain water.

Materials in contact with oil shall be such as not to contribute to the formation of acid in oil. Surface in contact with oil shall not be galvanised or cadmium plated.

Labels, indelibly marked, shall be provided for all identifiable accessories like terminals, WTI, OTI, thermometer pocket, etc. All label plates, name plates and diagram plate shall be of non-corrodible material.

5.7.5.4. Painting

The interior of transformer tank and other oil filled chambers and internal structural steel work shall be cleaned of all scale and dust by shot-blasting. These surfaces shall be painted with not less than two coats of heat resistant, oil insoluble and insulating varnish.

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. The final coat shall be of a glossy oil and weather resisting non fading paint of specified shade.

5.7.5.5. Electrical and Performance Requirements

Transformer shall operate without injurious heating at the rated KVA at any voltage within plus / minus 10% of the rated voltage of that particular tap.

Transformer shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.

Transformer shall be capable of operation continuously, in accordance with the applicable standard loading guide at its rated KVA and at any of the specified voltage ratios.

Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminal bushings, tap changers or other auxiliary equipment shall apply.

Transformers, complete with bushings / cable boxes, shall be designed and constructed to withstand without damage, the effects of external short circuits as per the specified standards. Account shall be taken of the different forms of system faults that can arise in service, such as line to earth faults and line to line faults associated with the relevant system and transformer earthing conditions.

The neutral terminal of winding with star connection shall be designed for the highest over-current that can flow through this winding.

Every care shall be taken to ensure that the design and manufacture of transformer shall be such as to reduce noise and vibration to the level obtained in good modern practice.

5.7.5.6. Core

The magnetic circuit shall be constructed from high grade cold rolled non-ageing grain oriented silicon steel laminations.

The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

The insulation structure for the core to bolts and core to clamp plates shall be such as to withstand a voltage of 2000V for one minute.

The core and coils assembly with all the clamping structures shall be free from deformation, shall not vibrate during operation and shall be so fixed in the tank that shifting will not occur during transport or short circuits.

The core clamping structure shall be designed to minimise eddy current loss.

The core shall be provided with lugs suitable for lifting the complete core and coil assembly during maintenance.

The frame work and clamping arrangements shall be securely earthed.

5.7.5.7. Windings

Windings shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Winding shall be copper double wound

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.

Windings shall not contain sharp bends which might damage the insulation or produce high dielectric stress.

Materials used in the insulation shall be insoluble and chemically inactive in hot transformer oil.

Terminals of all windings shall be brought out of the tank through bushings for external connections.

5.7.5.8. Tank

Tank shall be made from good commercial grade low carbon steel and shall be of welded construction.

Tank shall be designed for lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.

Tank together with radiators, coolers, conservator, bushings, vessel and other fittings shall be designed to withstand without permanent distortion the following conditions;

- (a) Full vacuum of 760 mm of Hg. for filling with oil by vacuum.
- (b) Internal gas pressure of 0.35 Kg/ Sq.cm. with oil at operating level.

The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

Pulling eyes shall be provided at the base for moving the transformer in either direction.

The material used for gaskets shall be cork-neoprene or approved equivalent.

5.7.5.9. Valves

Valves shall be provided with an indicator to show the open and closed positions. There shall be no oil leakage when the valves are in closed position.

Transformer shall be provided with following valves on the tank;

- i. Drain valve so located as to completely drain the tank.

- ii. Filter valve at top of transformer tank.
- iii. Oil sampling valves at top and bottom of main tank.
- iv. Air release plug.
- v. Valves between radiators and tank as per designs

5.7.5.10. Under Carriage

The under-carriage of the transformer shall be provided with detachable flat rollers. Wheels shall be provided with suitable bearings which will resist rust and corrosion. It shall be possible to swivel the wheels in two directions.

5.7.5.11. Radiators

Radiators shall be designed to withstand the vacuum and pressure conditions specified for the tank. They shall be so designed as to avoid pockets in which moisture may collect, to completely drain oil into the tank and to prevent formation of gas pockets when the tank is being filled.

The clearance between all pipe work and live parts shall be more than the clearance for live parts to earth.

5.7.5.12. Tappings

- i. Off /On circuit taps as specified shall be provided on the high voltage winding.
- ii. The transformer shall be capable of delivering its rated output at any tap position.
- iii. The winding including tapping arrangement shall be designed to preserve the electromagnetic balance between HV and LV winding at all voltage ratios.

5.7.5.13. Standard Accessories

In addition to the requirements given in the foregoing clauses, the following fittings shall be provided on each transformer as standard accessories;

- i. Conservator with drain plug.
- ii. Silica gel dehydrating breather.
- iii. Oil level gauge (plain)
- iv. Thermometer pocket.
- v. Rating and diagram plate.
- vi. Earthing terminals (two for the tank, one for the HV cable box, one for the LV cable box).
- vii. Explosion vent.
- viii. Holes on the bottom channels, to facilitate clamping of the transformer to the pedestal.
- ix. Air release plugs wherever necessary.
- x. First filling of oil.
- xi. Separate neutral bushing outside the LV cable box to facilitate neutral earthing.
- xii. Cable end box on both HT and LT side to accommodate spaciouly

5.7.5.14. Routine Tests

The following routine tests shall be conducted on each transformer at the manufacturer's works. Test records shall be submitted at the time of delivery.

- i. All routine tests as listed in the relevant IS specifications.

- ii. Measurement of winding resistance.
- iii. Ratio, polarity and vector group check.
- iv. Measurement of no load current and no load losses.
- v. Measurement of impedance voltage and load losses.
- vi. Insulation resistance test.
- vii. Separate source voltage withstand test.
- viii. Noise level measurement.
- ix. Power frequency voltage withstand test.
- x. Oil pressure test.

5.7.5.15. Type Tests

The manufacturer should have got their transformer of similar capacity successfully type tested at CPRI or any other recognized testing laboratories. The Contractors shall specifically confirm this in their Tender. Copies of type test reports shall be furnished at the time of delivery. Following are the type tests;

- i. Impulse voltage withstand test.
- ii. Short circuit test.
- iii. Temperature rise test.

5.7.5.16. Rejection

PRED reject the transformer during factory testing or during performance period, if any of the following conditions arise;

- i. Transformer fails in any of the routine tests.
- ii. No load loss / load loss exceeds the guaranteed value by 20%.
- iii. Impedance value differs the specified value by plus or minus 10%.
- iv. Oil or winding temperature rise exceeds the specified value by 5 oC.
- v. Transformer is proved to have been manufactured not in accordance with the agreed specification.

5.7.6. Low Voltage Switchboards

5.7.6.1. Scope

This specification covers the requirement of design, fabrication, testing at manufacturer's works, supply, erection testing and commissioning of low voltage (upto 415 C AC) switchboards like power control centre (PCC), motor control centre (MCC) etc, including the switchgear / components within.

All Main LT Panels shall meet the requirement as per IEC-61439.

5.7.6.2. Standards

Switchgear assembly and its accessories shall conform to latest applicable Indian Standard specifications / Codes of Practice and in particular, with;

IS 375 - Arrangement of busbars, connections, wiring, marking

IS 722 - AC Electrical meters

IS 1248 - Indicating instruments

IS 2147 - Degree of protection provided by enclosure for low voltage switchgear and Control gear.

IS 2208 - HRC cartridge fuse links
IS 2705 - Current transformers
IS 2834 - Capacitors
IS 3156 - Voltage transformers
IS 3231 - Electrical relays for power system protection.
IS 4064 - Normal duty air break switches and switch fuse units
IS 4237 - General requirement for switchgear and control gear.
IS 5578 - Factory built assemblies of switchgear and control gear.
IS 5082 - Aluminium for electrical purposes
IS 6005 - Code of practice for phosphating iron and steel
IS 6875 - Control switches and push buttons
IS 8623 - Factory built assemblies of switchgear and control gear.
IS 11353- Factory built assemblies of switchgear and control gear
IS 13118 - Air circuit breaker
IS 13703 - HRC Fuse links
(Part 1, 2)
IS 13947 - General requirement for switchgear and control gear
(Part 1)
IS 13947 - Air circuit breaker
(Part 2)
IS 13947 - Fuse switch and switch fuse units
(Part 3, 4, 5)

IEC-61439 (Part-2) - Power switchgear and control gear assemblies to be considered for Main LT
Panels.

5.7.6.3. General Constructional Requirements

The switchboard shall be vertical, free standing, floor mounted type, compartmentalized, modular type and suitable for indoor installation. It shall be dust and vermin proof and the enclosure shall provide a degree of protection of not less than IP: 52.

Switchboard shall be easily extendable on either sides by the addition of vertical sections, when required.

The design shall ensure maximum safety during operations, inspection, connection of cables, relocation of outgoing cables and maintenance (with the busbar system energized) and without taking any special precautions. It shall provide means to prevent shorting of any power due to accidental dropping of tools, etc. Checking and removal of component shall be possible without disturbing adjacent feeders.

All the similar parts / components shall be fully interchangeable without need for structural modifications.

The frame shall be fabricated using structural steel sections. The frames shall be enclosed by minimum 14 / 16 SWG cold rolled sheet steel. Doors shall be provided with stiffeners wherever required. Alternatively, panels can be fabricated out of CRCA folded steel sheets, with suitable reinforcements.

All openings, covers and doors shall be provided with neoprene gaskets. Suitable eye hooks shall be provided for shipping / easy lifting of panels.

Panels shall have base frame of 3 mm thick sheet steel with facility for directly bolting using foundation bolts. The design shall ensure that weight of the components is adequately supported.

The maximum height of the panels shall generally be restricted to 2200 mm and the maximum length of a shipping section to 2500 mm. The max. and min. operating height of the switch handles / push buttons shall be 1800 mm and 400 mm respectively.

Metal sheets shall be provided between two adjacent vertical panels running to full depth and height.

Panels shall be in single front execution unless specified as double front. Circuit breakers shall be in single front execution.

All auxiliary devices for control, indication, measurement and protection such as push buttons, control and selector switches, indicating lamps, ammeters, voltmeters etc. shall be mounted on front side of respective compartment.

Suitable cable and busbar alleys shall be provided for extra safety of working personnel. Cable alleys and busbar alleys shall be provided with hinged doors. Adequate number of slotted angle cable supports shall be provided in cable alleys.

All doors shall be provided with concealed type hinges. Rear doors wherever appropriate, shall also be of hinged openable type.

The switches / MCCB shall be interlocked with compartment door to prevent opening of door when switch / MCCB is ON.

5.7.6.4. Busbars

Busbars shall be of high conductivity aluminium conforming to grade of E91E of IS: 5082 supported on insulators of non hygroscopic type epoxy / SMC / DMC / FRP with high creepage surface (preferably epoxy materials). The main phase busbars shall be of uniform current rating throughout their length. The current rating of neutral shall be half that of phase busbars.

Maximum current density employed for aluminium busbar dimension calculations shall not be more than 1 ampere per sq.mm. A suitable section of earthing busbar shall be provided throughout the length of the switchboard.

The thermal design of busbar enclosure shall be based on installation of panel in poor ventilated condition. The cooling air volume shall take into account the busbar enclosure only. The maximum operating temperature of busbar shall be 85°C in normal conditions and 200°C for short circuit conditions.

The busbar and its supports shall be capable of withstanding dynamic and thermal stresses created due to short circuit conditions. Busbar shall be provided with heat shrinkable insulating sleeves of high di-electric strength which is also non-inflammable and self extinguishing type.

All the busbars shall be colour coded throughout its length. Minimum clearance between phase to ground shall be 20 mm, phase to phase shall be 25 mm and phase to neutral shall be 25 mm.

Interconnections and vertical busbars shall be compartmentalised and fully shrouded.

All busbar joints and connections shall be made by galvanised zinc passivated or cadmium plated, high tensile strength steel bolts with a spring washer and a plain washer on either sides of the busbars.

5.7.6.5. Power Connections

Interconnections between the main busbars and individual units shall be made by using Cu or Al busbar strips of adequate rating. These interconnections and terminals shall be fully shrouded.

For outgoing feeders above 100 A, provision shall be made by suitable bus link from switchgear terminals so that required number cables could be connected to these links.

5.7.6.6. Circuit Breaker Compartment

Circuit breaker (CB) compartment shall be fully draw out type. Suitable guides shall be provided to facilitate easy withdrawal of trolley. It shall be possible to withdraw the trolley without having to unbolt / unscrew any connections. Spring actuated and gravity operated shutters shall be provided for covering the busbars and other live parts when the CB is completely withdrawn.

There shall be three positions for the drawout trolley as below;

- Service Position: In this position both power and control circuits shall be connected and this is normal operating position of the CB.
- Test Position: The power contacts shall be disconnected, but control connections shall not be disturbed. It shall be possible to trip / close the CB in this position.
- Fully Drawout Position: The power and control circuits shall be disconnected. It shall be possible to close the cubicle door in this position.

Compartment door shall be interlocked against opening of door in ON condition. It shall not be possible to either push in or withdraw the trolley when the breaker is in closed condition.

CB shall be of air break, draw out type and shall be provided with series trip for overload and shunt trip for various other protections. It shall have mechanical tripping device on front part of the panel.

CB position shall be indicated by indicating lamps as below;

- Breaker close - Red
- Breaker open - Green
- Breaker trip - Amber
- Breaker test position - Blue

CB's open / close position should also be indicated mechanically. Such indication shall also be available with manual operating mechanism.

5.7.6.7. Moulded Case Circuit Breakers (MCCB)

The MCCB shall be a single unit of triple pole or 4 pole as required

Operating mechanism shall be quick make, quick break and trip free type. It shall not be possible to close the breaker under short circuit condition.

The ON, OFF and TRIP positions of the MCCB shall be clear and visible to the operator when mounted as in service. Front of board operating handle shall be provided.

MCCBs shall be provided with inverse-time-current tripping characteristic for sustained over load and instantaneous tripping characteristic for short circuit conditions. These shall be microprocessor type built in facility.

Under voltage release and any other features shall be provided when called for. Maximum tripping time under short circuit conditions shall be 20 milliseconds.

5.7.6.8. Switches

All switches shall be of heavy duty, air break type with quick make / break manual operating mechanisms. The operating handles shall be mounted on door of compartment having the switch. Switches should be rated to carry the designed load without over heating.

Barriers shall be provided to prevent inter-phasing arcing and live terminals shrouded to avoid accidental contact.

5.7.6.9. Contactors, Relays, Pushbuttons

The contactors shall be air break type, equipped with three main contacts and minimum 2 NO + 2 NC auxiliary contacts. The main contacts shall be rated for AC 23 operations. The auxiliary contacts shall be rated for 5A at 240V AC.

The coil of contactor shall be suitable for operation on 240V AC. The drop off voltage of contactor coil shall be between 15% to 65% of rated coil voltage.

Auxiliary relays / contactors shall be used for interlocking and multiplying the signals. Their ratings must not be less than 5A for 240V AC at PF of 0.8 to 1.0.

Thermal overload relays shall be of three elements, positive acting, ambient temperature compensated with adjustable range. Relays shall be of manually reset type. Relays shall be provided with minimum 1 NO + 1 NC contracts having a rating of 5A at 240V AC.

Door mounted over load relays / earth fault relays shall be of back connected, drawout type, suitable for flush mounting and fitted with dust tight covers. The relay cases shall have provision for inserting of test plug at the front for testing and calibration. It shall be possible to test relays without connection of wirings. It should be provided with hand reset type built in flag indicators to reset the flag without opening the relay case.

In case single phasing preventor is used, it shall be of current operated type and shall operate on the principle of sensing negative sequence component of current. SPP used shall be suitable for protection of non-reversing and reversing motors. The relay operation shall be independent of loading and RPM of the motor prior to occurrence of single phasing.

Timers used for star delta starters shall be of electronic type and shall have adjusting time of 0 - 60 secs.

Push buttons used shall follow following colour codes;

- i. **Emergency Stop / Stop : Red**
- ii. **Start / Close : Green**

5.7.6.10. Instrument Transformers

CT for instruments shall have accuracy of Class 1.0 and accuracy limit factor 5.0. CT shall be capable of withstanding peak short circuit for 1.0 second. The neutral side of CT shall be earthed. CT shall generally be of cast resin type.

Primary of PT shall be provided with fuse and secondary of it shall be provided with MCB. It shall be of Class 1 at 0.8 PF lag. Primary of VT shall be 415V and secondary 110 V.

5.7.6.11. Measuring Instruments

All measuring instruments shall be of size 96 sq.mm for MCC and 144 sq.mm for PCC and shall be of flush mounting type.

All AC ammeters, voltmeters, KW meters shall be of moving iron type for AC and permanent magnet type for DC. Accuracy Class shall be 1.0 for KW / KWH meter and 1.5 for ammeter and voltmeter. KW / KWH meters shall be suitable to measure unbalanced loads on a 3 phase 4 wire system.

Selector switches shall have 3 Indication position for reading phase units and 4th position for off position.

Frequency meter shall be of digital type.

5.7.6.12. Auxiliary Wiring and Terminals

The wiring for power, control, instrument, etc. shall be of PVC insulated flexible copper conductors of grade 1.1 KV. All wirings shall be neatly bunched.

Control wiring shall be of 2.5 sq.mm and power wiring shall be of 4 sq.mm size, minimum. Each wire shall be identified at both ends by ferrules and shall be terminated by using lugs.

Terminal blocks shall be of reputed make. Insulated barriers shall be provided between adjacent terminals. Minimum 10% spare terminals shall be provided on each terminal blocks.

5.7.6.13. Earthing

All vertical panels shall be connected to a common earth busbar. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Switchboards shall have 2 Nos. of 3/8" Dia bolts with nuts and washers at each end to connect earthing bus to plant earth grid. The earth busbar shall be painted green.

5.7.6.14. Labels

All incoming and outgoing feeders shall be provided with name plates on doors of each compartment, indicating the service and the rating. Danger plates shall be provided as per statutory requirements. Inside the panel, permanent stickers shall be provided for all components and terminal blocks giving identification, number and feeder details as per detailed wiring diagram.

Labels shall be of anodised AL, with white engraving on black background. They shall be properly secured with fasteners.

5.7.6.15. Painting

All metal surfaces shall be thoroughly cleaned and degreased. Fabricated structures pickled and rinsed. The under surface shall be applied a coat of phosphate paint and a coat of zinc chromate primer. The under surface shall be made free from all undulations and imperfections before undertaking the finishing coat.

After preparation of under surface, the panel shall be painted with two coats of enamel paint. Colour shade shall be light grey unless specified otherwise.

In case of epoxy painting, surface shall be thoroughly cleaned, epoxy primer and epoxy paint applied, baked in oven upto 120 °C and cured.

The panel finish shall be free from any imperfections like pin holes, orange peels, run off paint, etc.

5.7.6.16. Testing and Inspection

Panels shall be tested after completion of assembly, busbar interconnections, wiring and internal checks. All switchboards shall be tested extensively and as per IS: 8623 specification. Works shall be well equipped with the necessary testing equipment. The following tests shall be conducted.

i. Routine Tests:

- a) HV Test: To test high voltage withstand capacity of the current carrying parts.
- b) Megger Test: To check the insulation resistance.
- c) Phase Sequence: To check the phases configuration
- d) Functional Tests
- e) Coat meter: To check the painting thickness of the sheet steel fabrication.
- f) Gauge meter: To check the gauge of the fabricated steel.

- g) Heat run test kit: To check the adequacy of size of current carrying conductors.
 - h) Secondary injection Test set: To check the protection relay for its correctness.
 - i) Millivolt test Equipment: To check millivolt drop at any point of joint.
- ii. **Type test certificates shall be produced for:**
- a) Short circuit withstand capacity from Central Power Research Institute, Bangalore.
 - b) Dust / vermin / weather - proof test (i.e. IP: 54, IP: 55 etc. as per IS: 2147) from Central Power Research Institute, Bangalore.

5.7.7. MCB / HRC Distribution Boards

5.7.7.1. Scope

This specification covers the requirement of design, fabrication, testing at manufacturer's works, supply, erection, testing and commissioning of distribution boards conforming to IS: 2675. The distribution boards shall be suitable for 415V, 3 phase, AC supply or 230V single phase AC supply as required.

5.7.7.2. Type and Construction

Distribution boards shall be of totally enclosed type. The enclosure shall be made of best quality sheet steel of not less than 16 gauge thickness. The sheet steel shall be treated with a rigorous rust inhibition process before fabrication. The distribution boards shall have switch fuse unit, miniature circuit breaker or isolator as incoming and required number of circuit breakers or HRC fuses as out-goings. The rating shall be as per design.

5.7.7.3. Bus-Bars

Suitable bus bars made of high conductivity copper and mounted on non-hydroscopic insulating supports shall be provided. Separate bus bars for neutral and earth connections shall be provided.

5.7.7.4. Miniature Circuit Breakers

Miniature circuit breakers shall be of approved design and make. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front face of all the breakers shall be in line. The fault level of the MCBs shall be minimum 9KA.

5.7.7.5. H.R.C. Fuses

HRC fuses shall conform to IS: 2208 and fuse bases to IS: 1300. They shall be made out of best grade phenolic mouldings. They shall be non inflammable and non-hydroscopic, with hard glass finish. HRC fuses shall have non-deteriorating type characteristic. It shall be link type and shall conform to IS: 2208. Fuses shall be capable of clearing 20KA fault level.

5.7.7.6. Safety and Interlocks

All the live parts shall be shrouded such that accidental contact with live parts are totally avoided. The distribution boards interior assembly shall be dead front with the front cover removed. Main lugs shall be shrouded. Suitable insulating phase barrier made of arc resistant materials shall be provided. Ends of bus structures shall also be shrouded.

5.7.7.7. Cabinet Design

The distribution boards cabinet shall be totally enclosed type with dust and vermin proof construction. The cabinet shall be stove enameled. The interior surface shall be finished to off white shade. The interior components shall be mounted on a separate sheet steel DIN rail which is mounted and locked on to the studs provided inside the cabinet. The insulators used shall be heat resistant and non-

tracking. Live parts shall be shrouded to prevent accidental contact. The cabinet shall be equipped with a front door having a spring latch and a vault lock or screwed cover as specified. Cabinets shall have detachable gland plates at both top and bottom.

5.7.7.8. Directory

Distribution board shall be provided with a directory the load served by each circuit, rating of breaker / HRC fuses, size of the conductor etc. The directory shall be mounted in metal holder with a clear perspex sheet on the inside of the front door.

5.7.7.9. Installation

Distribution boards shall be surface mounted or recess mounted. The boards shall be fixed with suitable angle iron clamps and bolts. All cables / conduits shall be terminated using glands / grips / checknuts etc. Wiring shall be terminated properly using crimping lugs / sockets and PVC identification ferrules. No bare conductor shall be inside the board. Distribution boards shall be bonded to earth at least at 2 points using brass bolts and lugs. Suitable name plate and danger plate indicating the voltage shall be fixed to the front cover.

5.7.7.10. Testing

Distribution boards shall be tested at the factory as per IS and shall be tested for insulation resistance after erection.

5.7.8. Diesel Generator

5.7.8.1. Scope

The scope of work shall include design, manufacture, fabrication, packing, supply, delivery at site, storage, erection, testing and commissioning of Prime rating, continuous duty suitable to motor application diesel generator sets of capacity as per design at site conditions with associated plant and equipment.

The scope of work shall include but not be limited to:

- Diesel engine with all engine mounted equipment such as governors, lube oil pumps, C.W. pumps, injectors, turning gears, control and instruments.
- Fuel system suitable for High Speed Diesel including filtration, day tanks, piping work, fuel transfer equipment from day tanks to engine with controls.
- Lubrication oil system including clean and dirty storage tanks with transfer pumps, coolers, filtration, centrifuge and preheating if required, automatic engine oil reservoir top up system.
- Combustion air system with inlet filtration, turbo charging and cooling system.
- Exhaust system including ducting, silencer, expansion provision and chimney as per statutory requirements
- Cooling water system for engine jacket, oil cooler, charge air cooling including heat exchanger, piping, valves, pump, strainer and controls
- Starting motor, battery, battery charger etc
- Synchronous generators complete with excitation system and AVR.
- Fabricated steel base plate for each engine generator unit with anti-vibration mountings.
- Ventilation and air conditioning facilities.
- Local and remote controls and instruments for start, stop control and protection of all equipment.
- Auxiliary 415 V switchboard for auxiliaries, battery charger, electrical station services.
- All necessary supporting steelwork, access ladders and galleries.
- All pipe work, cabling, wiring, integral with, forming part of and linking the plant specified, including supports, support steel work, cable trays and ladders and conduits.
- Finish painting at site for all the items.

- Earthing and lightning protection system.
- Shop electrics, instrumentation and controls.
- Inlet to combustion air intake system.
- Outlet of the exhaust system outside the building including chimney as per KSPCB norms.
- All foundation bolts, fixings, supports and any embedded parts.
- Drawings, information manuals.
- One set of maintenance tools and appliance.
- Spare parts for 3 years operation of DG sets.
- Commissioning spares.
- Obtaining all necessary statutory clearances for operation of the DG set including consent from UKPCB.

5.7.8.2. Design Climate

The diesel engine shall be suitable for installation at the proposed site with climatic conditions as specified elsewhere in the document.

5.7.8.3. Diesel Engine and Auxiliaries

5.7.8.3.1. Type and Rating of Diesel Generating Sets

Each engine shall be four-stroke turbo charged, water cooled type, capable of driving the generator at the specified load under all climatic conditions. Each engine shall be directly coupled to alternator, all mounted on a common base frame.

Standard sized plant shall be provided with a continuous power rating at generator terminals as defined in BS: 5514 or IS: 3046 (e) as a minimum, at 0.8 power factor for each set under the following conditions.

- Fuel - HSD Oil
- Engine speed - 1500RPM (max)
- Engine inlet air temperature - 36.2 Deg. C (max)
- Atmospheric Pressure - 0.945 at a Relative humidity - 75% (However, max. temp and RH do not occur simultaneously)
- Water temperature - 33 °C

Under the above condition, D.G. Set should be capable of operating with a 10% over load for one hour.

5.7.8.3.2. Engine Access

The following should be provided

- Crank case removal access doors on each side and at each crank throw to camshaft drive and oil pump.
- Bearing shall be capable of removal without removing crank shaft.
-
- Cylinder heads independent of fuel injector and associated pipes.
-
- Exhaust valve: mounted in removable cages which obviate need to remove cylinder heads.

5.7.8.3.3. Engine Governing

Engine governing shall be in accordance with BS: 5514 / ISO: 3046 Part 4 Class A1, over speed protection shall also be included. Motor operated speeder gear shall be provided to allow the speed to be varied over the fuel output range. Local manual speed adjustment shall also be provided. The governor shall be adjustable for both drop and load limit to allow load sharing with other units.

5.7.8.3.4. Lubricating Oil System

The system shall be such that there is adequate oil circulation through all lubricated moving parts prior to starting and after stopping. Oil filters shall be duplex type so that one element can be cleaned while the engine is still operating. The filter shall have cleaning capability of 15 micron maximum.

5.7.8.3.5. Combustion air system

The inlet air for the engines shall be taken within the D.G. station building. The degree of filtration shall be as per BS: 1701.

5.7.8.3.6. Engine Exhaust System

A separate exhaust system shall be provided for each D.G. set. The system shall accommodate expansion movements and shall be arranged so that vibration from the engine is not transmitted to building or support structures. Condensation of flue gases when the engine is operating under any load and under any ambient conditions (down to 13.4 °C) should not take place to avoid corrosion in the system. The ducting system shall be sloped and equipped with drains at low points and at the base of chimneys. Connection shall be provided for flue gas sampling. A silencer shall be provided within the air exhaust system for each engine.

Chimneys to be supplied shall conform to IS: 6533. The chimney shall be arranged in such a way to prevent rain water entry as far as practicable.

Thermal insulation shall be provided on exhaust ducting. This shall be extended further downstream to the stack, if necessary, to avoid condensation of the flue gases under condition mentioned above.

5.7.8.3.7. Engine Jacket Cooling System

A separate enclosed engine jacket cooling system shall be provided for each engine. An expansion tank shall be provided for system to compensate for volume changes in the cooling water system and to provide sufficient system pressure, to prevent pump cavitation. The tank volume shall be at least 10% of the system volume and at least 100 litres. Soft water shall be used for engine jacket cooling system.

5.7.8.3.8. Acoustic Enclosure

Maximum level of sound at 1.0 meter from sound generating source shall be maintained at 70dB(A). Suitable acoustic enclosure / insulation shall be provided for maintaining the above sound level.

5.7.9. Light and Power Wiring

5.7.9.1. General

This shall be applicable for 3 ph, 4 wire, 415V, 50 Hz, AC supply and 240V, single phase, 3 wire, 50 Hz, AC supply. The installation, testing and commissioning of complete lighting system and power receptacles shall be carried out according to this specification. The installation shall be carried out as per below listed standards.

5.7.9.2. Standards

- IS: 732 - Electrical Wiring Installation (System Voltage not exceeding 650V).
- IS: 3646 - Code of practice for interior illumination.
- IS: 1944 - Code of practice for street lighting installation.
- IS: 6665 - Code of practice for industrial lighting.
- IS: 5133 - Boxes for enclosure of electrical accessories. (Part I)
- IS: 5216 - Guide for safety procedures and practices in electrical work.
- IS: 371 - Ceiling roses.
- IS: 694 - Wiring conductors. (Part II)
- IS: 5133 - Enclosure for electrical accessories. Part I
- ANSI/UL 8750, 2009: Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products

- IES LM-79-2008: Approved method for the electrical and photometric testing of solid-state lighting devices.
- IES LM-80-2008: Approved method for measuring lumen depreciation of LED light sources
- IEC61347-2-13, 2006: Particular requirements for D.C. or A.C. supplied electronic control gear for LED modules
- IEC 62031, 2008: LED modules for general lighting –Safety specifications
- IEC 62384, 2006: DC or AC supplied electronic control gear for LED modules –Performance requirements
- IEC/PAS 62612, ed1.0: Self-ballasted LED-lamps for general lighting services -Performance requirements
- IS:16103 (Part 1) 2012: LED Modules for General Lighting Part 1 Safety requirements
- IS:16103 (Part 2) 2012: LED modules for general lighting Part 2 Performance requirements
- IS:16107 (Part 1) 2012: Luminaires Performance Part 1 General requirements
- IS:16107 (Part 2 Sec 1) 2012 Luminaires performance Part 2 Particular requirements Section 1 LED Luminaire

5.7.9.3. Scope

The work shall include supply and fixing of all the equipment associated with lighting and power receptacles, routing and laying of conduits, wiring, termination, testing, commissioning and all other works necessary for completing the job. Supply and fixing of all mounting accessories, earthing wires, hardware and consumables like saddles, spacer plates, junction boxes, conduits, required fittings for fixing suspension points, joint boxes, connectors, jointing ferrules, fixing brackets ball and socket, screws etc.

5.7.9.4. Conduit System

5.7.9.4.1. Concealed Conduit System

All conduits including bends, unions, junction boxes etc. shall be cleaned and painted with bituminous paint before they are fixed in position. Conduits which are to be taken in the ceiling slab shall be laid on the prepared shuttering work before the concrete is poured. The conduits shall be properly threaded and screwed into the sockets, bends, junction boxes, outlet boxes and shall be made water tight by using bituminous yarn at the screwed ends. The conduit in ceiling slab shall be straight as far as possible. Before, the conduits controls junction boxes shall be set out clearly so as to minimize off-sets and bends.

Conduits concealed in the wall shall be secured rigidly by means of steel hooks / staples at 800 mm intervals. Before conduit is concealed in the walls, all chases, grooves shall be neatly made to proper dimensions to accommodate required number of circuits. The outlet boxes, point control boxes, inspection and draw boxes shall be fixed as and when conduits are being fixed. The recessing of conduits in walls shall be so arranged as to allow at least 12 mm plaster cover on the same. All grooves, chases etc. shall be refilled with cement mortar and finished upto wall surface before plastering of wall is taken up.

Where conduits pass through expansion joints in the buildings, adequate expansion fittings or other approved devices shall be used to take care of the relative movement. Whenever the conduits terminate into control boxes, distribution boards etc. conduits shall be rigidly connected to the boxes / boards with check nuts on either side of the entry to ensure electrical continuity. After conduits, junction boxes, outlet boxes etc. are fixed in position their outlets shall be properly plugged with PVC stoppers or any other suitable materials, so that water, motor vermin or any other foreign materials do not enter into conduit system.

All conduits end terminating into an outlet shall be provided with bushes or PVC or rubber after the conduit ends are properly filed to remove bur and sharp edges.

Necessary GI pull wires shall be inserted into the conduits for drawing wires and earth wires shall be run throughout the length of the conduit with the earth wire being efficiently fastened to the conduits by means of special clamps.

5.7.9.4.2. Open / Surface Conduit System

Wherever specifically called for, surface conduit system shall be adopted. Conduits shall be run in square and symmetrical lines. Before the conduits are installed, the exact route shall be marked at site and approval of PRED's Representative shall be obtained. Conduits shall be fixed by heavy gauge GI saddles, secured by suitable expansion plugs, at an interval of not more than 1.0 meter. Wherever couplers, bends or similar fittings are used, saddles shall be provided at either side at a distance of 300 mm from the centre of such fittings. Conduits shall be joined by means of screwed couplers and screwed accessories only. In long distance straight runs of conduit, inspection type couplers / junction boxes shall be provided. Threading shall be long enough to accommodate pipe to the full threaded portion of the couplers and accessories. Cut ends of conduits shall have no sharp edges nor any burrs left to avoid damage to insulation of wires.

Bends in conduit runs shall be done by using pipe bending machine. Sharp bends shall be accomplished by introducing solid bends, inspection bends or cast iron inspection boxes. Radius of solid bends shall not be less than 75 mm. Not more than three 90 Deg. bends shall be used in a conduit run from outlet to outlet.

All conduit opening shall be properly plugged with PVC stoppers / bushes. Conduits shall be adequately protected against rust by applying two coats of approved synthetic enamel paint after the installation is completed.

Wherever conduits terminate into control boxes, outlet boxes, distribution boards etc. it shall be rigidly connected to the box with check nuts on either side of the entry. The entire conduit system shall be bonded to the earth.

5.7.9.5. Outdoor Lighting

For outdoor lighting such as street lights, flood lights, the Contractor shall erect the poles / tower including foundation work, install the terminal boxes, and assembled fittings and the necessary wiring to the fitting and earthing.

5.7.9.6. Wiring

Wiring shall be colour coded to enable easy identification of phase and neutral conductors. The wiring throughout the installation shall be such that there is no break in neutral wire in the form of a switch or fuse units.

5.7.9.7. Enclosures for Electrical Accessories

Enclosure for electrical accessories such as switches, receptacles, fan regulators etc. shall be of cast iron or mild steel. Wall thickness of CI enclosures shall not be less than 2 mm and that of M.S. boxes shall not be less than 1.6 mm. The enclosure boxes shall be provided with a minimum of four fixing lugs located at the corners for fixing the covers. All fixing lugs shall have tapped holes to take machine brass screws. Sufficient number of knock outs shall be provided for conduit entries. Provision shall be made for bonding the enclosures to earth. The enclosure shall be protected against rust and corrosion inside and outside with red oxide primer followed by two coats of synthetic enamel paint. The enclosures shall be provided with 5 mm thick perspex sheet cover with rounded corners and leveled edges for mounting switches and receptacles. Wherever different phase conductors are brought into the same enclosure, phase barriers shall be used.

5.7.10. Switches, Receptacles and Accessories

5.7.10.1. General Requirements

Light control switches shall be rated 5A for controlling upto four light points and 15A for more than four light points. Light control switches shall be piano key type design suitable for flush mounting for general lighting, wherever specifically called for, tumbler switches shall be used.

All receptacles of 5A and 15A rating shall be flush mounting type with control switches piano key type of the same rating as that of the receptacle. All receptacles shall be of 3 pin type. The base of receptacle shall be high quality porcelain with pins made of brass alloy and plated with noble metal. All receptacles shall be provided with plug tops of approved quality.

5.7.10.2. Industrial type Receptacles

Industrial type receptacle shall be provided wherever specifically called for. Industrial receptacles shall be totally metal clad with porcelain base incorporating the pin. Sockets shall have three pins for single phase application and four pins and scraping earth for three phase applications. The receptacle shall be provided with suitable metal clad plug top with provision for cable entry. Receptacle shall have a spring loaded cover or metal covers with a chain. It shall have a suitably interlocked switch. Receptacle shall be mounted in a cast aluminium enclosure or sheet steel enclosure with receptacle mounted flush with the cover of the housing.

5.7.10.3. Lamp Holders, Ceiling Roses etc

Accessories for light outlets such as lamp holders, ceiling roses etc. shall be in conformity with requirements of relevant IS specifications. Only approved make of accessories shall be used.

5.7.10.4. Installation of Switches, Sockets and Accessories

All switches shall be wired on phases. Connections shall be made only after testing the wires for continuity, cross phase etc., with the help of megger. The arrangement of switches and sockets shall be neat and systematic. Outlets for fans shall be terminated into a ceiling rose or into a connector if concealed fan hooks are used.

5.7.11. Ceiling Fans

Ceiling fans shall conform to IS: 374 in all respects. The motor shall be of capacitor type and motor body shall be high conductivity aluminium die cast type. The motor and blades shall be statically and dynamically balanced. The fans shall be provided with ball bearing and bush bearing, which shall be accessible for lubrication, rubber shackle and downs shall be of suitable length. Length of the down rod shall be co-ordinated with down drops of light fittings so that no shadow will fall on the working plane. A regulator for five speed operation and stop shall be provided with every fan. Energy efficient Five star rated fans shall be used.

5.7.12. Exhaust Fans

Propeller type exhaust fans shall conform to IS: 2312 in all respects. The motor shall be of diecast aluminium case. Fan motor shall be of squirrel cage induction design. Single phase motors shall be designed to withstand the effects of moisture under normal conditions of use. Exhaust fans shall be complete with mounting rings, ring arms and a resilient suspension. The motor and blades shall be statically and dynamically balanced. Exhaust fan shall be connected to the electrical point by means of flexible chord.

5.7.13. Light Fittings and Accessories

5.7.13.1. Standards

The light fittings and their associated accessories such as lamps, reflectors, housings, ballasts etc shall comply with the latest applicable standards, more specifically the following:

All the light fixtures shall be high energy efficient LED type shall be used as per standard requirement

- Electric lighting fittings - General and safety requirements IS: 1913
- Industrial lighting fittings with metal reflectors - IS: 1777
- Decorative lighting fittings - IS: 5077
- Flood lights - IS: 1947
- Luminaries for street lighting - IS: 2149
- Bayonet lamp holders - IS: 1258
- Bipin lamp holders for tubular fluorescent lamps - IS: 3323
- Ballasts for use in fluorescent light fittings - IS: 1534
- Starters for fluorescent lamp - IS: 2215
- Ballast for HP MV lamp - IS: 6616
- Capacitors for use in fluorescent, HPMV & LP sodium vapour lamps circuit - IS: 1569
- Tubular fluorescent lamps - IS: 2418 (Part - I)
- High pressure mercury vapour lamps - IS: 2183

5.7.13.2. Light Fittings General Requirements

Fittings shall be designed for continuous trouble free operation under atmospheric conditions without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weatherproof and rain proof. Fittings shall be so designed as to facilitate easy maintenance including cleaning, replacement of lamps / starters etc.

All fittings shall be supplied complete with lamps. All Metal halide fittings shall be complete with accessories like ballasts, power factor improvement capacitors, starters, etc. Out door type fittings shall be provided with weather proof boxes.

Fluorescent lamp fittings shall be complete with all accessories like low loss electronic ballasts PF improving capacitors, starters capacitors for correction of stroboscopic effect.

Each fitting shall have a terminal block suitable for loop-in loop-out connection by 1100V PVC insulated copper conductor wires upto 4sq.mm. The internal wiring should be completed by the manufacturer by means of multi-stranded copper wire and terminated on the terminal block. All hardwares used in the fitting shall be suitably plated or anodized and passivated for use in industrial plants.

5.7.13.2.1. Earthing

Each lighting fitting shall be provided with an earthing terminal. All metal or metal enclosed parts of the housing shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity throughout the fixture.

5.7.13.2.2. Painting / Finish

All surfaces shall be stove-enameled or anodised as required. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 Deg. over 12 mm Dia. mandrel.

5.7.13.3. Decorative type Fittings

Decorative fluorescent fittings shall be provided with mounting / housing channel cum reflectors of CRCA sheet steel, stove enameled. Diffusers or louvres shall be translucent white polystyrene / aluminium as specified.

5.7.13.4. Accessories for Light Fittings Reflectors

The reflectors shall be made of CRCA sheet steel / aluminium / silvered glass / chromium plated sheet copper as required. The thickness of reflectors shall be as per relevant standards. Reflectors made of steel shall have stove enameled / vitreous enameled / epoxy coating finish. Aluminium used for reflectors shall be anodized / epoxy stove enameled / mirror polished. The finish for the reflector shall be as specified.

The reflectors shall be free from scratches blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient. Reflectors shall be readily removable from the housing for cleaning and maintenance without use of tools.

5.7.13.5. Lamp / Starter Holders

Lamp holders shall have low contact resistance, shall be resistant to wear. They shall hold lamps in position under normal conditions of shock and vibration prevalent in an industrial atmosphere. Lamp holders for fluorescent lamps shall be of spring loaded bipin rotating type. Live parts of the lamp holder shall not be exposed during insertion or removal of the lamp or after the lamp has been taken out. Lamp holders for incandescent and mercury vapor lamps shall be bayonet type upto 100W and Edison screw type for higher wattage. Starter holders for fluorescent lamps shall be so designed that they are mechanically robust and shall be capable of withstanding shocks during transit, installation and use.

5.7.13.6. Ballasts

The ballasts shall be designed for long life and low power loss. They shall be mounted using self locking, anti vibration fixtures and shall be easy to remove without demounting the fittings. The enclosures shall be dust tight and non combustible.

Ballasts shall be inductive, heavy duty type, filled with thermosetting, insulating, moisture repellent polyester compound, filled under pressure or vacuum. Ballasts shall be provided with tapes to set the voltage. The ballast wiring shall be of copper. They shall be free from separate ballast shall be provided in case of multi-lamp fittings, except in case of 2 x 20 W fittings. For all DFL and TFL fittings the ballasts shall be electronic type.

5.7.13.7. Starters

Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector of lamps and without use of any tool. Starters shall have brass contacts and radio interference capacitor.

5.7.13.8. Capacitors

The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits. The capacitor shall have a value of capacitance so as to correct the power factor of its corresponding lamp circuit to 0.95 lag or better. Capacitors shall be hermetically sealed, preferably in a metal enclosure to prevent seepage of impregnation and ingress of moisture.

5.7.13.9. Lamps

Incandescent lamps shall be clear type unless otherwise specified. Fluorescent lamps shall be "day-light colour" type unless otherwise specified and shall be provided with features to avoid blackening of lamp ends. Mercury vapor lamps shall be of high pressure, colour corrected type.

Lamps shall be capable of withstanding vibrations prevalent in an industrial atmosphere and connections at lead in wires and filament / electrodes shall not break under such circumstances.

5.7.14. Cable Installation Work

5.7.14.1. General Scope

The installation work shall include unloading, sorting, laying fixing, joining / termination, testing, commissioning and any other work items necessary for completing the job.

The cable shall be laid in built up trenches, directly buried in ground on cable trays, vertical raceways, clamped on structures / walls / ceiling, pulled through pipes and conduits as specified elsewhere in the document. The scope of cable laying shall include laying, pulling cables as above, proper dressing of cables and supply and fixing of saddles, spacers and nylon chord for tying as required.

5.7.14.2. Cable Termination

The scope of termination at each end shall include dressing and connection of each core of cables. The following shall be included in the scope of work. Making the required holes in gland plate for cable boxes / glands, fixing the cables boxes / gland, terminating the cables in the glands / cable boxes, earthing of cable armour, crimping of cable lug on each core, neatly clamping the cables inside switch gear / cables alleys / wiring through etc. Cable identifying lugs shall be supplied and installed. All cable termination shall be solder-less crimping type. Proper crimping tool shall be used by the Contractor. Single compression upto 95sq.mm and double compression glands above 95sq.mm shall be used.

5.7.14.3. Cables Directly Buried in Ground:

The depth of burial shall not be less than 750 mm from the finished ground level. Minimum width of the trench shall be 450 mm an axial distance of one diameter of the cable between cables. The trenches shall be cut square with vertical side walls and with uniform depth. Suitable shoring and propping may be done to avoid caving in of trench walls. The floor of the trench shall be rammed level.

The cable drum shall be rolled in the direction indicated. Minimum bending radius of cables shall not be less than 12 times the diameter of the cable for LT and 15times for HT cables. After the cable is laid and straightened, it shall be covered with 80 mm thick layer of sand. Cable shall be lifted and placed over this sand cushion. The cable shall then be covered by 80 mm thick sand cushion. Over this a layer of cable protection tiles or burnt bricks shall be provided so as to cover the cables by 50 mm on either side. The trench shall be backfilled with selected earth and consolidated. Cables shall be laid in hume pipes at road crossing and foundation entry points. Cable markers of cast iron / concrete indicating the voltage, number of cables and the direction of run of the cables shall be installed at intervals of 25 meters *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*.

5.7.14.4. Cables laid in Indoor Trenches / on Trays

Suitable clamps, hooks and saddles shall be used for securing the cables in position. Spacing between the cables shall be 25 mm wherever specified. The trench shall be filled up with fine sand. Necessary trench covers shall be provided as per standards.

5.7.14.5. Testing of Electrical Installations

Testing of electrical installations shall be as per IS: 732. The insulation resistance shall be measured between earth and whole system of conductors or any selection thereof with all fuses in place and all switches closed, all lamps in position, or both poles of the installation otherwise electrically connected together, by applying a direct current pressure of not less than twice the working pressure provided it need not exceed 500V for medium voltage circuits. Where the supply is derived from three wire or a polyphase system, the neutral of which is connected to earth either direct or through added resistance, the working pressure shall deemed to be that which is maintained between the outer or phase conductor and neutral.

The insulation resistance so measured shall not be less than 50 megohms divided by number of points or the circuits provided that the whole installation shall be required to have an insulation resistance of more than one megohm. The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or neutral or to other pole or phase conductors of the supply and its value shall be less than specified above. The test voltage of the meggar shall be 500VDC

5.7.14.5.1. Testing of earth continuity

The earth continuity conductor including metal conduits and metallic envelope in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead,

but excluding any added resistance or leakage circuit breaker measured from the connection with the earth electrodes to any point in earth continuity conductor in the completed installation shall not exceed one milliohm

5.7.14.5.2. Testing of polarity of non linked single pole switches

In a two wire installation, a test shall be made to verify that all non linked single pole switches have been fitted in the same conductor throughout and such conductor shall be labeled or marked for connection to an outer or phase conductor or the non earthed conductor of the supply. In three wire or four wire installation, test shall be made to verify that every non linked single switch is fitted on a conductor which is labeled or marked for connection to one of the outer phase conductor of the supply.

5.8. Instrumentation

5.8.1. Control and Automation Panels

5.8.1.1. Introduction

- The Industrial / Residential Pumping Stations and Sewerage IPS monitoring, alarm and control shall be achieved via respective PLC control ICA panel and also remotely from the SCADA operator room at located at common area of these Pumping Stations.
- A PLC based control system together with the HMI in each local ICA panel shall monitor and control its associated part of the plant, station equipment. SCADA system and ICA panels shall communicate with one another via a self-healing, fault tolerant and redundant communication network.
- Contractor / vendor shall submit the overall system architecture with the bid.

5.8.1.2. Scope of Works

- Contractor shall supply and install ICA panels with approved make PLC and HMI as per vendor list enclosed with the tender document. All other components shall be selected where practical from a single manufacturer's range. The vendor for ICA panel shall be subject to approval by Engineer/Owner.

5.8.1.3. Panel Type, Ingress Protection, Components and Enclosure Materials

- ICA panel shall be Form 2 free standing, IP 54 suitable for indoor mounting. Panel depth shall be 800 mm.
- All components shall be coordinated with the short circuit protective device such that a flow of current will cause no damage, and that normal operation of the equipment is unaffected.
- Proper ventilation system shall be considered for each panel. The panel's construction shall be such as to allow full accessibility from the front. Floor support and fixing bolts shall be provided by the contractor.
- The panel shall be sealed so as to be substantially dust proof. Cables shall enter and leave from the bottom. The panel shall be provided with a removable rustproof plated gland plate.
- The Contractor shall provide and fit all necessary cable glands. Each cubicle of the panel shall be equipped with a fluorescent tube light interlocked with a door limit switch.
- Control Panel shall have 20% free space for future expansion. Enclosure for Control ICA Panels shall be designed such that extensions can be made at either or both ends. The panel should be designed so that if required it may be split into sections for transportation bearing in mind the transportable weight. Each section is to be fitted with removable lifting eyebolts to facilitate handling. With transportation splits provision is to be made for any interconnecting wiring connections.
- Panel material shall be prime-quality, cold-rolled and annealed mild steel or zinc-coated mild steel sheet, suitably braced and stiffened as necessary with flat bar or angle to form a rigid structure. Height of instruments, switches, and indicators should be no more than a maximum of 1800 mm or less than a minimum 500 mm above the base of the panel assuming floor mounting unless otherwise specified
- Enclosure shall be sealed at cable entries with glands have IP56 protection degree. Gland plates shall not form part of the enclosure. Suitable cleats and supports shall be provided to ensure that cables are not supported by the cable glands.

- All cabling shall be glanded directly in the section housing its terminals. Cabling between compartments shall be via termination chambers, and terminals shall be provided at the point at which the control panel are split for shipping.
- All doors shall be earthed via flexible conductors. Every section of the panel shall be connected to the main earth bar. It shall be terminated in a separately mounted earth stud.
- A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. Control panels shall be completely wired to the terminals at the factory itself, requiring only connections to the external wiring circuits at site.
- Extra electrical sockets for test and repair purposes shall be provided in the local ICA panels. These sockets shall be according to British Standards suitable for flat and round pins. Local ICA panels shall also have equipped with space heaters, if required.
- The door shall have separate handle and locks. Each lock shall be provided with 2 keys. A document pocket containing a set of drawings and/or schedules shall be provided within the panel in an easily accessible position.
- Components shall be mounted on a separate removable mounting plate. The only exception being front of panel mounted equipment.
- Where removable covers exceed 1000 mm in height they shall be fitted with an engagement lip or similar to assist removal or replacement.
- Internal wiring shall be adequately sized for the required voltages and currents. Cable ducts shall be provided with at least 20% spare capacity after complete wiring. Separate ducting shall be provided for the wires carrying different voltages.
- ICA panels shall be of high standards quality in terms of visual appearance, colour, finish, smoothness of surface
- Labels shall be provided for all instruments, indication lamps, selector switches and push buttons installed in the panel door.
- Titles on name plates shall be written in English. Materials for nameplates shall be selected in accordance with the weather data and area conditions and shall be of the non-metallic type, with black inscriptions on white background.
- There shall be HMI with minimum display size of 15 inch (Refer to HMI specs in the below section).

5.8.1.4. Lightning Protection

An exposed cabling connecting to instrument located outdoors shall be provided with a lightning protection barrier at the point of ICA panel entry.

5.8.2. Programmable Logic Controller (PLC)

5.8.2.1. Introduction

This Specification covers minimum requirements of PLC as per proposed/preferred vendor list which shall be used to monitor and control The Industrial / Residential Pumping Stations and Sewerage IPS.

5.8.2.2. Scope of Works

The Contractor shall provide all assets associated with the programmable logic controller. This shall include all hardware and software items, including (but not limited to):

- All hardware including equipment racks, central processor units, I/O cards, communications modules and programming cables.
- All software including PC based configuration software (to include any —dongle||, license or other such software protection device required to utilize the software), fully documented and commented source code files.
- All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.

- The PLC shall be provided with sufficient communication ports to enable the laptop to be connected without a requirement to disconnect remote monitoring devices or any SCADA / HMI / programmable operator terminal units installed.

5.8.2.3. PLC Hardware Specifications

- PLC system shall comprise of a central processing unit, input/output modules and serial interface modules. The PLC shall be of modular construction with plug in I/O cards and facility to install expansion racks/modules when necessary. The system shall include 20% spare capacity in hardware and memory for future modifications in addition to the I/O signals for future pumps.
- PLC shall have dual redundant processor configuration. Over and above this, redundancies will be incorporated for input/output, power supply, communication network etc. Redundant I/O cards shall be used for closed loops, any other critical loop, shutdown and fire and gas loops.
- The equipment shall accept discrete and analogue (4-20mA) signals from both field and panel mounted instruments. Analogue inputs shall be scanned into a 12 bit binary (minimum) analogue to digital converter with buffered inputs.
- The PLC power supply shall be 230 VAC +/- 2% and 50 +/- 1% Hz UPS supply. The equipment shall be maintained in operation during a period of mains failure drawing power from the UPS system for a minimum back-up time of 3 hours. The UPS system shall include diagnostic and automatic self- test routines with volt-free contacts to initiate an alarm in the event of malfunction.
- The PLC controller family shall have a high degree of interchange capability. The power supply, battery and EEPROM Chips should all operate equally well regardless of the CPU being used.
- It should be possible that all assemblies and sub-assemblies performing similar functions shall be interchangeable.
- The system design shall accommodate the replacement of assemblies without having to disconnect field wiring; removable connectors shall be used to connect field wiring to the individual circuit board assemblies.
- All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings each of which indicates the manufacturer's catalogue number and item description.
- The power supply unit shall be modular in design, compatible with main CPU and expansion racks allowing easy on-site replacement in the unlikely event of failure.
- The power supply unit shall contain a battery compartment for installing a long-life Lithium battery to protect programming CMOS RAM memory. The battery power transfer shall be bump less.
- The battery shall be capable of supporting the memory for a period of minimum one year without having power applied to the system. The low battery condition shall be alarmed.
- This battery shall be replaceable while power is applied to the PLC.
- The user application program shall be stored in Random Access Memory (RAM) or a combination of RAM and Electronically Erasable and Programmable Read Only Memory (EEPROM).
- The user application program scan time, on average, shall be no greater than 50ms for logic and integer processing. Where three terms control (PID) and Floating point data processing is required, the application scan time shall be no greater than 100ms.
- RS232 Serial/Ethernet communication ports shall be provided to facilitate the following:
 - Connect the laptop for PC compatible programming software
 - Connect the Hand-Held Programmer to the PLC
 - Connect to one of the wide variety of third-party operator interfaces utilizing an open architecture software protocol.
 - Provide RS-422 signals with RS-485 compatibility. The characteristics of this port shall be software configurable and shall be modem compatible.
- When an I/O fault occurs, the processor shall report the location of the fault, the condition, the address and the circuit number if appropriate.
- All digital input units shall be capable of accepting, a volt-free contact signal, the source voltage shall be regulated 24VDC and shall be derived from the PLC panel.

- Where the input from an external source is not volt-free then suitable isolation devices shall be provided in order to prevent cross-connection of different supplies. This device may be e.g. interposing relay or optical-isolator. For frequencies of operation greater than 30 operations/hour, the use of electromechanical devices shall not be permitted. All interface/isolation devices shall provide visual indication of Signal State.
- Inputs signals from 'DUTY' equipment shall not be allocated to the same input module as signals from 'STANDBY' equipment performing the same function.
- Digital outputs used for AC inductive loads shall be fitted with arc suppression devices as close to the load as is practicable.
- Provide hardware watchdog relays driven by digital outputs from the PLC to detect major PLC processor fault, I/O error and low battery fault.
- PLC's to include facilities to retain the last state of the output modules at the time of the PLC failure. This shall be achieved by means of hardware or software.
- The power (AC and DC) for I/O shall be distributed by the use of suitably rated MCB's. Separate MCB shall be provided for the followings:
 - PLC and I/O rack power supplies.
 - External networking or communication if any.
 - Analogue DC power supplies.
 - Digital 24VDC power supplies.
 - Digital 230 VAC.
- The CPU shall have a memory protect key switch together with passwords to provide different levels of access privilege for the PLC when the programmer is in On-line.
- Indication of status of digital I/O shall be provided by LED's on the face of the I/O module.
- The processor unit shall have a real time clock with battery backup. A —battery low|| indication lamp shall be provided to monitor battery status.

5.8.2.4. PLC Software Specifications

- PLC Software shall be developed within the BS EN 61131-3 environment. Application program shall be developed by using software package that only conform to BS EN 61131-3 requirements.
- Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.
- All software shall be suitably documented to include the following as a minimum:
 - Suitable comments
 - Function description
 - Descriptions of all constants
 - List of cross-references
- On-line and off-line, CPU and I/O configuration and application program development shall be achieved with a PC compatible computer and programming and documentation software.
- The WINDOWS/ Windows NT Platform compatible software shall provide the capability of reading, writing, and verifying the configuration and program with a diskette / suitable backup arrangement.
- The software shall provide on-line help information throughout its execution paths.
- The software shall allow development of programming, storing the program to the PLC, monitor program and references address status while the PLC is in Run or Stop mode.
- The software shall be user friendly to generate printout of the program for documentation purposes selectable to print various options e.g. printing of complete program with instruction for each rung, the reference list, reference description, reference address and tables.
- The software shall have provisions for importing and exporting tag names, comments and descriptions in an .xls format
- The programming language shall be BS EN 61131-3 compliant.
- The CPU shall be capable of solving an application program whose source format shall be relay ladder diagram. The language shall support relay, timers and counters, arithmetic, relational, bit operation, data move, conversion, and control functions.

- The CPU shall be capable of solving an application program whose main program format is in Sequential Function CHART (SFC) with underlying code in relay ladder diagram.
- Control functions shall be provided to limit program execution, an immediate I/O update of all or a portion of the inputs or outputs for one scan while the program is running, or to update I/O during the program in addition to the normal I/O scan.
- Additionally, the function shall provide a mean to read inputs into memory auxiliary to true input table and execute outputs from discrete memory alternate to the true output table
- A method for structuring the ladder program shall be provided with the use of a JUMP Function. This will cause the program execution to jump to a specified location in the logic targeted by the location of the LABEL function.
- Diagnostic and fault detection requirements shall typically include I/O data corruption, single bit RAM failures, power supply failures, processor failures, and I/O bus failures.
- All PLC's shall be designed as hot standby and shall detect and report failures of all critical components so that appropriate control actions may be taken. All components that acquire or distribute I/O data or that are involved in execution of the control logic solution are considered critical components. A fault in the active unit shall cause a switch of control to the backup unit.

5.8.2.5. Alarm System

- The alarm system is part of the control system functions. The alarm systems shall contain all alarms for a safe and reliable operation of the pumping station. Alarms shall be generated when important operating data exceed their limits or when abnormal operating conditions occur in the pumping station. An accumulation of alarms, e.g. in case of system trips, must not cause any loss of alarms.
- Alarms shall be initiated by means of position or limit switches, protection relays, fuses and miniature circuit-breakers, auxiliary contacts of switchgear, breakers, etc., or generated by the
- programmed digital system itself.
- Tripping and auto-change over of motors, trip of circuit-breakers, status of isolation device, etc. shall be announced by flashing of the symbol on the HMI/SCADA operator station mimic diagram and
- on any related screen representation. Such trips shall also be announced on the alarm summary screen. In case of alarm, an acoustic signal shall be given. It can be cancelled by a horn-off acknowledgement pushbutton. The alarm acknowledgement pushbutton shall be different from horn acknowledgement.

5.8.2.6. PLC Standards

PLC programming shall follow industry best practice. Software development shall be carried out in accordance with the methodologies described in BS EN 61508, BS EN 61511 and IEC 61131. Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.

- BS 7671 16th Edition IEE Regulations for Electrical Installations
- BS EN 60204 Safety of machinery
- BS EN 61000 Electro-magnetic compatibility
- BS EN 61131 Programmable Controllers
- BS EN 50170 General purpose field communication system
- ISBN 0 86341 233 5 IEE Guidelines for the documentation of computer software for real time and interactive systems
- ISBN 0 11 883906 3 HSE Programmable Electronic Systems in safety related applications
- BS EN Equivalent Standard to BS/EN, please refer to Division 6 Section 06200 Standards and Regulations (Guidelines)

5.8.2.7. Documents and Drawings

On contract stage and before handing over, the contractor shall submit comprehensive documentation (ISSUED FOR APPROVAL) including but not limited to:

- PLC Program in hard copy as well soft copy.
- Technical data sheets for PLC hardware.

- Formal inspection and Functional test procedures
- O&M manual and installation instruction.
- I/O list.
- Automation System Architecture.
- GA drawing with BOM
- Loop drawing
- Heat load calculation
- Power distribution
- Wiring diagram
- FAT / SAT Procedure

5.8.2.8. Spare Parts

Spare parts shall be provided as recommended by equipment manufacturers which shall be subject to review and approval by the Owner and Engineer

5.8.2.9. Installation and Commissioning

The Contractor shall install and commission the supplied PLC. The Contactor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log Test
- Documentation, schedules, logs and final status report.

5.8.2.10. Training

Training shall be provided at site for the Owner's O&M personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control, maintenance of ICA equipment.

5.8.3. SCADA and HMI

5.8.3.1. Introduction

This Specification covers minimum requirements of SCADA & HMI used to monitor and control in the Industrial / Residential Pumping Stations, Sewerage IPS and field level instruments.

5.8.3.2. Scope of Works

- Industrial / Residential Pumping Stations, Sewerage IPS and field level instruments such as shall be monitored and controlled by SCADA system located at respective pumping station and monitored at control room at common utility area.
- The layout of the SCADA control room shall be proposed by the contractor for the Owner/Client's approval.
- The Contractor shall provide all assets associated with the SCADA & HMI. This shall include all hardware and software items, including (but not limited to):
 - All hardware including operator and engineering work stations, printers, servers, communication hardware and cables.
 - All software including PC based configuration software (to include any —dongle, license or other such software protection device required to utilize the software), fully documented and commented source code files.
 - All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.
- SCADA System shall be installed in temperature controlled RCC Room with all the required furniture and filing cabinet. The operator workstation VDUs shall be located on the operator desk console.

- To ensure high system availability, the SCADA equipment shall be configured in a dual redundant system configuration. The configuration of all proposed computers shall be of the latest revision at the time of the equipment supply and to the approval of the Employer's Representative.
- One printer shall be color laser A3 printer provided for creating hard copies of workstation VDU. Other printer shall be a Dot Matrix type printer for Alarm/Event recording and for continuous logging of all pumping stations and entire plant data.
- The SCADA software running on windows platform or latest industry proven version of Windows is preferred. The SCADA software shall have 'open system' client/server architecture allowing operation on and interfacing with a choice of hardware platforms. The SCADA software package shall be proven for similar application in India.

5.8.3.3. Standards

The following list of standards indicates the minimum requirements:

- IEC 60654 Operating conditions for industrial process measurement and control equipment
- IEC 60625 Interface system for programmable measuring instruments
- IEC 60902 Industrial process measurement and control – terms and definitions
- IEC 60839 Alarm and warning systems
- EN 50228 Instrumentation cables
- ISO 3511/1 Process measurement control functions and instrumentation symbolic representation
- BS 6739 Instrument loop checkouts

5.8.3.4. SCADA Computers

- The SCADA computers shall provide the required power, flexibility and scalability for the required application under a true multi-user, multi-tasking environment, and shall comprise servers and operator workstations.
- Work stations and servers shall be suitable and proven for the application.
- Minimum two computers shall be used as workstations and shall be provided with Network Management software and industrial automation process software, to ensure high system availability. The SCADA computers shall be configured as fault tolerant dual redundant hot standby and shall be connected to the PLC system via dual communication sub-system.
- Archiving system shall be provided which shall be based on magneto-optical storage technology. At least two archiving systems shall be provided, one for each workstation. In case one system failure, the other shall be capable of completely taking over the archiving function. Diagnostic software and historical file management, archival and retrieval shall be included.
- The workstations shall have a screen diagonal measurement of at least 21" with a minimum resolution of 1600 x 1280 pixels and shall include tilt and swivel facilities. A full function industrial Modem Fax 65KB, keyboard and mouse/track ball unit shall be provided with each computer.
- The computer hardware (RAID 1) proposed shall be from industry standard manufacturers, having permanent technical back-up and service facility available in INDIA, and shall be subjected to approval
- The SCADA computers shall be designed for non-obsolescence by allowing for sufficient future expansions, upgrades and enhancement in hardware and software including CPU, memory, hard disk, I/O hardware, and peripherals. The contractor shall provide the details of the expandability and upgrade path together with their tender proposal.

5.8.3.5. HMI Specification

- Human Machine Interface Unit shall be provided for each local control panel/station.
- HMI units shall have a backlit display with minimum display area of 15 Inches with a minimum resolution of 256 pixels x 128 pixels and a wide viewing angle. Colour displays only acceptable. The unit shall incorporate touch VDU. Touch screens shall be divided into touch cells, with each cell rated for a minimum of 1,000,000 presses or more.

- HMI units shall be powered by either a 230VAC or 24 VDC supply and shall have a power consumption of no greater than 100VA.

5.8.3.6. SCADA/HMI Design Concept

- SCADA/HMI units shall be configured to display data in a logically ordered format allowing quick and easy access to measured variables. Where displaying all data in one view would result in a cluttered or confusing display or where viewing and entry of control set points is possible from the SCADA/HMI, there will be a requirement for a number of views. Where data is split up across a number of views in this manner, data shall be displayed and accessed in a clear and logical way. The method used to switch between views shall be simple and intuitive. Periodic automatic scrolling of screens may be offered as an option but it shall be possible to disable this mode if desired.
- The SCADA/HMI unit shall store its view configuration in non-volatile memory to enable normal operation to resume without operator intervention on resumption of power supply following an outage. A battery backed real-time clock shall be provided.
- SCADA/HMIs shall be provided with a communication port to enable connection to the PLC for operational use.
- Where the SCADA/HMI is used to view and enter control set points, it shall be necessary to enter a password via the numeric membrane keypad or via a touch screen representation of a numeric keypad (depending on hardware configuration). When the password is correctly entered, the new set point value may be entered. The entered value will be error checked to ensure that the entered value is within the acceptable range. If the value entered is acceptable, the operator shall be alerted that the set point has been accepted and the entered value shall be written to the relevant PLC register. If the value is outside the acceptable limits, the operator shall be alerted that the entered value is outside acceptable limits, the entered set point shall not be written to the PLC and the existing set point data shall be used.
- Where a SCADA/HMI is supplied, the contractor shall provide all assets associated with the device. This shall include all hardware and software items, including (but not limited to):
- All hardware including communications modules and programming cables.
- All software including PC based configuration software (to include any —dongle||, license or other such software protection device required to utilize the software), fully documented and commented source code files.

5.8.3.7. Alarms Management System

- All alarms shall be displayed / logged as a clear message indicating condition, time and date stamped.
- Alarm Summary Screen: All alarms shall automatically send to the alarm summary page. Each alarm shall be time and date stamped. Colour coding shall be used to distinguish between (Alarm in alarm, and Alarm has been acknowledged).

5.8.3.8. Spares

Spares shall be provided as recommended by equipment manufacturer and it shall be submitted for review and approval by Owner and Engineer.

5.8.3.9. Installation and Commissioning

The Contractor shall install and commission the supplied SCADA/HMI system. The Contractor shall provide the following:

- Commissioning Plan
- Commissioning Manual
- Commissioning Log
- Test Documentation, schedules, logs and final status report

5.8.3.10. Training

Training shall be provided at site for the Owner's O&M personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control, maintenance of ICA equipment.

5.9. Chlorine Gas System

The Industrial and Residential Pumping Stations shall have chlorination Gas Feeding system with technical specifications as follows:

- Supply of fully automatic non corrosible cubicle type vacuum feed chlorinator confirming IS10553 (part-2) 1983 with latest amendments.
- The unit shall consist of the following parts for protection:
 - The cabinet is made out of FRP, fitted with a pressure gauge to show vacuum pressure and with a wall mounting block.
 - Vacuum regulator with Teflon diaphragm and Teflon working parts, which will stop the Chlorine to flow from cylinder in case of power failure and water shortage.
 - Borosilicate glass Rota meter to measure the flow of Chlorine gas
 - Injector to create the necessary vacuum at minimum water pressure of 1.5 Kg/Cm²
 - A Vacuum pressure breaker to prevent the possible water being drawn into Chlorinator and Chlorine cylinder
 - All connection pipes of Chlorine gas are made of copper with necessary fittings
 - Solenoid valve and fittings
 - Pump set (2 Hp, 5 Kg/Cm² head and 6 M³/Hr) with all accessories and fully automatic control panel

5.10. Fire Extinguishers

- Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.
- All the extinguishers shall be of TAC approved.

6. Proposed / Preferred Vendor's List

Submersible Pumps	Grundfos / Xylem / ABS (Sulzer) / Equivalent
Horizontal Centrifugal Pumps	Grundfos /Sulzer/ Kirloskar / Equivalent
Variable Speed Hydro pneumatic System	Xylem / Grundfos / Equivalent
Electrical Chain Hoist	Demag /Kone cranes (Morris)/ ElectroMech (Stahl) /Indef (Hercules) / Equivalent
EOT Crane	Demag/ Kone cranes (Morris) /ElectroMech (Stahl)/ Indef / Equivalent
Lifting Davit Crane	Thern / Vector Lifting / Reid Lifting / Equivalent
Penstocks	Hambaker Adams/ KWT/ Waterfront/ IBS Engineering /CTV / Equivalent
Telescopic Valves	Hambaker Adams/ KWT/Waterfront/ IBS Engineering /CTV / Equivalent
Pipes	
DI	Jindal / Electro Steel / Tata Kubota / Equivalent
HDPE	Jain/ Georg Fischer/ Dutron/ Supreme / Equivalent
UPVC	Georg Fischer/Astral / Equivalent
PVC	Georg Fischer/Astral / Equivalent
DWC	Supreme / Dutron / Astral / Equivalent
Valves	
Gate Valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG / Equivalent
Knife Edged Gate Valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG / Fouress / Equivalent
Ball Valves	Valtrock/Pentair/ Fluidtech valves/Aira / Equivalent
Non return valves	Kirloskar Brothers Ltd / Indian Valve Company / AV /VAG / Equivalent
Solenoid Valves	Mac/ Ascoeroin/eroir werke / Versa BV / Equivalent

Pressure transmitters	ABB / Rosemount (Emerson) / Honeywell / Yokogawa / Fuji Electric/ Siemens//Endress & Hauser / Burkert / Equivalent
Level Transmitters	ABB / Rosemount (Emerson) / Honeywell / Yokogawa / Fuji Electric/ Adept / Burkert / Siemens//Endress & Hauser, EIP / Equivalent
Flow meters	Krone Marshall / ABB / Endress & Hauser / Yokogawa / Emerson / EIP / Adept / Equivalent
Level Indicator/gauges	Chemtrol/ Forbes Marshall / Mobrey / Equivalent
Analyser	Emerson / Yokogawa/ ABB/Honeywell / Equivalent
Electric Actuators	AUMA/ Rotork/Emerson /Limitorque / Equivalent
PLC and SCADA System	Honeywell / Siemens / Alstom / Forbes Marshall /Schneider / GE Fanuc/Rockwell / Equivalent
Dissolved Oxygen Sensor and Transmitter	Jumo / Hach / Yokogawa / Equivalent
Residual Chlorine Sensor and Transmitter	Jumo / Emerson / Burkert / Equivalent
Chlorine Gas Feeder System	Ace / Fabchem / Equivalent
Diesel Generator	Kirloskar / Ojus Pwer / Sudhir / Equivalent
Warning Tape	Singhal Industries / Polycan Extrusion / RV Plast / Equivalent

D.3. POWER

xvi. DESIGN CRITERIA

1. GENERAL

- xvii. The distribution system shall be planned considering the Climate conditions, and basic electrical data.

2. Climate Conditions

- xxviii. The electrical equipment selected shall be such so as to give trouble free operation during the life of the equipment, under the most stringent atmospheric conditions prevailing at site.

Typical atmospheric data at site is as below:

xix. Maximum Design Ambient Temperature	50°C
xx. Maximum daily average Temperature	45°C
xxi. Minimum daily average Temperature	36°C
xxii. Relative Humidity	95% max 10% min
xxiii. Average number of Thunder Storms	3 - 5
xxiv. Altitude of operation	< 400m
xxv. Rainy months	June to Sept
xxvi. Basic Horizontal Seismic Coefficient	0.04
- xxvii. Equipment needs to be protected from the entry of ground water, tree roots, reptiles, lizards, wild animals etc. that can cause a short circuit.
- xxviii. For design purpose maximum ambient temperature of 50° C considered.

3. Tropicalization

- xxix. All electrical insulation, Panels or spacers and other materials, which could be damaged by fungus, termites or other parasitic growths, shall be suitably protected. Enclosures containing electrical control and switching equipment and instruments shall be equipped with electric heaters for moisture control. Heaters shall be of PTC type, without the use of thermostats.

4. Basic Electrical Data

4.1. System of Electrical Power Supply

- xxx. Classification of Supply (as per Supply code of UPCL norms & standard industrial practices)
- For all installations having contracted load up to 4kW - 230V AC Single phase supply
 - For all installations having contracted load above 4kW and up to 25kW – 415V Three phase
 - For all installations having contracted load above 25kW and up to 75kW/88kVA – 415V (Through high voltage distribution system at 415V (Metering on LV side) Three phase

- d) For all installations having connected load above 88KVA up to 3000 kVA – 11kV
- e) For all installations having connected load above 3000KVA up to 10000 kVA – 33kV
- f) For all installations having connected load above 10000KVA up to 50000 kVA – 132kV
- g) For all installations having connected load above 50000KVA – 220KV
- xxxi. The following limits as mentioned in table below of voltage regulation as prescribed in the Indian Electricity Rules (IE-1956) have been considered:

Table D-6: Voltage regulation as per IE-1956

S. No.	Voltage Level (kV)	Maximum Permitted Variation (%)
1	Up to 1100V	+6
2	650 – 33000V	+6/-9
3	Above 33 000V	-12.5/+10

- xxxii. The following limits as mentioned below shall be considered:
- xxxiii. The frequency shall be 50Hz + 3% as per Indian Electricity Rules and IS: 12360
- xxxiv. Combined frequency & Voltage Variation: +9%
- xxxv. Power Factor: An average power factor of 0.85 shall be considered for design purpose. The contractor need to analyze the reactive Power Consumption analysis during full load conditions and no load conditions of 33/11kV substation and same shall be submitted to client approval. Based on investigation, if required inductors or capacitors need to be installed in the substation to avoid leading power factors.
- xxxvi. Short Circuit fault current: In view of above, it is recommended to adopt following standard short time current ratings as minimum while selecting the equipment for various voltage levels. However, EPC Contractor shall perform necessary calculations for actual findings during detail designing and equipment's shall be selected accordingly.

Table D-7: Short Circuit Current of 33kV, 11kV & 415V

S. No.	Voltage Level (kV)	Proposed Maximum Short Circuit current (kA)
1	33	25kA / 3 sec.
2	11	25kA / 3 sec.
3	0.415	50kA / 1 sec

4.2 Insulation Co-Ordination

Standardized levels for the highest system voltages U_m related to the rated voltages are defined in IEC 60071-1 and are same in Indian Standard. According to these levels the test voltages for the insulation of high voltage equipment are defined. The following levels have been selected out of IEC 60071-1, IEC 60364 and IS-SP39.

Table D-8: Standardized Levels for the Highest System Voltages

Rated Voltage	U_n (kVrms)	0.4	11	33
Highest system voltage	U_m (kVrms)	1.1	12	36
Power frequency withstand voltages 50 Hz, 1 min, to earth	U_{pf} (kVrms)	2	28	70
Lightning impulse with stand voltage 1.2/50 μ s	U_{li} (kVpeak)	8	75	170

IEC 60815 defines 4 different pollution levels from light to very heavy pollution. To each pollution level the corresponding minimum nominal specific creepage distance is defined. The equipment to be installed in project area will be exposed to rainy /fog conditions and to pollution due to exhausts. To consider this situation the pollution level “heavy” according to IEC will be selected.

4.3 System Neutral Point

The choice of the system neutral points has been made to conform to the existing system. The treatment of the neutral point has been selected according to the following table.

Table D-9: System Neutral Point

Sr. No.	System	Neutral Point
1	33	Solidly earthed
2	11	Solidly earthed
3	0.415	Solidly earthed

5. Load Demand Norm

The total power demand calculated for IMC Khurpia is 144 MVA at diversity factor 0.8 for Industrial Area and 0.6 for other area. Power demand estimates for the KIMC is derived based on figures as mentioned in Table D-10 below. The following wattage per square meter should be considered by contractor as minimum requirement. Industrial benchmark is done on basis of couple of similar industry & accordingly considered. Rest of the area is taken from MAHADISCOM guidelines & experience from old projects of similar type like AITL -Shendra & BIDKIN

Table D-10: Wattage per square meter

Sr. No	Description	Watt/Sq.mt
1	Industrial	52.5
2	Residential	75
3	Commercial	110
4	Amenity / Public areas	50
5	Garden / Parks / Bus stop	10

Note: - Power demand estimation should not further include demand factor or any other parameter

6. Distribution Transformers

- xxxvii. All distribution transformers shall be of dry type in case of Indoor Installation (CSS) and Oil type in case of outdoor installations. All distribution transformers shall be Dyn11 vector group. LV star winding shall be solidly grounded. Distribution transformer shall be chosen from standard ratings.

7. Ring Main Units

- xxxviii. It is proposed that all the consumer upto 3MVA power demand shall receive power through 11kV Ring main units. However, all other consumers having maximum demand above 3MVA and below 10MVA shall receive supply through 33kV Ring Main Units (RMU). The RMUs shall be provided of each type of consumers.
- xxxix. For the power supply arrangement of each RMU, the contractor shall ensure the provision of necessary power supply feeders in respective substation and 2 spare feeders to each 11kV busbar.
- xl. To maintain the redundancy and reliability in the power supply distribution network, 11 kV and 33kV Ring main units shall be connected in a 'Ring'. Each ring shall be connected to separate sources through the feeders on the different buses.

8. HV & LV distribution system

- xli. HV distribution system shall be designed as an underground cable system in economical and technically viable way. HV supply shall be planned in Ring formation, with an open point, so as to operate the system as radial feeders.
- xlii. For LV Distribution, where CSS shall be used, CSS shall consist of 11kV switchboard, dry type transformer and LV board with switched capacitor bank. All these items shall be enclosed in a rust proof enclosure. The CSS enclosure must be type tested and same shall be submitted during detailed engineering stage. The distribution transformer loading shall be designed such that each transformer is not loaded beyond approximately 85%.

9. 415V Diesel Generator Sets

- xliii. Standby diesel generator sets shall be provided for essential loads i.e. street lights, treatment plants, pumping station and zonal substation etc

10. Cabling System

10.1 Types of Cables

- xliv. All MV and LV power cable shall be XLPE insulated, PVC sheathed, FRLS with stranded Aluminum conductor. Both MV & LV cables shall be laid in trench. Trench size shall be so selected that the in accordance with relevant Indian/International standards.
- xlvi. Control cables required at substations shall also be XLPE insulated, copper. Armored cables shall be used in case cables are directly buried in ground. Cable laid in ducts shall be unarmored.
 - Cable size selection criteria.
 - Cable sizes shall be selected considering the following:
 - Permissible current carrying capacity
 - Voltage drop
 - Short time current / overload requirements
 - Fault current carrying capacity considering the protection time settings.
 - Ambient conditions, cable laying and other related criteria.
 - Generally, for 33kV/11kV distribution, 3-core aluminum cable shall be provided. Under normal conditions, the voltage drop shall be restricted to 3%. Similarly, for LV cables, voltage drop shall be restricted to 3%.
 - All cables shall be de-rated as per the usage/installation factors as recommended in Indian Standard / by the cable manufacturer considering ambient and laying conditions.

11. Earthing System

- xlvi. Earthing of all electrical equipment shall be designed and provided as per the guidelines given in the latest IEEE-80 standard for the substations and IS-3043: Code of Practice for Earthing for treatment plants. The earthing design shall be based on the soil resistivity measurement carried out at various locations of substation and CSS/RMU sites. Wherever required the earth grid shall be placed 600mm below ground. Where high resistivity values are encountered chemical earthing shall be employed. Resistivity measurement shall in the scope of contractor.

12. Street Light

- xlvi. The street lighting system shall be designed considering the following. The basic design criteria for street Lighting as per the latest Indian standard.

Lux Level Calculation

- Type of luminaries.
- Control-scheme of luminaries.
- Power sources for street lighting.
- Power distribution for street lighting.
- Mounting arrangement of luminaries.
- Selection of street lighting poles.

12.1 Recommended values of Illumination

Taking into account the principles of vision, criteria of quality and characteristics of sources and luminaries the desirable minimum levels of illumination which are recommended as per IUT-Institute of Urban Transport and Indian Standard SP : 30 – 2011) Shall be adopted.

12.2 Selection of Street Lighting Poles

- Street Lighting Poles
Street Light poles structures should be designed to support single or multiple luminaire configurations.
- Factors affecting Pole Selection:

The following factors shall be considered in pole selection/design:

- Mounting Height (MH) – 11 Mtr. minimum height to be considered.
- Luminaire Selection and Configuration
- Auxiliary Equipment and Special Loading
- Wind Speed
- Street Lighting Pole material: -
Octagonal type street lighting poles shall be provided along with the smart features such as dimming etc.

13. Power distribution for street lighting

There shall be Compact substations planned which will be dedicated to supply power for street lighting feeder pillar. All the feeder pillars shall be IP-65 degree of protection and front operated. Feeder pillar construction shall be as per IEC-61439. Voltage drop criteria to be checked up to the end of the lighting fixtures and it must be in limit of 5%.

14. Lighting Control

LORA gateway controller shall be provided for the lighting control system.

15. Circuit breakers

It should be noted, that unless technically required no HRC fuses are to be provided anywhere in the system. For 33 KV, gas insulated switchgears shall be used.

Only MCCB's (current limiting type) of rating as per IEC 60947-2 and IS13947-2 and MCB's (current limiting type) as per IEC-70898 (IS-8828) with the short circuit ratings of the system shown.

The MCCB's at the LT Board are to be coordinated with the MCB's at the receiving end. Therefore, the rating of MCCB's is tentative, and shall be finalized during the detailed engineering phase to achieve proper discrimination. Current limiting type MCCB/MCB shall be used at suitable locations for protections co-ordinations.

16. Codes and Standards

The following primary standards and codes (latest editions/ revisions/ replacements) shall be used for planning and design of the electrical distribution system within the scope of works:

Sr. No.	Electrical Codes	Description
1	IS 3043/IEEE-80	Code of Practice for Earthing
2	IS/IEC-60947	LV Switchgear
3	IEC 62271-202	HV Prefabricated Sub-Station (CSS)
4	IS 3427 / IEC-62271-200	Metal Clad Switchgear
5	IS 13118/ IEC-62271	HV Circuit Breakers
6	IS 11171/IEC 60076	Dry Type Transformer
7	IS 5578	Arrangement For Switchgear Bus bars, Main Connection And Auxiliary Wiring
8	IEC 62305	Lightning protection system
9	IS 2026/IEC 60076	Power transformer

10	IS 7098	XLPE Power cables up to 33kV
11	IS 1180	Distribution transformers
12	IS 3646	Indoor lighting system

17. Preferred Make of Main Equipment

The material shall be procured from the list of manufacturers/ vendors mentioned below. Item for which make list is not available, makes to be approved by Client upfront. Any new addition of vendor to be approved by Client/ Client approving agency. Issuing approval shall be at sole discretion of Client only.

Sr.No.	Item/equipment	List of Makes of various equipments
1	DISTRIBUTION TRANSFORMERS	1. M/s ABB Ltd. 2. M/s Associated Electricals (Gzb) Pvt. Ltd. 3. M/s Bansal Transformer Pvt. Ltd., Roorkee 4. M/s Electromec Engg. Enterprises, Rampur 5. M/s EMCO, Thane 6. M/s General Electric 7. M/s Kirloskar 8. M/s Kotson's Pvt. Ltd., Agra 9. M/s Kwaliti Electrical Pvt. Ltd., Roorkee 10. M/s Marson's 11. M/s PME Power Solutions (India) Ltd., Noida 12. M/s Shree Ram Transformers, Meerut 13. M/s Svasca Industries (India) Ltd., Palval, Faridabad, Haryana 14. M/s Technical Associate Ltd., Lucknow 15. M/s Tesla 16. M/s United Electrical, Roorkee 17. M/s Vijai Electricals Ltd., Hyderabad 18. Schneider Electric, Vadodara
2	ACSR / AAAC Conductor	Apar/ Sterllite/ Kanti cable/ Pratik conductors/ Bombay wire products/ Vekateshwar wires / Prem cables/ Lunkad
3	STEEL TUBULAR POLES	1 M/s Anubhav Plast, Kanpur 2 M/s Endura Engg. Pvt. Ltd., Dehradun 3 M/s Fabrico (India) Pvt. Ltd., Meerut 4 M/s Mile Stone Fab., Hardwar 5 M/s Quality Steel Products Ltd., Kanpur 6 M/s Rishikay Steel Tubular poles, Dehradun 7 M/s Roll Tubes, Kanpur 8 M/s Shiva Power, Dehradun 9 M/s Uttaranchal Forging, Laltappar, Dehradun

Sr.No.	Item/equipment	List of Makes of various equipments
4	LT CABLE (ABC/XLPE/PVC)	1 M/s Asian Wires & Cable Industries, Haridwar 2 M/s CCI 3 M/s Gupta Infra Power, Mahua Khera Ganj, Kashipur 4 M/s Havell's India Ltd., New Delhi 5 M/s Kalinga Cables 6 M/s Krishna Electricals Industries Ltd., Gwalior 7 M/s KEI Industries Ltd. 8 M/s KEC 9 M/s Nicco 10 M/s Paramount Communications Ltd., New Delhi 11 M/s General Cable (Formerly Ms/ Plaza Cables) Delhi 12 M/s Polycab 13 M/s Ravin Cables Ltd., Mumbai 14 M/s Shaswat Cable 15 M/s Tirupati Plastomatics Pvt. Ltd., Jaipur 16 M/s Unisef Cables Industries, Ghaziabad 17 M/s Universal Cables Ltd., Satna
5	HT CABLE (ABC/XLPE)	1 M/s CCI 2 M/s Gupta Infra Power, Mahua Khera Ganj, Kashipur 3 M/s Havell's India Ltd., New Delhi 4 M/s Kalinga Cables 5 M/s Krishna Electricals Industries Ltd., Gwalior 6 M/s KEI Industries Ltd. 7 M/s KEC 8 M/s Nicco 9 M/s Paramount Communications Ltd., New Delhi 10 M/s Polycab 11 M/s Ravin Cables Ltd., Mumbai 12 M/s Tirupati Plastomatics Pvt. Ltd., Jaipur 13 M/s Universal Cables Ltd., Satna
6	11KV GO SWITCH / ISOLATORS	1. M/s Amrit Insulators, Bhatinda 2 M/s Azad Welding Works, Bulandshahr 3 M/s Rama Engineering Works , Bulandshahr 4 M/s Sidhi Vinayak, Dehradun 5 M/s Ultima Switchgear, Roorkee 6 M/s Rashtriya Electricals, Delhi
7	STAY SET	1. M/s CEE Build Co. Pvt. Ltd., Kolkata 2. M/s India Steel Corporation, Kolkata 3. M/s S.A. Enterprises, 5/1 Clive Row, Kolkata

Sr.No.	Item/equipment	List of Makes of various equipments
8	GI STAY WIRE, GI WIRE, GI EARTH WIRE	1. M/s CEE Build Co. Pvt. Ltd., Kolkata 2. M/s India Steel Corporation, Kolkata 3. M/s Manhorlal Hira Lal, Naya Ganj 4. M/s Nirmal Wires Pvt. Ltd., 76, Cotton Street, Kolkata 5. M/s S.A. Enterprises, 5/1 Clive Row, Kolkata 6. M/s Swastic Wires, Post Box No.119,10, Panchsheel Nagar, Raipur (MP)
9	11KV VCB/ 33KV SF-6 CB (AIS Panels)	1. M/s ABB Ltd. 2. M/s Areva Ltd 3. M/s Schneider Electric 4. M/s Siemens Ltd. 5. L&T
10	AB CABLE ACCESSORIES	1. M/s Ensto 2. M/s Raychem RPG 3. M/s Sicame
11	CAPACITOR	1. M/s ABB Ltd. 2. M/s Areva (Schneider) 3. M/s BHEL 4. M/s CGL 5. M/s EPCOS 6. M/s L&T Ltd. 7. M/s Shreem 8. M/s Siemens Ltd.
12	CURRENT TRANSFORMER/ POTENTIAL TRANSFORMER	1. M/s ABB Ltd. 2. M/s Schneider Electric 3 M/s CGL 4 M/s Siemens Ltd. 5 M/s KAPPA Electricals
13	POWER TRANSFORMER	1. M/s ABB Ltd. 2. M/s Scheider Electric 3. M/s Bharat Bijlee 4 M/s CGL 5. M/s EMCO, Thane 6 M/s VOLTAMP
14	CONTROL & RELAY PANEL	1. M/s ABB Ltd. 2. M/s Schneider Electric 3. M/s Siemens Ltd 4. M/s Ashida 5. Authorized System Integrator of above OEM present close to Customer Site (within 500 KM)
15	BATTERY (LEAD ACID MAINTENANCE FREE)	1. M/s Amara Raja (AMARON) 2. M/s Exide 3. M/s Hitachi 4. M/s Panasonic 5. M/s Yashua

Sr.No.	Item/equipment	List of Makes of various equipments
16	BATTERY CHARGER	1. M/s Amara Raja 2. M/s Exide 3. M/s Seeco 4. M/s Spectron
17	ACDB/ DCDB	1. M/s ABB Ltd. 2. M/s C&S 3. M/s Havell's 4. M/s Legrand 5. M/s L&T Ltd. 6. M/s Schneider 7. M/s Siemens
18	CABLE JOINTING & TERMINATION KIT (HEAT SHRINKABLE)	1. M/s Densons 2. M/s M-seal 3. M/s Raychem (RPG)
19	RELAYS (PROTECTION, AUX AND TIMERS), Numerical Relay with IEC 61850	1. M/s ABB Ltd. 2. M/s Schneider Electric 3. M/s Ashida 4. M/s Easun-Reyrolle 5. M/s Siemens 6. M/s. General Electric
20	MCCB, MCB, ACB, MPCB, Contactors / Auxiliary Contactors	1. M/s ABB Ltd. 2. M/s C&S 3. M/s Legrand 4. M/s L&T Ltd., 5. M/s Schneider 6. M/s Siemens
21	T&P ITEMS	Fluke, Motwane, Rishabh
22	METERS	Schneider, ABB, L&T, Secure Meters
23	RMU with FRTU/CSS/ 33 KV GIS Panels - Complete Assembly	ABB, Siemens, Schneider, L&T (Factory Built)
24	SECTIONALIZER	1. M/s ABB Ltd. 2. M/s Areva 3. M/s Siemens 4. M/s Schneider
25	Power Management SCADA System along with PLC/RTU	Schneider, ABB, Siemens, GE (Emerson) or (OEM Authorized SI with 5 Project Completion experience of Infra or Industry of Similar size with Support Presence close to Customer Project Location - Within 500 KM)
26	Ethernet Switches -Managed & Un Managed	Hirschmann/ Schneider/ Phoenix, CISCO, MOXA
27	Workstation Hardware - Server, Workstations, LAPTOP	Dell/ HP/ Lenova (OEM Built & not assembled from market)
28	UPS	Schneider Electric, Hitachi, Emerson, EATON

Sr.No.	Item/equipment	List of Makes of various equipments
29	Bus Ducts / Bus trunking	Ducati/ Larsen & Toubro/ Globe Electricals/ Schneider/ Audco/Zoloto
30	Cables (Control & Instrumentation)	Finolex/ Polycab/ Thermo Cables/ Universal/ RPG
31	Fluorescent fittings	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE,Anchor, Asian
32	Fluorescent tubes	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE/ Anchor/ Osram
33	CFL lamps	Philips/ Crompton /Bajaj /Wipro/ Asian/ Osram/ Havells
34	Diesel Generator	Cummins, Jackson, Power Control
35	Exhaust Fan/ Ceiling fan/ Air circulator/ Pedestal fan/ Bracket fan	Crompton Greaves/ Usha/ Orient/ GEC/Almonard/ Khaitan/ Havells/ Bajaj/ Philips / Polar/ Anchor
36	AC Units / Central Acs	Hitachi / LG/ Samsung/ Voltas/ Blue star/ Carrier / Godrej/Videocon/ Mitsubhisi /Lloyed
37	HDPE pipes	Jain Irrigation, Kimplas, Timeplast, Duraline
38	DI pipes	Jindal, KOBOTA, Electrosteel, Lanco
39	Glands (Brass - Single & Double Compression)	Comet / Dowell/ HMI/ Electromac/lotus/Leader
40	MS tubular pole	Unique/ Singh profile/National/ India pole/Bombay tube pole/Laxmi/ Ajay
41	GI Octagonal Pole & High Mast	Philips/Crompton/ Bajaj/ Surya/ Wipro /Valmont/ Transrail

TECHNICAL SPECIFICATION EQUIPMENTWISE

SECTION 1: TECHNICAL SPECIFICATION FOR 33/11kV, ONAN TYPE TRANSFORMER

1. SCOPE

This specification covers design, engineering, manufacture, assembly, testing, inspection before dispatch, forwarding, packing, transportation to site of three phase, 50 Hz, 12.5 MVA 33/11kV step-down outdoor ONAN Power Transformers complete with all accessories/fittings and spare parts as specified herein, for use in substations in Uttarakhand state. The Power Transformer shall conform in all respects to highest standards of engineering, design, workmanship, this specification and the latest revisions of relevant standards at the time of offer and the purchaser shall have the power to reject any work or material, which, in his judgment, is not in full accordance therewith. The transformer(s) offered, shall be complete with all components, necessary for their effective and trouble free operation. Such components shall be deemed to be within the scope of supply, irrespective of whether those are specifically brought out in this specification. It is not the intent to specify herein complete details of design and construction. The equipment offered shall conform to the relevant standards and be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable to perform continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements. In actual practice, notwithstanding any anomalies, discrepancies, omissions, incompleteness, etc. in these specifications and attached drawings, the design and constructional aspects, including materials and dimensions, will be subject to good engineering practice in conformity with the required quality of the product, and to such tolerances, allowances and requirements for clearances etc. as are necessary by virtue of various stipulations in that respect in the relevant Indian Standards, IEC standards, CEA Regulations, Electricity Act and other statutory provisions.

1.1. SERVICE CONDITION:

Equipment/material to be supplied against this specification shall be suitable for satisfactory continuous operation under the tropical conditions as follows:

Sr.No	Particulars	Value
1	Maximum ambient temperature (Deg. Celsius)	50
2	Minimum temperature (Deg. Celsius)	-5
3	Relative humidity range (%)	10 to 100
4	Maximum wind pressure (kg/sq m)	195
5	Maximum altitude above mean sea level (m)	3000
6	Isoceraunic level (days/year)	50
7	Seismic level (Horizontal acceleration) (g)	0.13

1.2. STANDARDS:

The equipment shall comply with latest revision of the following Indian Standards (IS) unless otherwise stipulated in the specification. All references to Indian Standards shall be deemed to be complying with latest amendments to the respective IS, if any

STANDARD	DESCRIPTION
IS:2026 (Part I to IV) & IEC 60076 (Part I to V)	Power Transformer
IS:6600/IEC 354	Guide for loading of oil immersed transformers
IS:335	New insulating oil for transformers, Switchgears

IS:3639	Fittings and accessories for power Transformers
IS:2099	High voltage porcelain bushings
IS:2705	Current Transformers
IS:3347	Dimensions for porcelain Transformer Bushings
IS:3202	Code of practice for climate proofing of electrical equipment.
IS:2147/IEC 529	Degree of protection
IS:2071	Method of high voltage testing
IS:3637	Gas operated relays
IS:1271	Classification of insulating materials for electrical machinery and apparatus in relation to their stability in services.
IS:5	Colour for ready mixed paints
IS:10028	Code or practice for selection, installation and maintenance of transformers, Part I, II and III
IS:5561	Electric Power Connectors
C.B.I.P. Publication	Manual on Transformers

If the standard is not quoted for any item, it shall be presumed that the latest version of Indian Standard shall be applicable to that item; and if the IS mentioned is upgraded then the latest version of IS shall be applicable.

1.3. SPECIFIC TECHNICAL REQUIREMENTS:

Sr.no	Parameters	Particulars
1	Rated MVA (ONAN rating)	12.5 MVA
2	No. of phases	3
3	Type of installation	Outdoor
4	Frequency	50hz
5	Cooling medium	Insulating oil
6	Rated voltage	
	High voltage winding	33 Kv
	Low voltage winding	11Kv
7	Highest continuous system voltage	
	a) HV side	36Kv
	b) LV Side	12Kv
8	No. of windings	Two
9	Range of tapings	Plus 5% to minus 10% of 1.25% each on HV winding
10	Neutral terminal to be brought out	On LV side only
11	Impedance on rated MVA base at 75°C , on normal tap	10% for 12.5 MVA.

12	Type of winding insulation	Uniform both for HV and LV
13	Over voltage operating capacity & duration	112.5 % of rated voltage (continuous)
14	Anticipated unbalanced loading	Around 10 %
15	Anticipated continuous loading of windings (HV/LV)	110 % of rated current
16	Maximum Flux Density in any part of the core and yoke at rated MVA, rated voltage i.e. 33kV / 11kV and system frequency of 50Hz.	1.9 Tesla
17	Impulse withstand test voltage (kV peak)	170 (HV) , 75 (LV)
18	Withstand time for three phase short circuit	3 seconds
19	Winding connection	
	LV Side	Star
	HV Side	Delta
20	Winding material (HV & LV)	Electrolytic Copper
21	Vector group	Dyn 11
22	Type of cooling	Insulating oil (ONAN)
23	Neutral earthing	LV neutral shall be solidly earthed
24	Winding temperature Indicator	One
25	Provision for Differential Protection arrangement	To be provided
26	Oil Temperature indicator	One
27	Maximum temperature rise on top of oil over an ambient temperature of 50 deg C (measured by thermometer)	45 deg C
28	Maximum temperature rise of winding over an ambient temperature of 500 C (measured by resistance)	55 deg C
29	Over load capacity	As per IS:6600
30	Degree of protection for marshaling box	IP 55
31	Noise level at rated voltage and frequency	As per NEMA publication no. TR-1
32	Minimum clearances in air (mm)	
	Phase to phase	HV - 350, LV – 280
	Phase to ground	HV- 320, LV – 205
33	Maximum current density for HV, LV windings for rated current	2.8 Amp/sq. mm
34	Core material	High grade, non-ageing Cold Rolled Grain Oriented (CRGO) silicon steel, confirming to HIB grade
35	Core assembly	Boltless Core type
36	Type of mounting	On wheels, mounted on rails
37	Maximum permissible no load loss at rated voltage and rated frequency	11kW

38	Maximum permissible load loss at rated current at 75 deg C	72kW
39	Nominal short circuit level 33 kV (Based on apparent power)	31.5kA
40	Nominal short circuit level 11 kV (Based on apparent power)	13.1kA

1.4. GENERAL TECHNICAL REQUIREMENTS:

- a) Transformer shall be capable of withstanding for two seconds without damage to any external short circuit with the short circuit MVA available at the terminals.
- b) The maximum flux density in any part of the core and yoke at rated MVA, voltage and frequency shall be such that the flux density under 12.5% over voltage condition shall not exceed 1.9 Tesla.
- c) With combined voltage variation of +12.5% and frequency variation of -5%, the flux density shall not exceed 1.9 Tesla.
- d) The maximum FLUX DENSITY in any part of the core and yoke at rated voltage and frequency shall not exceed 1.5 Tesla.
- e) Transformer shall be able to withstand without injurious heating, combined voltage and frequency fluctuation which produce the 125% over fluxing condition for one minute and 140 % for 5 seconds.
- f) The transformer shall be capable of operating continuously without danger on any particular tapping at the rated MVA $\pm 12.5\%$ of the voltage corresponding to the tapping.
- g) Transformer shall be capable of withstanding thermal and mechanical stress caused by any symmetrical and asymmetrical faults on any winding. This shall be demonstrated through calculation as per IS:2026.
- h) The thermal ability withstand short circuit shall be demonstrated by calculation.
- i) Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimize interference with communication circuits.
- j) Transformer noise level, when energized at normal voltage and frequency shall be as per NEMA TR -1 stipulations.
- k) If the equipment is to be installed in the hilly area, necessary correction factors as given in the Indian Standard for oil temperature rise, insulation level etc. shall be applied to the Standard Technical Parameters given above.
- l) The transformer shall be capable of being operated without danger on any tapping at the rated kVA with voltage variation of + 10% corresponding to the voltage of the tapping.

1.5. CONSTRUCTION FEATURES:

- a) 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 without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.
- b) Similar parts, particularly removable ones, shall be interchangeable.
- c) Pipes and pipe fittings, screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Steel bolts and nuts exposed to atmosphere shall be galvanized

- d) Nuts, bolts and pins used inside the transformers and tap changer compartments shall be provided with lock washers or locknuts.
- e) Exposed parts shall not have pockets where water can collect.
- f) Internal design of transformer shall ensure that air is not trapped in any location.
- g) Material in contact with oil shall be such as not to contribute to the formation of acid in oil.
- h) Surface in contact with oil shall not be galvanized or cadmium plated.
- i) Labels, indelibly marked, shall be provided for all identifiable accessories like relays, switches, current transformers etc. All label plates shall be of in corrodible material.
- j) All internal connections and fastenings shall be capable of operating under overloads and overexcitation, allowed as per specified standards without injury.
- k) Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs.
- l) No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted.
- m) Schematic Drawing of the wiring, including external cables shall be put under the propane sheet on the inside door of the transformer marshalling box.

1.6. CORE:

- a) Stage level inspection for core construction shall be carried out by the owner.
- b) Each lamination shall be insulated such that it will not deteriorate due to mechanical pressure and the action of hot transformer oil.
- c) The core shall be constructed either from high grade, non-aging Cold Rolled Grain Oriented (CRGO) silicon steel laminations conforming to HIB grade with lamination thickness not more than 0.23 mm to 0.27 mm or better.
- d) The maximum flux density in any part of the cores and yoke at normal voltage and frequency shall be such that the flux density with + 12.5 % voltage variation from rated voltage or frequency variation of -5% shall not exceed 1.5 Tesla. The bidder shall provide saturation curve of the core material proposed to be used. Laminations of different grade(s) and different thickness (s) are not allowed to be used in any manner or under any circumstances.
- e) Following documents shall be submitted during stage inspection as proof towards use of prime core material:
 - Purchase order
 - Invoice of the supplier
 - Mills test certificate
 - Packing list
 - Bill of lading
 - Bill of entry certificate to customs
- f) Core material shall be directly procured either from the manufacturer or through their accredited marketing organization of repute and not through any agent.
- g) The laminations shall be free of all burrs and sharp projections. Each sheet shall have an insulating coating resistant to the action of hot oil.

- h) The insulation structure for the core to bolts and core to clamp plates, shall be such as to withstand 2000 Volt DC voltage for one minute.
- i) The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core assembly shall not deviate from the vertical plane by more than 25 mm.
- j) All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.
- k) The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.
- l) The core clamping structure shall be designed to minimize eddy current loss.
- m) The framework and clamping arrangements shall be securely earthed.
- n) The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength.
- o) Oil ducts shall be provided, where necessary, to ensure adequate cooling inside the core. The welding structure and major insulation shall not obstruct the free flow of oil through such ducts.
- p) The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination, which may cause local heating. The supporting framework of the cores shall be so designed as to avoid the presence of pockets, which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.
- q) The construction is to be of 'boltless core' type. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The core and coil assembly shall be so fixed in the tank that shifting will not occur during transport or short circuits.
- r) The temperature gradient between core & surrounding oil shall be maintained less than 20 °C. The manufacturer shall demonstrate this either through test (to be mutually agreed) or by calculation.

1.7. WINDINGS:

- a) Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.
- b) All low voltage windings for use in the circular coil concentric winding shall be wound on a performed insulating cylinder for mechanical protection of the winding in handling and placing around the core.
- c) Winding shall not contain sharp bends which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.
- d) 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.
- e) 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 evacuation of air and moisture and impregnation by oil.
- f) Winding and connections shall be braced to withstand shocks during transport or short circuit.

- g) 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.
- h) All the insulating materials to be used in the transformer shall preferably be of class- A insulation as specified in Indian Standards. The test certificate of the raw materials shall be made available by the Transformer manufacturer on request during inspection and testing.
- i) The coil clamping arrangement and the finished dimensions of any oil ducts shall be such that it will not impede the free circulation of oil through the ducts. j) Coil clamping rings, if provided shall be of steel or suitable insulating material. Axially laminated material other than backlisted paper shall not be used.
- j) Terminals of all windings shall be brought out of the tank through bushings for external connections.
- k) The completed core and coil assembly shall be dried in vacuum at not more than 0.5mm of mercury absolute pressure and shall be immediately impregnated with oil after the drying process to ensure the elimination of air and moisture within the insulation. Vacuum may be applied in either vacuum over or in the transformer tank.
- l) The winding shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the winding can be made readily without special equipment. The coils shall have high dielectric strength.
- m) Coils shall be made of continuous smooth high-grade electrolytic copper conductor, shaped and braced to provide for expansion and contraction due to temperature changes.
- n) Adequate barriers shall be provided between coils and core and between high and low voltage coil. End turns shall have additional protection against abnormal line disturbances.
- o) The insulation of winding shall be designed to withstand voltage stress arising from surge in transmission lines due to atmospheric or transient conditions caused by switching etc.
- p) Tapings shall not be brought out from inside the coil or from intermediate turns and shall be so arranged as to preserve as far as possible magnetic balance of the transformer at all voltage ratios.
- r) Magnitude of impulse surges transferred from HV to LV windings by electromagnetic induction and capacitance coupling shall be limited to B.I.L. of LV winding.
- q) The current density adopted in all windings shall not exceed 2.8 A/ sq mm . The total net cross sectional area of strip conductors for calculating current density for each winding shall be obtained after deducting the copper area lost due to rounding up of the sharp edges of the rectangular conductors.

1.8. INSULATING OIL:

- a) The insulating oil for the transformers shall be of EHV grade, conforming to IS: 335/1983. No inhibitors shall be used in the oil.
- b) Transformer shall be shipped with oil filled at least to cover the core and coil assembly.
- c) The quantity of oil required for the first filling of the transformer and its full specification shall be stated in the bid. The bidder shall quote the price of transformer complete with first filling of oil plus 10% extra. However, the rate of transformer oil in Rupee per litre shall be quoted separately also. The transformer oil shall be supplied in non-returnable drums.
- d) The design and materials used in the construction of the transformer shall be such as to reduce the risk of the development of acidity in the oil.

- e) The Supplier shall warrant that oil furnished is in accordance with the following specifications. Supplier shall submit the test certificate accordingly.
- f) All further specifications of insulating oil shall be followed latest guidelines of UPCL.

1.9. INTERNAL EARTHING:

a) All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed. The top clamping structure shall be connected to the tank by a copper strip. The bottom clamping structure shall be earthed by one or more of the following methods:

- By connection through vertical tie-rods to the top structure.
- By direct metal to metal contact with the tank base.
- By a connection to the top structure on the same side of the core as the main earth connection to the tank.

b) The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out of the top cover of the transformer tank through a suitably rated insulator. A disconnecting link shall be provided on transformer tank to facilitate disconnections from ground for IR measurement purpose. Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

1.10. TANK:

a) The Transformer tank and cover shall be fabricated from high grade low carbon plate steel of tested quality of adequate thickness. The tank and the cover shall be of welded construction. All welds shall be stress relieved. Stiffener shall be provided for general rigidity. Tank surface shall be designed to prevent retention of water.

b) Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose.

c) All beams, flanges, lifting lugs, braces and permanent parts attached to the tank, shall be welded and where practicable, they shall be double welded.

d) The main tank body of the transformer, excluding tap changing compartments and radiators, shall be capable of withstanding pressure of 760 mm of Hg.

e) Inspection hole(s) with welded flange(s) and bolted cover(s) shall be provided on the tank cover. The inspection hole(s) shall be of sufficient size to afford easy access to the lower ends of the bushings, terminals etc.

f) All bolted connections to the tank shall be fitted with suitable oil-tight gaskets which shall give satisfactory service under the operating conditions for complete life of the transformer. Special attention shall be given to the methods of making the hot oil-tight joints between the tank and the cover as also between the tank cover and the bushings and all outlets to ensure that the joint can be remade satisfactorily and with ease, with the help of semi-skilled labor. Where compressible gaskets are used, steps shall be provided to prevent over-compression.

g) Suitable guides shall be provided for positioning the various parts during assembly or dismantling. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

1.11. TANK COVER:

The transformer top shall be provided with a detachable tank cover with bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably sloped so that it does not retain rain water.

1.12. UNDER CARRIAGE:

The transformer tank shall be supported on steel structure with detachable plain rollers completely filled with oil. Suitable channels for movement of roller with transformer shall be spaced accordingly. Rollers wheels shall be provided with suitable rollers bearings, which will resist rust and corrosion and shall be equipped with fittings for lubrication. It shall be possible to swivel the wheels in two directions, at right angle to or parallel to the main axis of the transformers. Jacking pads shall be provided on the transformer. It shall be possible to change the direction of the wheels through 90 degree when the transformer is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions.

1.13. VALVES:

a) Valves shall be of forged carbon steel up to 50 mm size and of gun metal or of cast iron bodies with gun metal fittings for sizes above 50 mm. They shall be of full way type with screwed ends and shall be opened by turning counter clockwise when facing the hand wheel. There shall be no oil leakage when the valves are in closed position.

b) Each valve shall be provided with an indicator to show the open and closed positions and shall be provided with facility for padlocking in either open or closed position. All screwed valves shall be furnished with pipe plugs for protection. Padlocks with duplicate keys shall be supplied along with the valves.

c) All valves except screwed valves shall be provided with flanges having machined faced drilled to suit the applicable requirements. Oil tight blanking plates shall be provided for each connection for use when any radiator is detached and for all valves opening to atmosphere. If any special radiator valve tools are required, the supplier shall supply the same.

d) Each transformer shall be provided with following valves on the tank:

- Drain valve so located as to completely drain the tank.
- Two filter valves on diagonally opposite corners, of 50 mm size.
- Oil sampling valves not less than 8 mm at top and bottom of main tank.
- One 15 mm air release plug.
- Valves between radiators and tank.

e) Drain and filter valves shall be suitable for applying vacuum as specified in the specifications.

1.14. PAINTING:

Surface Preparation for tank, pipes, etc.:

- All surfaces of transformer tank, pipes, etc. shall be thoroughly blast cleaned with sand or shot or grit in accordance with ISO 8501 Part 1 to a minimum standard of "Sa2½" to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Machined areas and threaded components etc. are to be covered during blasting to prevent damage.

- The air that is used for blasting should be dry and free from oil. The flanges, angles, tank curbs and other such areas shall be preferably blast cleaned prior to fabrication and paint these with one coat of primer. After adequate blast cleaning of each large surface where blasting time is more than three hours, an overall blast cleaning is to be done on the entire surface once more so that entire

surface areas is exposed as fresh for first coat of primer paint. The first coat of primer paint should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

a) Surface Preparation for radiator:

All internal and external surfaces of radiator shall be thoroughly cleaned either by chemical cleaning or by blast with sand or shot or grit in accordance with ISO 8501 Part 1 to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Suitable chemical should be used for chemical cleaning, if required. The air that is used for blasting should be dry and free from oil. After adequate surface cleaning, the first coat of primer paint/varnish should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

b) Surface Preparation for Control cabinets/Marshalling Boxes:

Surface Preparation for all Transformer Control cabinets/Marshaling Boxes shall be carried out confirming to following Indian standard in dust free area:

- IS: 3618: Degreasing by solvent wiping: Phosphate Treatment of Iron & Steel for Protection against corrosion.
- IS: 6005: Code of Practice for phosphating of Iron & Steel.

c) Chemicals:

Suitable chemicals should be used and concentration of chemicals /weight of Phosphate coating should be checked regularly as per recommendation of the chemical manufacturer and applicable IS.

d) Inspection :

The surface for application of paint should be dry, free from oil, dirt, acid & loose adhering powder and reasonably smooth in finish without uncovered areas, rusty surfaces and roughness.

e) Painting:

Control cabinets/Marshalling Boxes -Enamel paint shall be used with total paint thickness as minimum 80 microns.

f) Painting- external & internal surfaces:

Painting shall be carried out in closed and dust free area. The external surface shall be coated with suitable layers of paint and to form an impermeable layer so that air and water cannot reach the substrate. The paint selected shall be stable in outdoor condition such as rain, sunlight, pollution etc. Paint used for primer, under coat and top or finish coat should be from the same manufacturer and compatible to each other. In case in the rare event, paint used for primer, under coat and finish coat are not from the same manufacturer the compatibility test of the paint from different source shall be carried out. Painting shall be applied as per the recommendation of the paint manufacturer. The number of coats shall be such that the minimum dry film thickness (DFT) specified is achieved. The DFT of painted surface shall be checked with a measuring gauge to ensure specified DFT. Complete painting scheme for the transformer. Painting procedure and all details shall be followed as per UPCL specifications

1.15. BUSHING

Transformer shall be provided with bushing insulators on both H.V and L.V. sides. H.V and L.V. bushings shall be located on opposite side.

The electrical characteristics of bushing insulator shall be in accordance with IS: 2099. Dimensions and type of bushing shall conform to IS: 3347 and shall be as follows: -

H.V. Bushing (33kV) 36kV

Class Porcelain bushing with plain sheds for heavily polluted atmosphere

L.V. Bushing (11kV) 12 kV Class Porcelain bushing with plain sheds for heavily polluted atmosphere

Neutral Bushing Neutral of L.V. winding shall be brought out through porcelain bushing similar to L.V. Bushing for connection with earth terminal in line with LV bushing.

- a) All porcelain used in bushings shall be homogeneous, non-porous, uniformly glazed to brown color and free from blisters, burns and other defects.
- b) Stress due to expansion and contraction in any part of the bushing shall not lead to deterioration.
- c) Each bushing shall be capable to carry at least 200% of current of Continuous Maximum Rating (CMR) of transformer and the short time current shall be of the same as of transformer.
- d) Fittings made of steel or malleable iron shall be galvanized.
- e) Bushing shall be so located on the transformers that full flashover strength will be utilized.
- f) All applicable routine and type tests certificates of the bushings shall be furnished for approval.
- g) Bushing shall be supplied with bi-metallic/terminal connector/clamp/washers suitable for fixing to bushing terminal and the purchaser's specified conductors. The connector/clamp shall be rated to carry the bushing rated current without exceeding a temperature rise of 550o C over an ambient of 500o C. The connector/clamp shall be designed to be corona free at the maximum rated line to ground voltage.
- h) Bushing of identical voltage rating shall be interchangeable.
- i) Each bushing shall be so coordinated with the transformer insulation that all flashover will occur outside the tank.
 - The creepage distance shall be not less than 25 mm/kV and protected creepage distance shall be not less than 50% of total.
 - Arcing horns are to be provided with adjustable horn gap except the neutral bushing.
 - Each terminal, including the neutral, shall be distinctly marked on both primary and secondary in accordance with the connection diagram fixed upon the transformer which shall conform to latest IS 2026 (Part IV).
- j) Insulation Level: The transformer and bushing shall be capable to withstand test voltage as specified below:

Insulation level

Nominal voltage (in kV rms)	11 kV	33 kV
Highest voltage for equipment (in kV rms)	12	36
1.2/50 micro sec. impulse withstand voltage (in kV peak)	75	170
1 minute power frequency withstands voltage (in kV rms)	35	75
Minimum creepage distance (mm)	300	900
Minimum clearance (mm): Phase to phase	280	350
Minimum clearance (mm): Phase to earth	205	320

1.16. PROTECTION & MEASURING DEVICES

Oil Conservator Tank

The conservator shall be of capacity to meet the requirement of expansion of the total cold oil volume in the transformer & cooling equipment and it should be such that the oil level will always be visible through the plain oil level gauge

- A conservator will have volumetric capacity of at least 10 % of the total volume of oil in tank. Moreover the oil in conservator up to minimum level mark on the oil gauge shall be at least 3 % of the total volume of oil in transformer excluding oil in OLTC.
- The conservator tank shall be bolted into position so that it can be removed for cleaning purposes.
- The conservator shall be fitted with magnetic oil level gauge with low level electrically insulated alarm contact
- Plain conservator fitted with silica gel breather.
- It shall be provided with oil filling hole with cap on top and a drain valve at the bottom.

1.17. OIL PRESERVATION EQUIPMENT (OIL SEALING)

The oil preservation shall be diaphragm type oil sealing in conservator to prevent oxidation and contamination of oil due to contact with atmospheric moisture.

Breather

The conservator shall be fitted with a dehydrating silica gel filter breather. It shall be so designed that,

- Passage of air is through a dust filter & Silica gel
- Silica gel is isolated from atmosphere by an oil seal.
- Moisture absorption indicated by a change in colour of the crystals of the silica gel can be easily observed from a distance.
- Breather is mounted not more than 1400 mm above rail top level.

1.18. PRESSURE RELIEF DEVICE

The pressure relief device provided shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage of the equipment. The device shall operate at a static pressure of less than the hydraulic test pressure of transformer tank. It shall be mounted direct on the tank. A pair of electrically insulated contacts shall be provided for tripping when the device operates.

1.19. BUCHHOLZ RELAY

Each transformer shall be provided with gas and oil actuated Relay (Buchholz Relay) equipment conforming of IS: 3637 double float type with one set of alarm contacts, one set of trip contacts and a testing pet cock. The contacts shall be wired with a P.V.C. armored cable. A machined surface shall be provided on the top of Relay to facilitate the setting of Relay and to check the mounting angle in the pipe and cross level of the Relay. The pipe work shall be so arranged that all gas arising from the Transformer shall pass into the gas and oil actuated Relay. The oil circuit through the Relay shall not form a delivery path in parallel with any circulating oil pipe. A copper tube shall be connected from the gas collector to a valve located at about 1200 mm above ground level to facilitate sampling with the transformer in service.

1.20. OIL TEMPERATURE INDICATOR (OTI)

The transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent potential free alarm and trip contacts. Maximum reading pointer and resetting device shall be mounted in the local control panel. A temperature sensing element suitably located in a pocket on top oil shall be furnished. This

shall be connected to the OTI by means of capillary tubing. Accuracy class of OTI shall be + 1% or better. One NO electrical contact capable of operating at 5A AC at 230 Volt supply.

1.21. WINDING TEMPERATURE INDICATOR (WTI)

- a) A device for measuring the hot spot temperature of the winding shall be provided. It shall comprise the following.
- b) Temperature sensing element
- c) Image Coil.
- d) Auxiliary CTS, if required to match the image coil, shall be furnished and mounted in the local control panel.
- e) 150 mm dial local indicating instrument with maximum reading pointer mounted in local panel and with adjustable electrically independent ungrounded contacts, besides that required for control of cooling equipment, one for high winding temperature alarm and one for trip.
- f) Calibration device.
- g) Two number NO electrical contact each capable of operating at 5 A ac, 230 Volt supply.
- h) The scale on the dial of the thermometer should be 0 Deg.C to 150 Deg.C. The angular displacement of thermometer should be 270 Deg. The signaling contact of WTI & OTI shall be set to operate at the following temperature:
 - OIL : Alarm-80 deg. C, Trip – 90 deg. C
 - WINDING : Alarm-85 deg. C, Trip – 95 deg. C

1.22. MARSHALLING BOX

Sheet steel (not less than 2 mm thick), weather, vermin and dust proof marshaling box fitted with required glands, locks, glass door, terminal Board, water-tight hinged and padlocked door of a suitable construction shall be provided with each transformer to accommodate temperature indicators, terminal blocks etc. The box shall have sloping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshaling box. The degree of protection shall be IP-55. The temperature indicators shall be so mounted that the dials are visible by standing at the ground level.

The schematic diagram of the circuitry inside the marshaling box be prepared and fixed inside the door under a prospane sheet.

The marshaling box shall accommodate the following equipment:

- Temperature indicators
- Terminal blocks and gland plates for incoming and outgoing cables.
- Space heater with thermostat and MCB

All the above equipment except (b) shall be mounted on panels and back of panel wiring shall be used for inter-connection. The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door (s) of the compartment(s) shall be provided with glazed window of adequate size.

To prevent internal condensation, a metal clad heater with thermostat shall be provided. The heater shall be controlled by a MCB of suitable rating mounted in the box. The ventilation louvers, suitably padded with felt, shall also be provided. The louvers shall be provided with suitable felt pads to prevent ingress of dust.

All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartment shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

1.23. ON LOAD TAP CHANGER

The transformers shall be provided with an On-Load Tap Changer (OLTC) of well reputed and of proven make as per technical requirement for varying the effective transformation ratio while the transformer is ON load and without providing phase displacement. The salient features of the OLTC shall be as under:

The tap changing mechanism should be suitable for automatic, remote control operation from remote control panel in the control room in addition to being capable of local manual as well as local electrical operation.

The On Load Tap Changer (OLTC) shall include the following:

- An oil immersed tap selector and arcing switch on arc suppressing tap selector provided with ohmic or resistor type high speed diverter switch, for reduction of make and break arcing voltages, overloads and short circuits.
- Diverter switch should be with snap action mechanism with energy accumulator mounted directly on the diverter switch.
- Separate oil compartment
- Easy removable diverter switch unit.
- Motor driven mechanism
- Control and protection devices
- Local tap changer position indicator
- Manual operation device
- Make of OLTC – Indigenous make (type test certificates from (CPRI). Control voltage – Any of the auxiliary power supply voltage.

The on-load tap changer shall be designed so that the contacts do not interrupt are within the main tank of transformer. The tap changer selector and arcing switch on arc suppressing tap selector switch shall be located in one or more oil filled compartments. The diverter switch should be provided with gas vent and Buchholz relay. It shall be designed as to prevent the oil in tap selector and diverter switch compartments from mixing with the oil in transformer. The barrier board between OLTC and the transformer tank shall be made of Silicon Bonded Resin Paper (SBRP).

The tap changer shall be capable of permitting parallel operation with other transformers of the same type. The transformer shall give full load output on all taps without exceeding the limit of permissible temperature

rise in oil and winding. The manual operation device shall be so located on the transformer that it can be operated by a man standing at the level of transformer track. It shall be of robust construction and shall be capable of frequent operations. It shall not be possible to operate the electric drive when the manual operating gear is in use.

Necessary interlocks blocking independent control when the units are in parallel shall be provided.

The controls shall be so arranged as to ensure that when a tap change operation has commenced, it shall be completed independently of the operation of control relays or switches. Local or remote control switch shall cause one tap movement only, until the control switch has returned to the off position between successive operations. Under abnormal conditions such as may occur when the

contractor controlling one tap change sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units./ Limit switches shall be provided to prevent over running of mechanism.

The transformer and the tap changing equipment shall be designed to permit full rated operation with tap changing equipment temporarily installed in any intermediate position. Details of out of step protection provided for the taps should be furnished in the tender.

The control scheme for the tap changer shall be provided for independent auto/non-auto control of the tap changer when the transformers are in independent service. Voltage relating relay should be designed for maximum operational simplicity for regulating the secondary voltage of power transformer with OLTC. The required EAD band settings are set by setting the nominal value and lower and upper levels independently.

In addition, provisions shall be made to enable non-auto/automatic parallel control also so that the tap changers of two or more transformers will be operated simultaneously when one unit is in parallel with another so that under normal conditions the tap changer will not become out of step and this will eliminate circulating current. Additional features like "Master / Follower" and visual indication, during the operation of motor shall also be incorporated.

A mechanical tap position indicator shall be provided on the tap changer in addition to remote indication equipment in the control room on remote control cubicle of OLTC. Necessary interlocks, for independent control when the units are in parallel shall be provided.

The whole of motor drive unit comprising the motor and its control gear including contractors, indicator, local electrical push buttons, five-digit operation counter, handle for manual control etc. as well as terminals for the control and indication wiring shall be housed in a dust proof kiosk mounted on tap changer, A heating element with thermostat and MCB shall also be provided in kiosk for ensuring trouble free operation of the drive in cold weather. Arrangement shall be made for padlocking the kiosk. Tap position indication shall be visible by a number appearing in a small glass window on the front of the kiosk. For remote indication, an indication type instrument or digital type shall be provided on a panel on the 415 volts, 3 phase, 50 c/s external supply.

Any enclosed compartment not oil filled shall be adequately ventilated. All contractors, relay coils or other parts shall be suitably protected against corrosion or deterioration due to condensation, fungi etc.

The oil in the compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a pipe connection from

the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. A separate oil Buchholz relay with trip contacts shall be provided for the On-Load Tap Changer chamber. Each tap changer shall also be provided with a pressure relief valve outside OLTC to protect against sudden pressure development on OLTC.

Each compartment in which the oil is not maintained under conservator head shall be provided with a suitable direct reading oil level gauge.

A permanently legible lubrication chart shall be fitted with the driving mechanism chamber.

Local electrical control switches and the local operating gear shall be clearly labeled in suitable manner to indicate the direction of operation of tap changer.

The remote-control panel of OLTC gear to be installed in the control room should match in color and dimensions sheet steel size etc. with the purchaser's transformer control panel for which details would be furnished to the successful contractor.

In addition to the fittings, auxiliaries and accessories considered necessary by the contractor the following shall be provided:

A. FOR LOCAL ELECTRICAL CONTROL

- Raise lower selector switch with a intermediate 'OFF' position.
- Auxiliary transformer (if necessary) along with MCBs and links.
- Step by step contractor
- Thermal over load relay for the motor
- Reversing contractor
- ON/OFF automatic trip air circuit breaker for motor supply
- Local/Remote change over selector switch.

B. FOR REMOTE ELECTRICAL INDEPENDENT / AUTO-CONTROL

- All equipment listed in (A) above.
- Tap position indicator for mounting on control panel in the control room.
- Signal lamp and buzzer, for indicating "Tap Change in Progress".
- Raise lower switch push button type with intermediate off/position for remote control.
- Emergency stop button (push button type) with visual indication.
- Visual and alarm indication for non completion of operation within pre-set time
- Provision of interlocking system for blocking independent control when the units are to run in parallel by providing interlock able phase sequence selector switch.
- All auto-visual indications should be brought to the Remote Tap Changer Cubicle (RTCC) panel.
- DC supply isolators, DC supply 'ON' indicator & DC failure, both along with cancellations.

1.24. FITTINGS

The following fittings shall be provided on the transformers:

- Conservator with oil filling hole with cap and drain valve.
- Magnetic type oil level gauge (150 mm dia.) with low oil level alarm contacts.
- Prismatic/toughened glass oil level gauge.
- Silica gel breather with oil seal and connecting pipe complete with first fill of activated silica gel.
- A double float type Buchholz relay with isolating valve, bleeding pipe and a testing cock. The relay shall be provided with shut off valve on the conservator side as well as on the tank side.
- Pressure relief devices (including pressure relief valve) and necessary air equalizer connection between this and the conservator with necessary trip contacts.
- Air release plugs in the top cover.
- Inspection covers, access holes with bolted covers for access and inspection of inner ends of bushing, core/coil assembly etc.
- Winding temperature indicating device for local mounting complete in all respects.
- Dial thermometer with pocket for oil temperature indicator.
- Lifting lugs for the top cover, core and coils and for the complete transformer.

- Jacking pads.
- Haulage lugs.
- Protected type mercury/alcohol in glass thermometer and a pocket to house the same.
- Top and bottom filter valves on diagonally opposite ends with pad locking arrangement on both valves.
- Top and bottom sampling valves.
- Drain valve with pad locking arrangement and blanking plate.
- Rating and connection diagram plate valve schedule plate.
- Two numbers tank earthing terminals with associated nuts and bolts for connections to purchaser's grounding strip.
- Bidirectional flanged rollers.
- Marshalling Box (MB)

1.25. COOLING ACCESSORIES:

Requisite number of radiators provided with:

- One shut off valve on top
- One shut off valve at bottom
- Air release device on top
- Drain and sampling device at bottom
- Lifting lugs.
- Air release device and oil drain plug on oil pipe connectors.
- Terminal marking plates for Main Transformer.
- Off-Load Tap Changer.
- HV Bushing with terminal connector and arcing horn.
- LV Bushing with terminal connector.
- LV Neutral Bushing for ground connection.

Note: The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

The contacts of various devices required for alarm and trip shall be potential free and shall be adequately rated (minimum 230V and 5 amp) for regular making and breaking current duties as specified.

1.25.1. AUXILIARY POWER SUPPLIES

The following power supplies shall be available at site

- AC 3 phase, 400 volts, 50 Hz earthed
- AC 1 phase, 230 volts, 50 Hz earthed
- 30V DC and/or 110 V DC

1.25.2. NAME PLATE

Transformer rating plate shall contain the information as given in clause 15 of IS-2026 (Part-I). The details on rating plate shall be finalized during the detailed engineering. Further each transformer shall have inscription of Purchaser name-UPCL.

1.25.3. CONTROL CONNECTIONS AND WIRING TERMINAL, BOARD AND FUSES

- Normally no fuses shall be used anywhere. Instead of fuses MCBs (both in AC & DC circuits) shall be used. Only in cases where a MCB cannot replace a fuse due to system requirements, a HRC fuse can be accepted.
- All wiring connections, terminal boards, fuses, MCBs and links shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation and the bare ends of stranded wire shall be sweated together to prevent seepage of oil along the wire.
- Panel connections shall be neatly and squarely fixed to the panel. All instruments and panel wiring shall be run in PVC. All wiring to a panel shall be taken from suitable terminal boards.
- When 400-volt connections are taken through junction boxes or marshalling boxes, they shall be adequately screened and 400 volts Danger Notice must be affixed to the outside of the junction boxes or marshalling box. Proper color code for Red, Yellow, Blue phases wires shall be followed. All circuits, in which the voltage exceeds 125 volts, shall be kept physically separated from the remaining wiring. The function of each circuit shall be marked on the associated terminal boards.
- All box wiring shall be in accordance with relevant IS. All wiring shall be of stranded single core copper (48 strands) of 1100 Volt grade and size as under:
 - CT circuits – 2x2.5 sq.mm.
 - AC/DC Power circuit – 1x2.5 sq.mm.
 - All other circuit - 1x2.5 sq.mm.
- All wires on panels and all multi-core cables shall have ferrules, for easy identifications, which bear the same number at both ends, as indicated in the relevant drawing.
- The same ferrule number shall not be used on wires in different circuits on the same panels.
- Ferrules shall be of white insulating material and shall be provided with glossy finish to prevent the adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil.
- Stranded wires shall be terminated with tinned terminals, claw washers or crimped tubular lugs. Separate washers shall be suited to the size of the wire terminated. Wiring shall, in general, be accommodated on the sides of the box and the wires for each circuit shall be separately grouped. Back of panel wiring shall be arranged so that access to the connecting items of relays and other apparatus is not impeded.
- Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of stranded (48 No.) copper wire or strip having a cross section of not less than 2.5 sq. mm. Where strip is used, the joints shall be sweated.
- The wiring diagram for marshalling box shall preferably be drawn as viewed from the back and shall show the terminal boards arranged as in services.
- Terminal blocks shall be 1100 volts 10 Amp grade molded material complete with stud type brass terminal, washers, nuts and identification strips.
- Terminal block rows should be spaced adequately not less than 100 mm apart to permit convenient access to external cables and terminations.

- Terminal blocks shall be placed with respect to the cable gland (at a minimum distance of 200 mm) as to permit satisfactory arrangement of multi-core cable tails.
- Terminal blocks shall have separate pairs of terminals for incoming and outgoing wires. Insulating barriers shall be provided between adjacent connections. The height of the barriers and the spacing between terminals shall be such as to give adequate protection while allowing easy access to terminals. The terminals shall be adequately protected with insulating dust proof covers. No live metal shall be exposed at the back of the terminal boards.
- All interconnecting wiring, as per the final approved scheme between accessories of transformer and marshalling box is included in the scope of this specification and shall be done by the Transformer supplier.
- The schematic diagram shall be drawn and fixed under a transparent propane sheet on the inner side of the marshalling box cover.
- All marking of terminals shall follow IS 11953

1.25.4. INSPECTION AND TESTING DURING MANUFACTURING

General

- The supplier shall carry out a comprehensive inspection and testing during manufacture of the transformer. An indicative of checks to be carried out during manufacturing are given below.
- This is, however, not intended to form a comprehensive program as it is supplier's responsibility to draw up and carry out such a program duly approved by the purchaser.
- The supplier shall carry out type tests, special tests and routine tests on the transformers.
- Only one no. transformer of each rating will be subjected to type test.
- All type, special and routine tests shall be carried out at supplier cost.
- The pre-shipment checks shall also be carried out by the supplier.
- The requirements of onsite tests are as listed in the specifications.
- Certified test report and oscillographs shall be furnished to the purchaser/consultants for evaluation. The Supplier shall also evaluate the test results and rectify the defects in the equipment based on his and the Purchaser's evaluations of the tests without any extra charges to the Purchaser. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.
- The bidder shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity.

Checks during Manufacturing

- Tank and Conservator
 - Inspection of major weld.
 - Crack detection of major strength weld seams by dye penetration test.
 - Check correct dimensions between wheels, demonstrate turning of wheels,
 - through 90o and further dimensional check.
 - Leakage test of the conservator.
- **Core**
 - Sample testing of core materials for checking specific loss properties,

- magnetization characteristics and thickness.
- Check on the quality of varnish if used on the stampings.
- Check on the amount of burrs.
- Visual and dimensional check during assembly stage.
- Check on completed core for measurement of iron loss.
- Visual and dimensional checks for straightness and roundness of core, thickness of limbs and suitability of clamps.
- High voltage DC test (2 kV for one minute) between core and clamps.
- **Insulating Material**
 - Sample check for physical properties of materials.
 - Check for dielectric strength
 - Check for the reaction of hot oil on insulating materials.
- **Winding**
 - Sample check on winding conductor for mechanical continuity and electrical conductivity.
 - Visual and dimensional checks on conductor for scratches, dent mark etc.
 - Sample check on insulating paper for PH value, electric strength.
 - Check for the bonding of the insulating paper with conductor.
 - Check for the reaction of hot oil and insulating paper.
 - Check and ensure that physical condition of all materials taken for windings is satisfactory and free of dust.
 - Check for absence of short circuit between parallel strands.
- **Checks Before Drying Process**
 - Check condition of insulation on the conductor and between the windings.
 - Check insulation distance between high voltage connections, between high voltage connection cables and earth and other live parts.
 - Check insulating distances between low voltage connections and earth and other parts.
 - Insulating test for core earthing.
- **Checks during Drying Process**
 - Measurement and recording of temperature and drying time during vacuum treatment. Check for completeness of drying.
- **Assembled Transformer**
 - Check completed transformer against approved outline drawing, provision for all fittings, finish level etc.
 - Jacking test on the assembled Transformer.

- All standard test in accordance with IS: 335 shall be carried out on Transformer oil sample before filling in the transformer.
- Porcelain, bushings, bushing current transformers, wherever provided, winding coolers, control devices, insulating oil and other associated equipment shall be tested by the contractor in accordance with relevant IS. If such equipment is purchased by the supplier on a sub-contract, he shall have them tested to comply with relevant requirements.
 - Check for proper packing and preservation of accessories like radiators, bushings, explosions vent, dehydrating breather, rollers, Buchholz relay, control cubicle connecting pipes & conservator etc.
 - Check for proper provision of bracing to arrest the movement of core and winding assembly inside the tank.
 - Gas tightness test to conform tightness.

1.25.5. LOSSES

Transformers with lower losses shall be preferred. Maximum allowable losses shall be as follows:

Table 6: Losses

kVA rating	No load loss (kW)	Load loss at 75°C
12500 11	72	

There would not be any positive tolerance in losses. The manufacturer can offer losses less than above.

1.25.6. CAPITALIZATION OF LOSSES

For total cost evaluation, the capitalized cost of losses will be taken into account as per the following:

Capitalized cost of Transformer = Initial cost of Transformer + Rs. A x WI + Rs. B x Wc

Where: WI = Iron loss in kW & A = 137408 Rupees for iron loss WC = Copper loss in kW & B = 41222 Rupees for copper loss

In the event of either the iron or copper loss exceeding its guaranteed value as stated in the technical data schedule, the relevant rate above shall be applied to the excess and the resulting amount shall be deducted from the contract price.

1.25.7. STAGE INSPECTION

The purchaser reserves the right to carry out stage inspection of power transformers. During stage Inspection compliance of following shall be checked.

- Core assembly - diameter, window height, leg center, stack width, stack thickness, thickness of laminations, proof towards prime source of laminations
- Windings - conductor size, I.D., O.D & height of winding, major and minor insulations for both H.V and L.V windings
- Tank - length, breadth, height and thickness of plates of transformer tank, quality of fittings and accessories.

The supplier shall offer for final inspection of the transformers subject to clearance of the stage inspection report by the purchaser.

1.25.8. COMPLETENESS OF EQUIPMENT

All fittings and accessories, which may not be specifically mentioned in the specification but which are necessary for the satisfactory operation of the plant, shall be deemed to be included in the specification and shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not, without any financial liability to the purchaser under any circumstances.

1.25.9. SPARE PARTS

The Bidder shall provide a list of mandatory & recommended spare parts together with their individual prices. This list shall identify all essential spares and consumable items for any recommended maintenance for a period of five years after commissioning.

The Purchaser may order all or any of the spare parts listed at the time of contract award and the spare parts so ordered shall be supplied as part of the definite works. The Purchaser may order additional spares at any time during the contract period at the rates stated in the contract document. A spare parts catalogue with price list shall be provided and this shall form part of the drawings and literature to be supplied.

The Bidder shall give an assurance that spare parts and consumable items will continue to be available through the life of the equipment, which shall be 25 years minimum. However, the supplier shall give a minimum of 12 months' notice in the event that the supplier or any sub-suppliers plan to discontinue manufacture of any component used in this equipment.

Any spare apparatus, parts or tools shall be subject to the same specification, tests and conditions as similar material supplied under the definite work section of the contract.

They shall be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the plant and must be suitably marked and numbered for identification.

Spare parts shall be delivered suitably packed and treated for long periods in storage. Each pack shall be clearly and indelibly marked with its contents, including a designation number corresponding to the spare parts list in the operation and maintenance instructions.

A complete set of all the special tools, devices, slings or tackles required for the adjustment and maintenance of the equipment shall be supplied in the quantity listed in the Price Schedule. Each set of tools shall be mounted in a lockable cabinet. These shall also be provided under this contract. Eye bolts which have to be removed after use shall be accommodated in the cabinet.

1.26. TESTS

1.26.1. TYPE TESTS

The following shall constitute type tests. Special tests shall also constitute part of type tests:

- Measurement of winding resistance
- Measurement of voltage ratio and check of voltage vector relationship
- Measurement of impedance voltage/short-circuit impedance (principal tapping) and load loss
- Measurement of no-load loss and current
- Measurement of insulation resistance
- Dielectric tests
- Temperature-rise test, on tap having maximum losses
- Off load tap changer tests (as per BS:4571 / BS EN 60214)
- Tank Vacuum test

- Tank Pressure test

1.26.2. SPECIAL TESTS

- Short circuit test
- Measurement of zero sequence impedance
- Measurement of acoustic noise level

Type test reports (less than five years old as on the due date of tender) of tests carried out at CPRI /NABL accredited laboratory along with certified drawings shall be furnished by the bidder with offer otherwise offer shall be rejected. The offered transformer must be manufactured as per type tested design.

The supplier shall furnish calculations in accordance with IS: 2026 to demonstrate the thermal ability of the transformer to withstand Short Circuit forces.

1.26.3. ROUTINE TESTS

The following shall constitute routine tests:

- Visual examination and checking the dimensions
- Winding DC resistance.
- Voltage ratio on each tapping and
- Check of voltage vector relationship and polarity.
- Impedance voltage / short circuit impedance (principle tapping, maximum and minimum tapping)
- Magnetic balance test -
- Load loss.
- No-load loss and current
- Insulation resistance
- Separate source AC voltage withstand test
- Induced over voltage withstand test
- Measurement of Zero sequence impedance
- Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt/R1 mt)
- Oil leakage test of transformer tank at a pressure equal to normal pressure plus 35 kN per sq mtr measured at the base of tank.
- Measurement of neutral unbalance current (not to exceed 2% of full rated current of transformer)
- High voltage withstand test on auxiliary equipment and wiring.

In case of Temperature Rise test, if it is not feasible to carry out this test at CPRI /ERDA, bidder may hire services of the laboratories and carry out Temperature Rise test at supplier's works with testing equipment of CPRI /NABL. Test has to be carried out by testing engineer of CPRI/NABL and certification of the same have to be given on CPRI/NABL's letter head.

1.26.4. TEST PROCEDURES

Oil leakage Test

The tank and oil filled compartments shall be tested for oil tightness completely filled with air or oil of viscosity not greater than that of insulating oil conforming to IS: 335 at the ambient temperature and applying a pressure equal to the normal pressure plus 35 kN/m² measured at the base of the tank. The pressure shall be maintained for a period of not less than 12 hours for oil and one hour for air and during that time no leak shall occur.

Pressure Test

Where required by the Purchaser, one transformer tank of each size together with its radiator, conservator vessel and other fittings shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN/m² whichever is lower, measured at the base of the tank and maintained for one hour.

Vacuum Test

One transformer tank of each size shall be subjected to the vacuum pressure of 760 mm of mercury. The tanks designed for full vacuum shall be tested at an internal pressure of 3.33 kN/m² (25 mm of mercury) for one hour. The permanent deflection of flat plates after the vacuum has been released shall not exceed the value specified in C.B.I.P. Manual on Transformers (Revised 1999) without affecting the performance of the transformer.

1.26.5. TESTING EQUIPMENT/METER CALIBRATION

All testing equipment / meters used shall be calibrated within valid time limit at ERDA / NABL accredited laboratory. Calibration seals provided by the calibrating agency on testing equipment's / meters shall be in good condition.

1.27. PRE-DELIVERY INSPECTION AT MANUFACTURER'S WORKS

All routine & acceptance tests shall be witnessed and certified by purchaser's representative at manufacturer's works. The vendor shall give at least 10 days advance intimation to the purchaser to enable them to depute their representative for witnessing the tests. The said representative shall have full facilities for unrestricted inspection of supplier's works, raw materials, manufacturing processes and conducting necessary tests. The said representative shall verify the calibration seals provided by the calibrating agency on testing equipment's/ meters. Test reports of routine tests carried out by the manufacturer shall be submitted to the inspecting authority at the time of inspection for his approval. Acceptance of any quantity of materials shall in no way relieve the supplier of his responsibility for meeting all requirements of the specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

In case of waiver of inspection, vendor shall carry out all (i) routine and (ii) acceptance tests and submit test reports for approval of the purchaser, before dispatch of material.

The entire cost of testing for acceptance & routine tests and checking of length etc shall be borne by the supplier.

1.28. QUALITY ASSURANCE

Following quality plans shall be submitted within 30 days from the date of placement of contract:

- Quality Assurance Plan (QAP) to be adopted by manufacturer in respect of raw materials and bought out items, including source and test reports of (i) important raw materials and (ii) bought out items.
- Material Quality Plan (MQP) to be adopted by manufacturer in respect of manufacturing process.

The QAP & MQP shall be approved by the purchaser within 15 days from the receipt of compliance, if any. The vendor shall follow the approved QAP & MQP in true spirit. If desired by the purchaser, he shall give access to all the documents and materials to satisfy the purchaser that QAP & MQP are being properly followed.

1.29. GUARANTEE

The manufacturers of the transformer shall provide a guarantee of 54 months from the date of commissioning or 60 months from the date of dispatch whichever is earlier.

1.30. DRAWING / DOCUMENTS

1.30.1. TEST REPORTS FOR BOUGHT OUT ITEMS

The Supplier shall submit the test reports for all bought out/sub supplier items for approval.

- Buchholz relay
- Sudden pressure rise relay in OLTC
- Sudden pressure rise relay on main tank
- Winding temperature indicators
- Oil temperature indicators
- Bushings
- Bushing current transformers in neutral (if provided)
- Marshaling box
- Any other item required to complete the works.

The supplier shall furnish following drawings/documents for approval of purchaser within 4 weeks from the order.

- Detailed overall general outline drawing showing front and side elevations and plan of the transformer and all accessories including radiators and external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, bushing lifting height, clearances between HV and LV terminals and ground, quantity of insulating oil etc.
- Foundation plan showing loading on each wheel and jacking points with respect to center line of transformer.
- GA drawings/details of bushing.
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- GA drawing of marshalling box.
- Control scheme/wiring diagram of marshalling box.
- Technical leaflets of major components and fittings.
- Oil temperature indicator and winding temperature indicator settings
- Completed technical data sheets.
- Details including write-up of tap changing gear.
- Bi- metallic connector for connection to conductor/cable.

- Maintenance and Operating Instructions.
- As built version of the drawings and documents.

Executive Engineer (Stores), UPCL will be the final authority for approving the drawings submitted by the tenderer.

1.30.2. INSTRUCTIONS MANUAL

Three sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection, operation and maintenance of the transformer. The manuals shall include amongst others, the following particulars:

- Marked erection prints identifying the components, parts of the transformer as dispatched with assembly drawings.
- Detailed dimensions, assembly and description of all auxiliaries.
- Detailed views of the core and winding assembly, winding connections and tapings, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.
- Salient technical particulars of the transformer.
- Copies of all final approved drawings.
- Detailed O&M instructions with periodical check lists and format etc.

SECTION 2: TECHNICAL SPECIFICATION FOR 33kV RING MAIN UNIT

1. SCOPE

A. This specification covers design, manufacture, assembly, Stage inspection, testing before supply, inspection, packing and delivery of SF6 gas filled 33 kV, 630 Amps, Extensible type, Outdoor, SCADA Compatible Motorized Ring Main Unit with 630Amps Vacuum Circuit Breaker.

B. The Ring Main Unit shall be complete with all the accessories and auxiliary equipment's required for their satisfactory operation in Distribution Network of UPCL in Uttarakhand State, India.

C. The Ring Main Unit should have compatibility with Open Protocol Control and data Acquisition system. The Ring Main Units capable of being monitored and controlled by the Supervisory Control and data Acquisition (SCADA)/ Distribution Management System (DMS). The Ring Main Units should have the castell lock for avoiding dual supply and safety purpose.

D. The Ring Main Unit shall be complete with various combinations of Load Break Isolators as incomers & Circuit Breaker as outgoing feeders.

E. The Ring Main Units to be supplied against this specification are required for vital installations where continuity of service is very important. The design, materials and manufacture of the Ring Main Unit shall, therefore, be of the highest order to ensure continuous and trouble-free service over the years.

F. It is not the intent to specify, completely here in all the details of design and construction of the Ring Main Unit. However, the Ring Main Unit shall conform, in all respects to high standards of engineering, design and workmanship as per Indian standards or International standards. It shall be capable of performing in continuous commercial operation up to the supplier's guaranteed life of Ring Main Unit in a manner acceptable to the purchaser who will interpret the meanings of drawings and specifications and shall have power to reject any work or material which, in his judgment, is not in accordance therewith. The Ring Main Unit offered shall be compact, maintenance free, easy to install reliable, safe and easy to operate and complete with all parts necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of supplier's supply,

irrespective of whether those are specifically brought out in this specification and/or in the commercial order or not.

G. Recommended spares: The bidder shall furnish in his offer a list of recommended spares with unit rates for each set of Ring Main Unit that may be necessary for satisfactory operation and maintenance of Ring Main Unit for a period of 5 years. 33 kV, 630 Amps, Extensible / Non extensible type, Outdoor, SCADA Compatible Motorized Ring Main Unit with 630Amps Vacuum Circuit Breaker Technical Specification for 33 kV, 630 Amps, Extensible / Non extensible type, Outdoor, SCADA Compatible Motorized Ring Main Unit with 630Amps Vacuum Circuit Breaker The purchaser reserves right of selection of items and quantities of these spares to be ordered. The cost of such spares shall not be considered for tender evaluation.

H. Erection and maintenance tools: The bidder shall submit a list and unit rates of all the special tools, equipment and instruments required for erection, testing, commissioning and maintenance of the Ring Main Unit. The purchaser shall decide the quantity of tools to be ordered. Prices of these tools shall not be considered for tender evaluation. However, the list of necessary tools/equipment which will be supplied free of cost with each Ring Main Unit may be furnished separately.

2. SYSTEM PARTICULARS:

- Nominal System Voltage : 33kV
- Voltage variation on supply side : 10 %
- Corresponding Highest System Voltage : 36kV
- Frequency : 50 Hz with ± 3 % tolerance
- Transient condition : -20 % or + 10 % combined
Variation of Voltage and frequency.
- Number of Phase : 3 Phases
- Neutral earthing : Solidly earthed.
- Fault level (minimum) kA /Sec : 25/3
- Lightning Impulse Withstand Voltage (kVp) : 170
- One minute dry/wet power frequency
withstand voltage primary (kV rms) : 70
- Rated Dynamic Withstand Current for 1
second duration (kAp) : 62.5

3. SERVICE CONDITIONS:

The SF6 gas filled 33 kV, 630 Amps, Extensible / Non extensible type, Outdoor, SCADA Compatible Motorized Ring Main Unit with 630Amps Vacuum Circuit Breaker to be supplied against this specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

- Maximum ambient temperature (Degree C) : 50
- Maximum temperature in shade (Degree C) : 45
- Minimum Temperature (Degree C) : 3.5
- Relative Humidity (percent) : 10 to 95
- Maximum Annual rain fall (mm) : 1450

The climatic conditions are prone to wide variations in ambient conditions and hence the SF6 gas filled 33 kV, 630 Amps, Extensible / Non extensible type, Outdoor, SCADA Compatible Motorized Ring Main Unit with 630 Amps Vacuum Circuit Breaker shall be of suitable design to work satisfactorily under these conditions.

4. OBJECTIVE OF WORK & TOLERANCES:

It is intended to have

- A. Enhanced safety and reliability.
- B. Maintenance free Ring Main Units.
- C. Reduction in space requirement
- D. Integrated remote control and monitoring-SCADA compatible

Tolerances: Tolerances on all the dimensions shall be in accordance with provisions made in the relevant Indian/International standards amended up to date and in these specifications. Otherwise, the same will be governed by good engineering practice in conformity with required quality of the product.

CODES & STANDARDS

Sr. No.	Standards	Particulars
1.	IEC 62271- 200/ IEC 60 298/ IS 12729 : 1988	General requirement for Metal Enclosed Switchgear
2.	IEC 265	Medium Voltage Switches
3.	IEC 60129/ IEC 62271 – 102/ IS 9921	Alternating Current disconnectors (Load Break Isolators) and earthing switch
4.	IEC 62271-100/IEC 60056/ IS13118 : 1991	Specification for alternating current breakers
5.	IEC 62271 – 1/ IEC 60694	Panel design, SF6/ Vacuum Circuit Breakers
6.	IEC 60044 –1/ IEC 60185/ IS 16227 (Part-1)/(Part-2) /2016	Current Transformers
7.	IEC 60265/IS 9920 : 1981	High voltage switches
8.	IEC 376	Filling of SF6 gas in RMU
9.	IEC 60273/ IS : 2099	Dimension of Indoor & Outdoor post insulators with voltage > 1000 V
10.	IEC 60273/ IS 13947 (Part1)	Degree of protection provided by enclosures for low voltage Switchgear and control gear.
11.	IEC 60694	Common clauses for high voltage switchgear and control gear standards
12.	IEC 62271-103	High voltage switches for rated voltages above 1 KV and less than 52 KV.
13.	IEC 60137	Bushings for alternating voltages above 1000 V

Sr. No.	Standards	Particulars
14.	IEC 60233	Tests for hollow insulators for use in electrical equipment
15.	IEC 60376	New Sulphur hexafluoride (SF6)
16.	IEC 60480	Guidelines for checking and treatment of Sulphur hexafluoride (SF6)
17.	IEC 61243-5	Voltage detection systems
18.	IEC 60044-2	Potential transformers
19.	IEC 62271-209	Cable connections for gas insulated switch gears
20.	IS:2544/1973	Porcelain Post Insulators / Resin cast insulators
21.	IS 8828/1996	MCB
22.	IS 12063/1987	Degree of protection provided for enclosures for electrical equipment.
23.	IS 5/2005	Colors for ready mixed paints and enamels.
24.	IS 5578/1984	Marking of insulated conductor.
25.	11353/1985	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals
26.	IS 1248/2003	Indicating instruments.
27.	IS 14697/1999 amended up to date & as per updated technical specifications of UPCL	HT Static trivector TOD Energy meters
28.	IS 6875 amended up to date	Control switches.

5. AUXILIARY POWER SUPPLY:

- a) A. C. supply shall be provided for Control & Protective devices, lighting fixtures, space heaters and motors.
- b) D.C. supply shall be provided for alarm, control and protective device.

The rating, quality and location of electrical supply system that will be made available by the supplier for operation of the Ring Main units are described below:

i.	A. C. Supply	230 volts with $\pm 10\%$ variation
ii	D.C. Supply	24 V DC to 30 V DC with +10% to – 15% variation
iii	Frequency	50 Hz with $\pm 3\%$ variation

6. APPLICABLE STANDARDS:

a) The design, manufacture and performance of the Ring Main Units shall comply with all currently applicable statutes, regulations and safety codes. Nothing in this specification shall be construed to relieve the bidder off his responsibilities.

b) Unless otherwise specified, the Ring Main Units offered shall conform to the latest applicable Indian, IEC, British, U.S.A. or International Standards and in particular, to the following:

All Indian Electricity Rules/ Bills amended up to date applicable for clearances, safety and operation of the equipment. The Ring Main Unit meeting with the requirements of any other standards, which ensures equal or better quality than the standard mentioned above shall also be acceptable. If the Ring Main Unit, offered by the bidder conforms to other standards, salient points of difference between the standards adopted and the specific standards shall be clearly brought out in relevant schedule. In case of any difference between provisions of these standards and provisions of this specification, the provisions contained in this specification shall prevail. One copy of such standards with authentic English Translations in Hard Copy shall be furnished along with the offer

7. GENERAL REQUIREMENT OF RING MAIN UNIT:

The Ring Main Unit shall be installed at 33 kV junction points which feed the anchor units. The Ring Main Unit shall be both Non extensible/Extensible. Two Load break isolators for incoming & circuit breakers as outgoings shall be enclosed in the main tank using SF6 gas as insulating and vacuum as arc quenching medium. No of Outgoing of circuit breaker is depending on the no of outgoing feeders to each plot.

a) The Inner tank shall be stainless steel sheet of minimum 2mm thickness and robotically welded with a pressure relief arrangement.

b) Both the load break switches and circuit breaker shall be suitable for motorization.

c) The total breaking time for transient fault should not exceed 40-60 ms (CB + Relay+ trip coil).

d) The main tank (Inner enclosure of Circuit Breaker & Load break Isolators assembly) and all Switchboard assembly shall be housed in a single compact metal clad suitable for both indoor/outdoor applications.

e) The design of enclosure for Switchgear, Ring Main Unit & Switchboard housing shall be in accordance with IEC 298. The design of Ring Main Unit shall be in accordance with the Technical Specification. The switchgear and switchboard shall be designed such that the position of the different devices shall be visible to the operator on the front of switchboard and easy to operate and prevent access to all live parts during operation without the use of tools. There shall be no access to exposed conductors.

f) Circuit Breaker supplied with each Ring Main Unit shall be Vacuum Circuit Breaker. Insulating media for Bus Bar, Load Break Isolator, Earth Isolator and other associated equipment in Inner enclosure should be SF6 Gas.

g) An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following arc interruption. A temperature compensating gas pressure indicator offering a simple indication shall constantly monitor the SF6 insulating medium.

h) Each Ring Main Unit shall include its own power supply unit (including auxiliary transformer, batteries, and battery charger), which shall provide a stable power source for the Ring Main Unit. The auxiliary transformer of rating 500VA 33kV/230 Volt shall be provide a stable power source which will supply 230V AC for Remote Terminal unit (RTU).

- i) The Ring Main Unit shall also provide the necessary space for housing the Remote Terminal unit (RTU). In addition, space must be provided for auxiliary power transformer, which shall serve as the AC power supply 230 V inputs, along with all other Ring Main Unit devices.
- j) Within this context, the general requirements of the Ring Main Unit shall include, but shall not be limited to provision of the following monitoring and control features:
- k) Positions of local/remote switches as used to control local and remote access to circuit breakers and load break switches.
- Power supply indications including battery failure and voltage alarms.
 - Open/Closed position of load break switches, circuit breakers, and earthing switches.
 - Enclosure door-open indications
 - SF6 gas-pressure low alarm
 - Circuit breaker spring and load break switch charge (switch readiness) indications
 - Circuit breaker relay indications
 - Indications of fault current in the Ring Main Unit main feeder circuit as detected by the Fault Passage Indicator (FPI).
 - Measurement of 33 kV voltages, current, power, energy, and power factor values as per voltage level.
 - Load break switch and circuit breaker open/close control
 - Fault Passage Indicator (FPI) reset control
 - Automatic Water Level Control
 - Relay settings control

The acceptance of the RMUs shall not be complete until they have been demonstrated on a point-to-point basis to be fully interoperable with the Remote Terminal unit (RTU).

l) The Ring Main Unit shall be provided with necessary take off terminal units for automations and all these units should be shielded in an outdoor metal-body enclosure for making them suitable for Outdoor / Indoor use. The insulation/dielectric media of Inner enclosure the Non ferrite & Non magnetic grade stainless steel tank should be SF6 gas. The Ring Main Units shall be extensible on both sides.

m) The Ring Main Units should be motorized and suitable to be connected to Field

n) / Feeder Remote Terminal unit (F-RTU) so as to be monitored and controlled through Supervisory Control and data Acquisition (SCADA)/ Distribution Management System (DMS).

o) A remote terminal unit (RTU) is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA (Supervisory Control and Data Acquisition) system by transmitting telemetry data to a master system, and by using messages from the master supervisory. The Supervisory Control and Data Acquisition (SCADA) system is the heart of Distribution Management System (DMS).

p) The Ring Main Unit shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its transformer / feeders, it shall be equipped with a corresponding set of circuit breakers and self-powered numerical relays. The Ring Main Unit shall include potential-free contacts and control contacts so as to connect to SCADA/DMS via FRTUs, so as to:

- Monitor and control the open/closed status of the Ring Main Unit circuit breakers and load break switches.
 - Monitor the local/remote position of Ring Main Unit motorized (in case of failure of motor) manually-operated switches that can be used to enable and disable remote monitoring.
 - Monitor the health of the power supply, which will include battery failure and low voltage indications.
 - Monitor the open/closed status of Ring Main Unit earthing switches.
 - Monitor the open/closed status of RMU enclosure doors in case of Hinge doors.
- q) FRTU, Modem, Power and I/O cable interface between FRTU and Control panel of Ring Main Unit /sectionalizers are in the scope of supply.

8. PRINCIPLE REQUIREMENT OF RING MAIN UNIT:

8.1. ENCLOSURE:

- a) The Ring Main Unit enclosure (Outer) shall be made up of CRCA Sheet of 2 mm thickness or galvanized Sheet of 1.6 mm thickness. The rating of enclosure shall be suitable for operation on three phases, three wire, 33 kV, 50 cycles,
- b) A.C. System with short-time current rating of 25kA for 3 seconds for 33kV with Panels. The complete Ring Main Unit Outer enclosure shall be of degree of protection IP 54 (Main Door close) and IP 41 (Main Door open).
- c) The enclosure shall provide full insulation, making the Switchgear insensitive to the environment like temporary flooding, high humidity etc. The active parts of the Switchgear shall be maintenance-free and the unit shall be minimum -maintenance.
- d) The Ring Main Unit Outer enclosure shall be painted with Polyurethane based powder paint. The color of Ring Main Unit Outer enclosure shall be Dark Admiralty Grey, Shade No. 632 as per IS: 5, 2007.
- e) Each switchboard shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics.
- f) The Ring Main Unit metal parts shall be made of high thickness high tensile steel which must be grit/short blasted, thermally sprayed with Zinc alloy (not galvanized), phosphate and subsequently painted with Polyurethane based powder paint, the overall (Including outer and inner paint layer), the thickness of paint layer shall be not less than 150 microns for CRCA Sheet and 80 microns for galvanized Sheet.

8.2. INNER ENCLOSURE (MAIN TANK):

The tank shall be robotically welded stainless-steel sheet of minimum 2 mm thickness. The tank shall be sealed and no handling of gas is required throughout the 25 years of service life. However, the SF6 gas pressure inside the tank shall be constantly monitored by a temperature compensating gas pressure indicator offering a simple go, no-go indication. The gas pressure indicator shall be provided with green pressure and red pressure zones. There shall be one Non – return valve to fill up the gas. The manufacturer shall give guarantee for maximum leakage rate of SF6 gas will be lower than 0.1 % per year. An absorption material such as activated alumina in the tank shall be provided to absorb the moisture from the SF6 gas to regenerate the SF6 gas following arc interruption. The degree of protection of the inner enclosure shall be IP 67.

Oil or Air filled Switchgear will not be considered. The temperature rise test shall be carried out on complete Ring Main Unit and test reports shall be submitted with the offer.

The compact Ring Main Unit shall be provided with a pedestal made up of M.S. Angle to mount the unit on plain surface. The height of the bottom of cable box shall be 310 mm to provide the turning radius for the HT cable termination.

8.3. CONFIGURATIONS RECOMMENDED:

The following configurations of Ring Main Units are recommended:

Non-Extensible:

Non extensible Ring Main Unit with one number of 200A circuit breaker for transformer protection up to 630 kVA and two number of Load Break Isolators for network sectionalizing with earth isolator.

Extensible:

Extensible Ring Main Unit with one number of 630A circuit breaker and two Load break isolators with earth isolator arrangement having provision for adding one number of 630A circuit breaker for one extensible and two 630A circuit breakers for two extensible Ring Main Unit.

8.4. BUS BARS:

The three numbers of continuous Bus bars made up of EC grade tinned copper of rating current 630A shall be provided. The Short time rating current shall be 25 kA for 3 seconds for 33kV. The Bus bar connections shall Anti- oxide greased.

8.5. SULPHUR HEXA FLUORIDE GAS (SF6 GAS):

The SF6 gas shall comply with IEC 376,376A and 376B and shall be suitable in all respects for use in Ring Main Units under the stipulated service conditions. The SF6 gas shall be tested for purity, dew point air hydrolysable fluorides and water content as per IEC 376,376A and 376B and test certificate shall be furnished to the bidder indicating all the tests as per IEC 376 for each lot of SF6 Gas.

8.6. LOAD BREAK SWITCHES (LOAD BREAK ISOLATORS):

- The Load Break Isolators for Incoming and Outgoing supply must be provided, and the load break isolators are fully insulated by SF6 gas.
- The operating mechanism shall be spring assisted mechanism with operating handle for ON /OFF. Earth positions with arrangement for padlocking in each position. Also independent manual operations with mechanically operated indicator. The earth switch shall be naturally interlocked to prevent the main and earth switch being switched "ON" at the same time. The selection of the main and earth switch is made by a lever on the fascia, which is allowed to move only if the main or earth switch is in the off position.
- The load break isolators shall be remotely operated. Each load break switch shall be of the triple pole, simultaneously operated, automatic type with quick break contacts and with integral earthing arrangement.
- The rated current of Isolator shall be 630 Amps continuous at maximum ambient temperatures. No Derating shall be allowed. For the isolator at an Ambient temperature of 50 °C, which means that Isolator rating should be 630 Amps maximum ambient temperature of 50 °C. The temperature rise of Isolator shall be 550C maximum. The relevant type test report to prove the temperature rise below 55 °C shall be submitted by the bidder with the offer.

8.7. CURRENT TRANSFORMER:

- The Current Transformers being prone to failure due to various reasons, the quality and reliability of the Current Transformers are of vital importance. Current Transformer's insulation used shall be of very high quality, details of which shall be furnished in the technical offer.

- The Current Transformers shall be single wound double ratio, one Current Transformers for metering and one Current Transformers for protection.
- The instrument security factor for metering Current Transformers shall be low enough but not greater than 5 at lower ratio. This shall be demonstrated on metering Current Transformers in accordance with the procedure specified in IS: 16227, I & II and relevant IEC.
- The Current Transformers shall be ring type (Tape wound / resin cast). Contact tips of terminals shall be silver plated. Correct polarity shall be invariably marked on each terminal.
- A panel shall be provided in each Ring Main Unit enclosure to mount a single wound double ratio, Current Transformers for metering and protection purposes. Current Transformers access for maintenance or any other purpose shall be from the back of these panels.
- Secondary terminals of Current Transformers shall be brought out suitably to a terminal block, which will be easily accessible for testing and terminal connections.
- Further characteristics and features of Current Transformers used for metering and protection are listed as follows:

Metering Current Transformers:

- Type : Ring Type
- Material : Resin Cast
- Burden : 2.5VA
- Ratio : 200-100/1 Amps
- Accuracy Class for metering : 0.5

Protection Current Transformers:

- Type : Ring Type
- Material : Resin Cast
- Burden : 2.5VA
- Ratio : 200-100/1 Amps
- Accuracy Class for protection : 5P10.

8.8. METERING VOLTAGE (POTENTIAL) TRANSFORMER:

The Potential Transformers shall be of Resin Cast and they shall conform to IS: 16227, I & III. Their design and construction, in particular, shall be sufficiently robust to withstand the thermal and dynamic stresses during short circuits.

A panel shall be provided in each Ring Main Unit enclosure to mount Potential Transformers. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be provided and indicated by bidder in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.

HRC fuses shall be provided on the HV side.

Further characteristics and features of Potential Transformers used for metering are listed as follows:

- Type : Ring Type
- Material : Resin Cast

- Burden : 50 VA
- Ratio : 33 kV/ $\sqrt{3}$ /110V/ $\sqrt{3}$
- Accuracy Class for metering : 0.5

8.9. AUXILIARY VOLTAGE (POTENTIAL) TRANSFORMER:

The Auxiliary Potential Transformers shall be of Resin Cast and they shall conform to IS:16227, I & III. Their design and construction, in particular, shall be sufficiently robust to withstand the thermal and dynamic stresses during short circuits.

A panel shall be provided in each Ring Main Unit enclosure to mount Auxiliary Potential Transformers. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be provided and indicated by bidder in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.

Contact tips of primary/secondary contacts shall be silver plated. Correct polarity shall be distinctly marked on primary and secondary terminal.

Further characteristics and features of Potential Transformers used for metering are listed as follows:

- Type : Ring Type
- Material : Resin Cast
- Burden : 500 VA
- Ratio : 33 kV/ $\sqrt{3}$ / 230V
- Voltage Regulation : 5 %

8.10. EARTHING OF BUS BARS (EARTH SWITCH):

The unit shall consist of a 630 Amp Tee Off spring assisted three position rotating arc type SF6 circuit breaker unit, with integral fault making/dead breaking earth switch, the function shall be naturally interlocked to prevent the main and earth switch from being switched 'ON' at the same time and the CB not allowed to close in 'Earth On' position. The selection of the main/earth switch lever on the fascia, which is allowed to move only if the main or earth switches in the off position. The lever may be padlocked in either the main or earth position.

The cables shall be earthed by an integral earthing switch with short-circuit making capacity, in compliance with IEC 129 standard. The earthing switch shall be operable through the main circuit mechanism and manual closing shall be driven by a fast-acting mechanism, independent of operator action.

8.11. CIRCUIT BREAKER (VACUUM MEDIA FOR ARC QUENCHING):

The 3 pole circuit breaker for the protection of Distribution transformers or feeder shall be enclosed in the main tank. The rated breaking and making current at rated voltage shall be as follows:

For 33 kV System: Rated breaking capacity shall be 25 kA for 3 second. Rated making current shall be 62.5 kA for 3second.

The manual operation of the circuit breaker shall not have an effect on the spring charging mechanism.

The circuit breaker shall be fitted with a mechanical flag, which shall operate in the event of fault occurrences. The breaker indications ON and OFF positions shall be indicated by suitable flag. For ON position indication by Red flag and OFF position indication by Green flag shall be provided.

The circuit breaker shall be operated by the same unidirectional handle or switch. The rated operating sequence shall be O-3min-CO-3 min- CO.

8.12. BUSHINGS:

All the bushings shall be of same height, parallel, on equal distances from the ground and protected by a cable cover. It is preferable to have bushings accessible from the front / rear side of the Ring Main Unit.

8.13. CABLE BOXES:

All cable boxes shall be air insulated suitable for dry type cable terminations. The cable boxes at each of the two ring switches suitable HV cables of size 3C x 300 sq.mm and circuit breaker cable suitable up to 3C x 300 sq.mm. Necessary Right angle boot should be supplied to the cable terminations. Compound filled cable boxes are not acceptable.

The cable box shall be arc resistant as per IEC 62271-200 amended up to date.

The internal arc fault test on cable box shall be carried out for 33 kV systems at 25 kA for 1 second.

The clearance between phase to phase and phase to earth shall be as per IEC 61243 – 5 amended up to date. The cable termination and gland arrangements shall be appropriate for the type and style of cables used at the time.

The cable boxes for an isolator in its standard design should have sufficient space for connecting two cables per phase. Necessary Right angle Boot should be supplied to the cable terminations. The type of the Right angle Boot should be cold applied insulating Boot.

8.14. VOLTAGE INDICATOR LAMPS AND PHASE COMPARATORS:

The Ring Main Unit shall be equipped with a voltage indication. There should be a facility to check the synchronization of phases with the use of external device. It shall be possible for the each of the function of the Ring Main Unit to be equipped with a permanent voltage indication as per IEC 61958 to indicate whether or not there is voltage on the cables.

The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp must be used to indicate live cables.

Three outlets can be used to check the synchronization of phases with the use of an external device.

8.15. EXTENSIBLE:

Each combination of Ring Main Unit shall have the provision for extension by load break isolators / breakers in future, with suitable trenching chamber, accessories and necessary Bus bars. Extensible isolators and circuit breakers shall be individually housed in separate SF6 gas enclosures. Multiple devices inside single gas tank / enclosure will not be acceptable. In case of extensible circuit breakers, the Breaker should be capable of necessary short circuit operations as per IEC standard i.e 25 kA for 1 second for 33 kV system. The Breaker should have a rated current carrying capacity of 200 A for Distribution Transformers and Feeders.

8.16. WIRING AND TERMINALS:

A. The wiring should be of high standard and should be able to withstand the tropical weather conditions. All the wiring and terminals (including take off terminals wiring for automation, DC, Control wiring), Spare terminals shall be provided by the bidder. The wiring cable must be standard single-core multi stranded, non-sheathed, Core marking (ferrules), stripped with non-notching tools and fitted with end sleeves, marked in accordance with the circuit diagram with printed adhesive marking strips.

- B. The wiring shall be carried out using single core multi-strand copper conductor super flexible PVC insulated and shall be flame retardant low smoke type wires of
- C. 1.1 KV Grade for AC Power, DC Control and CT circuits. Suitable colored wires shall be used for phase identification and interlocking type ferrules shall be provided at both ends of the wires for wire identification. Terminal should be suitably protected to eliminate sulphating.
- D. Connections and terminal should be able to withstand vibrations. The terminal blocks should be stud type for controls and disconnecting link type terminals for CT leads with suitable spring washer and lock nuts. Flexible wires shall be used for wiring of devices on moving parts such as swinging Panels (Switch Gear) or panel doors. Panel wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals, terminal blocks and wiring gutters. The cables shall be uniformly bunched and tied by means of PVC belts and carried in a PVC carrying trough.
- E. The position of PVC carrying trough and wires should not give any hindrance for fixing or removing relay casing, switches etc., Wire termination shall be made with solder less crimping type of tinned copper lugs. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted with both ends of each wire. Ferrules shall fit tightly on the wire when disconnected. The wire number shown on the wiring shall be in accordance with the IS.375.
- F. All wires directly connected to trip circuits of breaker or devices shall be distinguished by addition of a red color unlettered ferrule.
- G. Inter-connections to adjacent Panels (Switch Gear) shall be brought out to a separate set of Terminal blocks located near the slots or holes to be provided at the top portion of the panel. Arrangements shall be made for easy connections to adjacent Panels (Switch Gear) at site and wires for this purpose shall be provided and bunched inside the panel. The bus wire shall run at the top of the panel. Terminal block with isolating links should be provided for bus wire. At least 10% of total terminals shall be provided as spare for further connections. Wiring shall be done for all the contacts available in the relay and other equipment and brought out to the terminal blocks for spare contacts. Color code for wiring is preferable in the following colors:

Voltage supply: Red, Yellow, Blue for phases, Black for Neutral CT circuits: Red, Yellow, Blue for phases, Black for Neutral 230V AC circuits: Black for both phases and neutral

Earthing: Green

The wiring shall be in accordance to the wiring diagram for proper functioning of the connected equipment. Terminal blocks shall not be less than 650V grade and shall be piece-moulded type with insulation barriers.

The terminal shall hold the wires in the tight position by bolts and nuts with lock washers. The terminal blocks shall be arranged in vertical formation at an inclined angle with sufficient space between terminal blocks for easy wiring.

The terminals are to be marked with the terminal number in accordance with the circuit diagram and terminal diagram. The terminals should not have any function designation and are of the tension spring and plug-in type.

8.17. EARTHINGS:

The Ring Main Unit outdoor metal clad, Switch Gear, Earth contact of Load break isolators, Neutral and body of Distribution Transformer, M.S. Channels / M.S. Angles etc, shall be equipped with an earth bus securely fixed along the base of the Ring Main Unit.

When several units of the Ring Main Unit (Extra Isolators / Breakers) are mounted adjoining to each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply. The size of earth bus bar of tinned copper flat shall be as per IEC/IS standards and shall be fixed with the Ring Main Unit. Provision shall be made on end of Ring

Main Unit for connecting the earth bus to the earth grid by erecting suitable 2 earth pipes of 40mm diameter MS rod of 3 meters in pits. Both the earth pipes are also to be connected in a grid formation. Necessary terminal clamps and connectors shall be included in the scope of supply.

8.18. MOTORIZATION:

All the functions within the Ring Main Unit i.e Isolators / Breakers should be fitted with motor mechanism and closing coil making it suitable to make it ON from remote.

Control Supply and Auxiliaries following has to be considered:

- Shunt trip coil – 24VDC for Isolators and Breakers
- Closing Coil – 24VDC
- Motor Mechanism – 24VDC
- 6NO+6NC – Potential free auxiliary contacts for breakers / isolator
- Auxiliary supply should be – 24VDC
- Battery/ Battery charger with battery backup of at least 1hours
- Local / Remote switch for breaker and Isolators.

8.19. METERING:

The Ring Main Unit should be provided with separate Metering Module Consisting of Bus connected Potential Transformer and metering cum protection Current Transformer to be provided for VCB function i.e. for Distribution Transformer / Feeder along with provision of installing Tri-vector Meter (TVM). The Potential Transformer with PT Fuse and Ring Core type Current Transformer provided shall be made up of Epoxy Cast Resin. The CT ratio shall as per transformer rating.

8.20. TAKE OFF TERMINAL UNITS FOR AUTOMATION:

The Ring Main Unit should be provided with necessary take off terminal units for automations. Remote operation of the Ring Main Units line switches must be possible using motors fitted to the operating mechanism.

It shall be possible to fit the motors either directly in manufacturing plant or on site as and when required. Installation on site shall be possible with the Ring Main Unit fully energized and manufacturer should provide detailed instructions for installation to the control mechanism.

The fitting of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or circuit breaker.

The bidder may wish to advise of options and cost for remote supervisory control units of the Ring Main Unit and MV network supervisory control system.

Complete Ring Main Unit shall be capable of withstanding 630A current without any damage being caused, in accordance with the recommendations IEC 694 and IEC 298.

Control and Interlocks:

The circuit breaker shall normally be controlled remotely from SCADA system closing through Motor and tripping through spring.

The isolators and earth isolator shall normally be controlled remotely from SCADA system closing and opening through Motor.

However, it shall also be designed to control locally from Ring Main Unit panel. Suitable mimic on Panel shall be provided.

Facilities shall be provided for mechanical tripping of the breaker in an emergency. Facility shall also be provided for manual charging of the stored energy mechanism for a complete duty cycle.

Necessary mechanical & Electrical interlocks shall be provided between CB, Isolator & Earth switches for safe operation.

Each CB, Isolator & earth switch shall have 8 NO + 6 NC Auxiliary spare of good quality (corrosion free and easy for making connection) for future use by owner. It should be located at accessible position in panel.

All the binary inputs/outputs shall be wired to the terminals & kept ready for SCADA connectivity.

8.21. FAULT PASSAGE INDICATORS (FPI) ON SHORT CIRCUIT AND EARTH FAULT:

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The Fault Passage Indicators (FPI) shall be integral part of Ring Main Unit.

The Fault Passage Indicators (FPI) shall facilitate for detection of short circuit fault and earth fault through Current Transformer inbuilt in Fault Passage Indicators.

8.22. TROPICALISATION:

Due regard should be given to the climatic conditions under which the equipment is to work. Ambient temperature normally varies between 20 °C and 32 °C, although direct sun temperature may reach 45 °C. The climate is very humid and rapid variations occur, relative humidity between 90% and 100% being frequently recorded, but these values generally correspond to the lower ambient temperatures. The equipment should also be designed to prevent ingress of vermin, accidental contact with live parts and to minimize the ingress of dust and dirt. The use of materials, which may be liable to attack by termites and other insects, should be avoided.

8.23. SAFETY OF PEOPLE:

Any accidental overpressure inside the sealed chamber will be limited by the opening of a pressure limiting device in the enclosure. Gas will be released to the rear of the unit away from the operator. Manufacturer shall provide type test report to prove compliance with IEC 298 appendix AA 'Internal fault

8.24. AUTOMATIC WATER LEVEL CONTROLLER USING MERCURY FLOAT SWITCH:

The float switch shall be provided in Ring Main Unit at 200 mm below live contacts to avoid flash over due to water.

The float switch is a device used to detect the level of water within the Ring Main Unit. The float switch shall be used in the Ring Main Unit as an indicator, an alarm (at Control Room), tripping of Vacuum Circuit Breaker and opening of Load Break switch.

A mercury switch is a switch whose purpose is to allow the flow of electric current in an electrical circuit in a manner that is dependent on the switch's physical position.

Mercury switches shall have 4 NO + 4 NC Auxiliary contacts in a sealed glass envelope which contains a bead of mercury. The envelope may also contain air, an inert gas, or a vacuum. Gravity is constantly pulling the drop of mercury to the lowest point in the envelope. When the switch is tilted in the appropriate direction, the mercury touches a set of contacts, thus completing the electrical circuit through those contacts. 'Normally Open' contact becomes 'Normally Close' contact, hence signals to breaker and motor for tripping of Vacuum Circuit Breaker and opening of Load Break switch. These signals shall be goes to Sub Station Control Room / SCADA Control Room via RTU with opening reason for further action.

8.25. OPERATING LEVER:

An anti-reflex mechanism on the operating lever shall prevent any attempts to re- open immediately after closing of the switch or earthing switch.

All manual operations will be carried out on the front of the switchboard.

The effort exerted on the lever by the operator should not be more than 250 N for the switch and circuit breaker.

The overall dimensions of the Ring Main Unit shall not be increased due to the use of the operating handle. The operating handle should have two workable positions 180° apart.

8.26. FRONT PLATE:

The front shall include a clear mimic diagram which indicates different functions.

The position indicators shall give a true reflection of the position of the main contacts.

They shall be clearly visible to the operator.

The lever operating direction shall be clearly indicated in the mimic diagram.

The manufacturer's plate shall include the switchboard's main electrical characteristics.

8.27. DANGER BOARD:

The danger Board plate as per relevant IS: 2551, 1982 shall be riveted on the front plate of the Ring Main Unit.

8.28. INTERNAL ARC RATING:

The Ring Main Unit shall have a design such that in the event of an internal arc fault, the operator shall be safe. This should be in accordance with IEC 298 and relevant Test certificates shall be submitted with the Tender.

The Ring Main Unit shall be tested for an internal arc rating of 25 kA for 1 Sec for 33 kV.

Suitable temperature rise test on the Ring Main Unit shall be carried out & test reports shall be submitted with tender for technical bid evaluation.

8.29. SPECIFIC REQUIREMENT FOR AUTOMATION:

The Ring Main Units should be provided with provision of following minimum signals available at separate SCADA terminal box.

Minimum signals for SCADA/DMS - to be wired to separate TBs

Sr. No.	Particulars	Contacts
1.	CB Close / Open	Potential free contacts
2.	LBS Close / Open	Potential free contacts
3.	LBS & CB Earth Switch Close / Open	Potential free contacts
4.	CB Test/Service Position	Potential free contacts
5.	Spring charge Status indication	Potential free contacts
6.	SF6 gas pressure low	Potential free contacts
7.	O/C Operated	Potential free contacts
8.	E/F Operated	Potential free contacts

9.	Local/Remote	Potential free contacts
10.	Common Power Supply Healthy	Potential free contacts
11.	Motor MCB Healthy Status	Potential free contacts
12.	Battery charger Fail	Potential free contacts
13.	RMU Door Open	Potential free contacts
14.	CB Trip Coil Healthy	Potential free contacts
15.	Current Transformer Status	Potential free contacts
16.	Potential Transformer Status	Potential free contacts
17.	FPI Control	Potential free contacts
18.	CB control	Potential free contacts
19.	LBS Control	Potential free contacts
20.	Water Level Alarm	Potential free contacts
21.	CB Open	Potential free contacts
22.	LBS Open	Potential free contacts

A. Specific requirement for SCADA Connectivity:

- Fault Passage Indicator shall be provided per isolator
- DC control supply system should be 24V DC.
- Battery charger to cater load of minimum 10 motorized operation cycles (Close-Open) in absence of battery.
- Battery to cater load of minimum 10 motorized operation cycles (Close-Open) in absence of battery charger. The battery backup should be minimum of 6 Hrs.
- Miniature Circuit Breakers (MCB) shall be provided for battery charger supply, RMU Motor supply & FRTU supply (Minimum 2 Amp circuit for future use of FRTU).
- Individual control circuit of Isolator/Circuit Breaker to have point of isolation/protection.
- Individual motor circuit of Isolator/Circuit Breaker to have point of isolation/protection.
- The Ring Main Unit shall have minimum protection of IP54 for Outer Enclosure with gland plate & knock outs. Provision for control cable entry should
- preferably be from Right/ Left top through LV cable box & shall be independent of HV Isolator/Circuit Breaker status. It should be vermin proof.
- Control cable gland plate shall be independent of power cable gland plate.
- A point of earthing for control cables shall be electrically isolated from power cable earthing.
- Ambient temperature of 50°C max. Allowable temperature rise of battery & battery charger above ambient 40°C.

- Local / Remote switch shall be provided on all the isolator & breaker panels for selection of controls.
- Current Transformer & Potential Transformer terminals for all the circuit breakers for Distribution Transformers / Feeders only.

B. Following is the list of I/O requirements for Ring Main Unit modules. Please note that all DI & DO should be potential free contacts.

1. List of potential free contacts for Isolator (Terminals shall be provided):

a) Digital Indications:

- Isolator ON --02 No. & 2 NC
- Isolator OFF --02 No. & 2 NC
- Isolator Earth switch Status (ON/OFF)
- FPI Operated
- LOCAL/REMOTE switch position

b) List of commands:

- Isolator Close
- Isolator Open
- FPI reset

2. List of potential free Contacts for Circuit Breakers (Terminals shall be provided):

a) Digital Indications:

- Circuit Breaker ON
- Circuit Breaker OFF
- Auto Trip
- LOCAL/REMOTE switch position

b) List of commands:

- Circuit Breaker Close
- Circuit Breaker Open

3. Requirement of Tri-Vector Meter (TVM):

a) The terminals shall be provided for CT and PT Connections

b) Space shall be provided for Tri-Vector Meter (TVM) mounting on Outer Enclosure pane

8.30. DISTRIBUTION AUTOMATION SYSTEM INTERFACES:

The Ring Main Unit shall be equipped so that it can be monitored and controlled via the SCADA. In this respect, it shall interoperate with the RTU that will be housed in the Ring Main Unit Control Cabinet. The RTU in turn will interoperate with the SCADA via the remote communications system.

The Ring Main Unit shall have provisions for opening and closing its switches / breakers using output from the RTU. The Ring Main Unit shall also supply analog and status signals to the RTU for monitoring the condition of the Ring Main Unit's distribution network circuits as well as the components of the Ring Main Unit

8.31. TESTS:

8.31.1. TYPE TESTS:

The Ring Main Unit and accessories offered in the tender should have been successfully type tested at NABL laboratories in India or equivalent International Laboratories in line with the relevant standard and technical specification, within the last 5 (five) years from the date of offer. The bidder shall be required to submit complete set of the type test reports in physical format along with the offer. The bidder must provide the original copies of type test reports for verification purpose or produce authentic documents to confirm the type tests are authentic in case of tests carried out at equivalent International Laboratories

In case these type tests are conducted earlier than five years, all the type tests as per the relevant standard shall be carried out by the successful bidder at NABL in presence of purchaser's representative free of cost before commencement of supply. The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for rejection.

Type tests:

- Short time current withstand test and peak current withstand test.
- Lightning Impulse voltage with-stand test
- Temperature rise test.
- Short Circuit current making and breaking tests.
- Power frequency voltage withstand test (dry).
- Capacitive current switching test confirming to IEC.
- Mechanical operation test.
- Measurement of the resistance of the main circuit.
- Degree of protection of Inner enclosure and outer enclosure
- Switch, circuit breaker, earthing switch making capacity.
- Switch, circuit breaker breaking capacity.
- Internal arc withstand Test for Inner Enclosure and Cable Chamber.
- Checking of partial discharge on complete unit.

The details of type test certificate according to the composition of the Switchboard shall be submitted with the offer.

In addition, for switches, test reports on rated breaking and making capacity shall be supplied.

For earthing switches, test reports on making capacity, short-time withstand current and peak short-circuit current shall be supplied.

In addition to that, Test report of Vacuum Interrupter along with Catalogues & Literatures to be submitted along with the Offer.

8.31.2. ACCEPTANCE AND ROUTINE TESTS:

All acceptance and routine tests as stipulated in the respective applicable standards amended up-to-date for all the equipment shall be carried out by the supplier in the presence of purchaser's representative without any extra cost to the purchaser before dispatch.

The bidder shall have full facilities to carry out all the acceptance and routine test as per the applicable standards.

After finalization of the program of acceptance/routine testing, the supplier shall give 15 days' advance intimation to the purchaser, to enable him to depute his representatives for witnessing the

tests. The routine tests should be carried out by the manufacturer at his works in presence of EE (Testing) UPCL and EE (IW), MMC, UPCL.

All the Ring Main Units must be routine tested for the following:

- Conformity with drawings and diagrams,
- Measurement of closing and opening speeds,
- Measurement of operating torque,
- Checking of filling pressure,
- Checking of gas-tightness / SF6 gas leak test.
- Dielectric testing and main circuit resistance measurement.
- Power frequency voltage
- Resistance test for the circuit
- Mechanical operation tests.
- Micro-ohm test for the assembly inside the tank.
- Circuit breaker analyzer test so as to ensure the simultaneous closing of all poles for VCB.
- Partial Discharge test on the complete gas tank so as to be assure of the proper insulation level and high product life.
- High voltage withstands.
- Secondary test to ensure the proper functioning of the live line indicators, fault passage indicators and relays.

All major type tests shall have been certified at an independent authority with the tests carried outside country of manufacture shall be translated in English and submitted in hard copy.

The supplier in the presence of UPCL's representative shall carry out all above acceptance and routine tests. The supplier shall give at least 15 days advance intimation to the UPCL to enable them to depute their representative for witnessing the tests. The cost towards transport, stay and other expenses shall be borne by the supplier.

The UPCL reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/laboratory or at any other recognized laboratory/research institute in addition to the above-mentioned type, acceptance and routine tests at the cost of the UPCL to satisfy that the material complies with the intent of this specification.

8.32. INSPECTION:

The inspection may be carried out by the purchaser at any stage of manufacture. The successful bidder shall grant free access to the purchaser's representative/s at a reasonable notice when the work is in progress. Inspection and acceptance of any equipment under this specification by the purchaser shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

The supplier shall keep the purchaser informed, in advance, about the manufacturing program so that arrangement can be made for stage inspection.

The purchaser reserves the right to insist for witnessing the acceptance/routine testing of the bought-out items. The supplier shall keep the purchaser informed, in advance, about such testing program.

9. TRAINING:

All successful bidders for Ring Main Units shall provide training facilities for the UPCL's Engineers. The training shall be for not less than 8 man weeks. Syllabus and other details of the training shall be finalized in consultation with the UPCL. Boarding, lodging and traveling expenses for the deputed trainees will be borne by the UPCL. Charges for training shall be quoted in the offer separately. These will not be considered for evaluation of the offer.

10. GUARANTEED TECHNICAL PARTICULARS:

The bidder should fill up the details in schedule A – “Guaranteed Technical Particulars” and the statement such as “as per drawing enclosed”, “as per UPCL requirement”, “as per IS”, “as per specification” etc. shall be considered as details not furnished and such offers will be rejected.

Annexure ‘A’

Principal Technical Parameters of Ring Main Unit and accessories:

Sr.No.	Description	33 kV Ring Main Unit
1.	Indoor / Out door	Out door
2.	Configurations (Type)	3 Way, M+LLV+ L= Isolator. V= VCB. M=Metering
3.	Reference Standard	IEC-62271-100, 200,103,IEC-62271-1
4.	Rated Voltage in kV	33
5.	Highest System Voltage in kV, Max.	36
6.	Number of Phase	3
7.	Frequency in HZ.	50 Hz $\pm$ 3%
8.	Short Circuit rating	
	a) Breaking Symmetrical for 3 Sec. in KA	25
	b) Breaking Asymmetrical for 3 Sec. in KA	25
	c) Short time for 3 Sec. in KA.	25
9.	Insulation Level	
	a) Impulse withstand in KV peak.	170
	b) 1 Minute 50 Hz. Voltage withstand in KV rms	70
10.	Internal arc rating for 1 sec. in kV	25
11.	Construction: Material and Size	
	Inner Enclosure	Main Stainless-Steel Tankwith 2 mm Thickness
	Outer Enclosure	CRCA Sheet of 2 mm thickness or Galvanized Sheet of 1.6 mm thickness
12.	Degree of protection	
	Inner Enclosure	IP 67
	Outer Enclosure	IP 54 (Main Door close) and IP 41 (Main Door open)
13.	The Ring Main Unit and accessories completely wire and tested at factory	Yes
14.	Paint	Polyurethane based powder paint

Sr.No.	Description	33 kV Ring Main Unit
15.	Color	Dark Admiralty Grey, Shade No. 632 as per IS: 5, 2007
16.	Thickness of coat, Min.	150 microns for CRCA Sheet and 80 microns for galvanized sheets
17.	Reference Standard	IS: 1897, 2008
18.	Grade and Material	Electrolytic Grade Copper
19.	Cross sectional area in mm ²	400
20.	Size in mm or as per design	40 x 10
21.	Current Density in Amps/mm ² , Max.	1.6
22.	Continuous Current in Amps	630
23.	Maximum temperature rises over an ambient temperature 50°C.	55°C
24.	Short time current rating for 3 Sec in kA rms	25
25.	Clearance in mm from bare bus bar or as per design	
	Phase to Phase for Isolator or as per design	78
	Phase to Phase for VCB	78
	Phase to Earth for Isolator or as per design	78
	Phase to Earth for VCB or as per design	78
26.	Bus Supports	
	Reference Standard	IEC 60243-1, ASTM D 648
	Voltage Class in kV	33 kV
	Creepage distance in mm or as per design	180 in SF6 gas
	Bus Bar support spacing in mm or as per design	420
27.	Filling SF6 gas pressure (Filling pressure at 200°C), Min.	1.4 Bar
28.	Operating SF6 gas pressure at 200°C, Min.	0.5 Bar
29.	Reference Standard	IEC 62271-100
30.	Rated Voltage in kV	33
31.	Highest System Voltage in kV, Max.	36
32.	Type	Vacuum Type
33.	Rated Frequency in Hz.	50 Hz ± 3%
34.	No. of Poles	3
35.	Rated Current	630A
36.	Maximum temperature rise over an ambient temperature 50°C.	55°C
37.	Rated operating Duty	O-3min-CO-3min-CO
38.	Rupturing capacity at rated voltage in MVA, Min.	As per design
39.	Breaking Capacity at rated voltage & operating duty	
	Symmetrical in kA rms	25
	Asymmetrical in kA rms	25
40.	Rated making current in kA peak	62.5
41.	Short time current for 3 sec in kA rms	25
42.	Transient Recovery Voltage	
	Rate of rise in kV/μs	0.64 kV/μs as per IEC 62271-100
	Peak Voltage in kV	70
43.	Insulation Level	

Sr.No.	Description	33 kV Ring Main Unit
	Impulse Voltage with stand on 1.2/50 μ s full wave in kV	170
	1 minute power frequency voltage withstand in kV	70
44.	Total breaking time for transient fault (CB + Relay+ trip coil) in ms	<45 ms
45.	Opening time No load condition in ms	<45 ms
46.	Opening time under SF6 gas low or vacuum loss condition in ms	<45 ms
47.	Number of breaks per pole	Single
48.	No of breaker operations permissible without requiring inspection replacement of contacts and other main parts	
	At 100% rated current	2000
	At 100% rated breaking current, Min.	20
49.	Type of contacts	
	Main	Butt Type
	Arcing	Butt Type
50.	Material of contacts	
	Main	Copper
	Arching	Copper
	Chromium / Silver plated	Chromium / Silver plated
51.	Mechanical Endurance Test for Circuit Breaker, Number of operations	2000
52.	Spring charging mechanism	Motor Operated
53.	Operating mechanism for closing of Circuit Breaker	
	Type	Spring operated Mechanism
	No of breaker operations stored	One
	Trip free or fixed trip	Trip Free
	Earthing for operating mechanism and metal parts	Solidly Earthed
	Earth terminal size and material, Min.	Electrolytic grade Copper 25 x 3mm
54.	Operating mechanism for tripping of Circuit Breaker	
	Type	Spring Operated Mechanism
	No of breaker operations stored	One
	Trip free or fixed trip (V)	Trip Free
	Earthing for operating mechanism and metal parts	Solidly Earthed
	Earth terminal size and material	Electrolytic grade Copper 25 x 3mm
55.	Breaker Accessories	
	Mechanical safety Interlock	Provided
	Automatic safety Interlock	Provided
	Operational Interlock	Provided
	Emergency manual trip	Provided
	Operation counter	Provided
	Spring charge / discharge indicator	Provided
	Manual spring charging facility	Provided

Sr.No.	Description	33 kV Ring Main Unit
56.	Reference standard	IEC-62271-102 / IEC- 62271-103
57.	Nominal Voltage in KV	33
58.	Highest System Voltage in kV, Max.	36
59.	Rated Frequency in HZ	50 Hz $\pm$ 3%
60.	No. Of poles	3
61.	Rated Current in Amps	630
62.	Maximum temperature rise over an ambient temperature 500C.	60°C
63.	Operation	Close-Open-Earth
64.	Rupturing Capacity at rated voltage	630 Amps at 33kV
65.	Maximum over voltage factor when switching off Loaded feeder cable in kA	62.5
66.	No. of isolator operation permissible without requiring inspection, replacement of contacts and other main Parts	
	Mechanical Endurance in Number of operations	1000
	At 100% rated making current in Number of operations	100
	At 100% rated breaking current in Number of operations	100
67.	Isolator provided with the following Mechanical safety	
	Mechanical ON and OFF Indication	Provided
	Cable Earth Indication	Provided
	Operational Counter	Provided
	Manual Spring Charging facility	Provided
68.	Reference standard	IS:16227, I & II
69.	Type	Ring Type, Resin Cast/Tape wound
70.	Nominal Voltage in KV	33
71.	Highest System Voltage in kV, Max.	36
72.	Rated Frequency in HZ	50 Hz $\pm$ 3%
73.	Current Transformer Ratio	200-100/1Amps
74.	Short circuit withstand	
	Short time current for 1 sec. in kA rms	5
	Dynamic current in kA peak, Min.	7.5
75.	Class of insulation	Class B
76.	Basic insulation level in kV rms	3
77.	Maximum temperature rise over an ambient temperature 500C.	600C
78.	Class of Accuracy	
	Metering Core	0.5
	Protection Core	5P10
79.	Rated Burden	2.5 VA
80.	Over Current Rating in %	120
81.	Continuous Over Load in %	120
82.	Reference standard	IS:16227, I & III
83.	Type	Resin Cast/Tape wound
84.	Nominal Voltage in KV	33
85.	Highest System Voltage in kV, Max.	36

Sr.No.	Description	33 kV Ring Main Unit
86.	Rated Frequency in HZ	50 Hz $\pm$ 3%
87.	Voltage Transformer Ratio	33 kV/ $\sqrt{3}$ /110V/ $\sqrt{3}$
88.	Rated Primary Voltage in kV	33 kV/ $\sqrt{3}$
89.	Rated Secondary Voltage in V	110V/ $\sqrt{3}$
90.	Rated Burden in VA	50
91.	Accuracy Class	0.5
92.	Insulation Class	B
93.	Voltage Factor	1.2 Continuous and 1.9 for 8 hrs.
94.	One Minute Power Frequency Dry Withstand Voltage Rating	
	Primary Winding Induced Test in kV rms	70
	Secondary Winding in kV rms	3
	Rated Impulse Voltage in kV peak	170
95.	Reference standard	IS:16227, I & III
96.	Type	Resin Cast/Tape wound
97.	Nominal Voltage in KV	33
98.	Highest System Voltage in kV, Max.	36
99.	Rated Frequency in HZ	50 Hz $\pm$ 3%
100.	Voltage Transformer Ratio	33 kV / 230V
101.	Rated Primary Voltage in kV	33 kV
102.	Rated Secondary Voltage in V	230V
103.	Rated Burden in VA	500 VA
104.	Voltage Regulation in %	5
105.	Insulation Class	B
106.	Voltage Factor	1.2
107.	Application & Construction Type	Indoor, Single Phase/Two Pole
108.	One Minute Power Frequency Dry Withstand Voltage Rating	
	Primary Winding Induced Test in kV rms	70
	Secondary Winding in kV rms	3
	Rated Impulse Voltage in kV peak	170
109.	Reference Standard	IEC 60255
110.	Type and Model	3 Over Current(O/C) and 1 Earth fault(E/F)
111.	Current Transformer Secondary Input to Relay	1 A
112.	Operating Curve Type	Inverse Definite Minimum Time (IDMT)Relay
113.	Auxiliary Supply	Self-Powered relay for Protection
114.	Rated Frequency in HZ	50 Hz $\pm$ 3%
115.	Over Current Protection	
	Low set Over Current protection	20-200% of CT secondary rated current with increment/decrement by 1%
	High set Over Current protection	100-2000% of CT secondary rated current with increment / decrement by 50%
116.	Earth Fault Protection	
		5% to 80% of the CT rated

Sr.No.	Description	33 kV Ring Main Unit
	Low set Earth Fault protection	current in steps of 1%
	High set Earth Fault protection	100-1000% of the CT rated current in steps of 50%
117.	Mounting	Flush Mounted
118.	Operational Indicator	LCD display and LED annunciation lamps
119.	Contact Details	4 Binary Input(BI) and 6 Binary Output(BO)
120.	Self-diagnosis feature	Yes
121.	Password protection	Yes
122.	Communication Protocol	RS 232 or RS 485 Port or IEC 104, Communication Protocol
123.	Event / fault record, Min.	10 Event and 5 Fault Records available
124.	Setting groups	2 Groups available
125.	Circuit Breaker control available	Yes, Only Trip
126.	DC Voltage in Volt	24
127.	Maximum Tripping Current at rated voltage in Amps.	5
	Minimum Permissible voltage variation in %	85 to 110
128.	Reference Standard	IS: 14697, 1999 IS: 15959, 2011
129.	Make	Secure / L&T / other UPCL approved make
130.	Auxiliary supply Voltage	110V/√3
131.	Class of Accuracy	0.5S
132.	Type of Display	Customized backlite liquid crystal display
133.	Measuring Parameters as per UPCL Specification	
		Instantaneous parameters
		Block Load Profile parameters
		Billing Profile Parameters
		Name Plate details Programmable Parameters
		Event Conditions
		All logging parameters for each of the event condition for 3 Φ / 4W
134.	Operating point/Current short circuit in Amp	Adjustable 100/200/300 /400/500 /600/700 /800/900/1000 /1100/1200A (±15%)
135.	Operating point/Current earth fault in Amp	Adjustable 10/20/30/40 /60/80/100A (±15%)
136.	Response Time in ms	For Short Circuit Adjustable 40/60/80/100/120 /160/200/240 ms Sec(±100m Sec) For Earth Fault Adjustable

Sr.No.	Description	33 kV Ring Main Unit
		40/60/80/160 ms (± 100 m Sec)
137.	Auto Reset Time in Hrs	1/2/4/8 hrs (+ / - 1%) after fault
138.	Input AC Voltage in V	230
139.	Rated Frequency in Hz	50 Hz $\pm$ 3%
140.	Output DC Voltage in V	24
141.	Current Rating in Amps	10
142.	Output DC Voltage for charger	
	Boost Mode in V	27 to 28
	Float Mode in V	27 to 28
143.	Operating Temperature in $^{\circ}$ C	-25 to 60
144.	Temperature Compensation	Junction temperature of SMPS crosses 142 $^{\circ}$ C, thermal shutdown occurs.
145.	Short Circuit and Overload Protection	Provided
146.	High Voltage Isolation	2 kV for 1 minute
147.	Efficiency	Above 85 %
148.	Type	Dry Type
149.	Ah Efficiency	> 95%
150.	Self-Discharge	Self-Discharge
151.	Operating Temperature	Normal : +20 $^{\circ}$ C to +30 $^{\circ}$ C & Limits : -20 $^{\circ}$ C to +50 $^{\circ}$ C
152.	Voltage (V)	24V (2 x 12V)
153.	Ah Capacity	7Ah / 12 Ah / 26 Ah
154.	Type	Analogue
155.	Material	Stainless Steel
156.	Accuracy of calibration pressure	+/-1% at 200C
157.	Pressure Element	Stainless Steel Welded
158.	Dial	2"
159.	Pointer	Dark
160.	Window	Round
161.	Gas pressure low signal	Indicated by Red Color Zone
162.	Non Return Valve(NRV) Material	Stainless Steel
163.	Type	33 kV touch proof screened termination kit
164.	Materials	Epoxy / EPDM / Silicon Rubber
165.	Size	Up to 3 x 400 sq. mm 33 kV HT cables
166.	Height of Bus bar / transformer / feeder Cable box from ground level	As per Manufacture design
167.	Arrangement for mounting an extra cable at incoming and outgoing side box of Bus bar.	As per Manufacture design
168.	Arrangement for mounting an extra cable at outgoing side box of transformer / feeder.	As per Manufacture design
172.	Position of Automatic Water Level Controller	200 mm below live contacts
173.	Auxiliary contacts	4 NO + 4 NC
174.	Breaker Tripping and Load break Isolator opening due to water level increases signals to Control room	Yes

Sr.No.	Description	33 kV Ring Main Unit
175	Material	Anodized Aluminum / Stainless Steel
176.	Thickness	18 swg / 1.00 mm
177.	Size	145 mm x 116 mm
178.	Inside	Powder Coated
179.	Outside	Polyurethane based powder paint. Dark Admiralty Grey, Shade No. 632 as per IS: 5, 2007.

SECTION 3: TECHNICAL SPECIFICATION FOR 11kV RING MAIN UNIT

1. GENERAL

The RMU for the compact substation shall be 3 way or 4 way ,6 way 12 kV extendable type, free standing, outdoor, metal clad SF6 insulated Ring Main Unit (RMU) along with metering, PTs, CTs etc.

The outdoor type RMU shall be extendable type and stand alone.

Two numbers, fault making / load breaking, motor operated, line side switches, fitted with indications for phase and earth fault along with associated CTs. The load break switches shall be connected via underground XLPE Cables.

Outgoing feeder of RMU shall have , Tee-off, spring operated, Circuit breaker with sealed for life vacuum interrupter complete with meters, CTs, Protective and auxiliary relays to control desired number of 11/0.433kV distribution transformer or equipment's with complete arrangement to connect the tee-off circuit breaker to the 11 kV side of the power transformer.

The springs for closing the load break switches & tee-off circuit breaker shall be motor operated.

The opening & closing for the load break switches as well as tee-off circuit breaker shall be carried out electrically from remote via SCADA, besides local / hand operation. Built in compact battery [with no maintenance of any type] with charger shall be part of supply for this purpose.

The breaker shall have necessary over current and low sensitivity earth fault protection on the delta connected, 11 kV side of the distribution transformer. Further the protections on distribution transformer shall operate this breaker with required alarms. It shall have basic metering features also to monitor these in RMU.

RMU shall also be equipped with necessary Remote Terminal Units, transducer's etc. complete in all respects, since these RMU's shall be having provision for SCADA with remote control. The provision for requisite control & indications shall be provided in the RMU's & substations.

Fault passage indicators, Feeder Remote Terminal Units, with self-healing feature, communicating with each other in the Ring circuit shall ensure automatic isolation of faulty cable and restoration of supply in case of cable fault in the system, using Fibre- Optic based communication.

There shall be continuous monitoring of supply on 12 kV cables via capacitive voltage indicators.

The RMU shall be complete in all respects including elbow type cable termination arrangement [with shrouds] in air from bottom, gland plate, double compression glands, foundation channels, bolts, inter connection arrangement etc.

The external dimensions shall be identical throughout the length of the 11kV board.

The operation of any of the switching functions shall be simple with only three possible positions viz. closed, open and earthed. The earthing switch shall be placed on cable side. The earthing of cable is to be done by an independent fault making switch.

All the necessary safety interlocks between switching devices, earthing switch and cable box covers shall be integrated.

The accessories and LV auxiliaries (i.e. motor mechanism, coils, auxiliary switches etc.) shall be the same for the entire range of switching functions, load break switches or circuit breakers. They can be installed on site without any dedicated tool and training.

Any other item not included above but required to complete the works shall be deemed to be included in RMU, without any financial liability to the purchaser.

2. STANDARDS

Unless otherwise specified, all equipment and material covered in this specification shall conform to the latest applicable Indian / IEC Standards. Equipment complying with any other international standards will also be considered if it ensures performance of equipment equal to or superior to Indian Standards. Copy of such a standard shall also be supplied.

Sr.No	Standard Number	Description
1	IEC 62271-1	High-voltage switchgear and control gear – Part 1: Common specifications
2	IEC 62271-200	High-voltage switchgear and control gear - A.C. metal- enclosed switchgear and control gear for rated voltage above 1 kV and up to and including 52 kV.
3	IEC 62271-103	Switches for rated voltages above 1 kV and less than 52 kV
4	IEC 62271-100	High-voltage switchgear and control gear – Part 100: High- voltage alternating current circuit breakers
5	IEC 62271-102	High-voltage switchgear and control gear – Part 102: High- voltage alternating current disconnectors and earthing switches
6	IEC 61958	High-voltage prefabricated switchgear and control gear assemblies – Voltage presence indicating systems.
7	IEC 60529	Degrees of protection provided by enclosures (IP Code)
8	IS:722	A.C. electricity meters
9	IEC 60044-8	Instrument transformers – Part 8: Low Power Current Transducers
10	IEC 60044-1	Instrument transformer – Part 1: Current transformer
11	IEC 60044-2	Instrument transformer – Part 2: Voltage transformer
12	IEC 60255	Electrical relays
13	IS: 5	Colours for ready mixed paints and enamels
14	IS:1248	Electrical Indicating Instruments
15	IS:1554	PVC insulated cables up to and including 1100 volts

Sr.No	Standard Number	Description
16	IS:4794	Push Button Switches
17	IS:6005	Code of practice for phosphate coatings of iron and steel
18	IS:2099	Bushings for alternating voltages above 1000 V
19	IEC:62271-202	Pre-Fabricated Substation
20	IS:13118, IS:3427	Switchgear cubicles
21	IS:9920, IEC:60265	Ring main unit
22	IS:10118	Code of practice for selection, installation and maintenance of Switchgear
23	IS: 2026	Distribution Transformer
24		Indian Electricity Rules
25		Indian Electricity Act
26	IS:13072	Sulphur hexafluoride for electrical purposes

3. TECHNICAL PARTICULARS (STANDARD VALUES)

The Ring Main Unit (RMU) should consist of three phase, two load break switches and one or two (depending type no. of outgoing) tee-off VCB, Circuit Breaker Compact Unit, SF6 insulated and sealed for life complying to latest version of IEC 622-71 -200

- a) Rated system voltage (kV) : 12
- Rated current for load break switch [A] : up to 630 Amps
- Rated current for tee-off Breaker [A] : up to 630 Amps
- Nominal system voltage [kV] : 11
- System Earthing : Solid
- b) Basic Insulated level
- Lightning Impulse withstand voltage (kV) : As per Indian Standard
- Power frequency withstand voltage for One minute (kV rms) : As per Indian Standard
- c) Frequency (Hz) : 50
- d) Bus bar rated current (A) : up to 630 Amp
- e) Rated short time symmetrical three phase current (kA for 3 sec for load break switches & Tee-off breaker) : 20
- f) Earth switch for load break switches (kA for 3 sec) : 20

g)	Earth switch for tee-off breaker (kA for 3 sec)	:	20
h)	Rated making current (kA peak)	:	65
i)	Rated breaking current for circuit Breaker		
	[kA for 3 s]	:	20
j)	Rated breaking current for circuit Breaker		
	[kA for 3s]	:	25
k)	Filling & rated gas pressure	:	<1 bar, gauge
l)	Internal arc test [kA for 1 sec]	:	20m
m)	Interrupting time in millisecond less than	:	40
n)	Operating Duty	:	O-0.3s-CO-3min-CO
o)	Degree of protection for enclosure	:	IP 54
p)	Paint thickness (micron)	:	60

Notes:

- Type, routine, internal arc test reports shall be supplied by the contractor along with tender.
- RMU for CSS shall be non-extendable type and RMU for outdoor distribution shall be extendable type. Storage [without heaters, in humid environment]: from 0°C to +50°C
- Operation : 0°C to +50°C
- Partition class : PM
- Main HV circuit : IP67
- Front connection in cable box, suitable for armored, XLPE insulated Aluminum cable, as per calculated & specified size. Termination with elbow type plugs in bushings with insulating boots.

4. LOAD BREAK SWITCH

The switch shall be combining the functions of a load break switch, disconnecter and associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on cable side. The mechanism shall be anti-reflex, lever- operated type, with intuitive operation and clear mimic panel indications.

Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided.

Switch shall have a provision for remote opening and closing through SCADA also. Earthing switch operation shall be locally.

It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard. Switch should not be damaged even when closed on a dead short circuit for the permitted period of short circuit.

Each load break switch shall be of the triple pole, gang operated, with quick break contacts.

5. CIRCUIT BREAKER FOR TRANSFORMER

The Circuit Breaker shall have a switch disconnecting the circuit breaker with an associated earthing switch. It shall have three positions (closed, open / disconnected, earthed) earthing to be on

transformer side. Circuit Breaker shall have a provision for remote opening and closing through SCADA. Earthing switch operation shall be locally.

It shall carry rated current continuously and short circuit current for the duration specified without exceeding the permitted temperature rise as per relevant IEC / Indian standard.

Circuit breaker shall be opened with a push button and closed with the “closing lever”. The mechanism shall be anti-reflex, lever-operated type, with intuitive operation and clear mimic panel indications. Switch shall have built-in fail safe interlocks between main switch and earthing switch. Standard built-in padlocking facility for main switch, earthing switch and interlock shall be provided. The circuit breaker and load break switch can be locked in the open, close or earth position by 1 to 3 padlocks of ESI size.

Breaker should not be closed when cable cover is open.

In case of fault the breaker shall be tripped through a self-powered relay.

Circuit Breaker Interrupting Unit:

Tee-off Circuit breaker shall have Vacuum interrupting arrangement.

The design & construction of the Vacuum circuit breaker shall be compatible with the latest Vacuum circuit breaker technology. The Vacuum interrupter bottles shall be completely maintenance free & mechanically strong for 30 years life. Test certificate to be provided.

Suitable interlock shall be provided against breaker operation in the event of loss of Vacuum Circuit breaker should allow low chopping current level. Graph showing short circuit Vs tripping permitted for Circuit Breaker.

Duty Requirement:

The circuit breaker shall be totally restrike free under all duty conditions and shall be capable of performing the duties satisfactorily.

The circuit breaker shall meet duty requirement for any type of fault location, also for line charging current. The operating duty of the circuit breaker shall be as follows:

O-0.3s-CO-3min-CO

The circuit breaker shall be suitable to break the required induction current in accordance with the BIS / IEC standard. The value thereof shall be clearly specified at the time of offer.

The circuit breaker shall meet its duty requirement in case of application for controlling U/G cables, power transformer. The rated transient recovery voltage for terminal fault and short line faults shall be as provided in the relevant IEC / BIS.

Constructional Details:

Complete switchgear including bus bars shall be contained in an earth screened stainless steel tank, filled with SF6 gas, degree of protection not less than IP-67, as per requirement of IEC standards. To prevent gas leakage the gas pressure shall be maintained low within one atmospheric gauge. The filled gas shall provide the required insulation and also current breaking for load break switches.

There should not be any condensation of SF6 gas on internal insulating surface of the circuit breaker and Load Break Switches. Temperature compensation shall be provided and the system shall be an integral part of breaker.

SF6 gas shall be sealed for life in the compartment so as to satisfy “Sealed Pressure Systems” requirement of IEC-60694 (Clause 5.15.3). Throughout the life of the equipment there shall not be any “topping up” of SF6 gas. The rated life of the equipment must not be less than 30 years as per IEC-60694. During this operational life of the switchgear, absolutely no gas filling is

required. The container should be evacuated before gas filling and it should be diffusion-tight. The design of the RMU housing shall be such that in the event of an internal arc fault, the safety of the operator shall be ensured. All the safety requirements as required in IEC 62271-200 shall be provided.

The switchboard when charged must not have any access to live parts so as to endanger the life of operating personnel.

The RMU shall be so designed that the position of different devices is visible to the operator in front of the switchboard. The operating switches, handles etc. shall be at a height at which these or easy to operate, without any extra effort. All the items in the equipment shall be identified with long life labeling, cautions etc. The labeling must clearly indicate the required function. All the items in the equipment shall be identified with long life labeling, precautions etc. The labeling must clearly indicate the required function. There shall be operation counters for Load Break Switches and breaker with a provision to sound an alarm when the permitted operations are approaching.

It shall be possible to lock the operating mechanism in any of the three positions when the contacts have fully homed and also to independently lock the "ON" and "EARTH" positions. The position "ON", "OFF" and "EARTH" of the switch shall be clearly indicated such that the direction of movement of the operating handle(s) from one position to another is readily apparent.

The operating mechanism shall be maintenance free without the need of any lubrication during its life time of 30 years. The operating mechanism shall undergo a mechanical endurance test as specified in IS/ IEC 62271-200. The ring main shall be dust, moisture & vermin proof and suitable for indoor or outdoor installation. All the cabinets shall be free standing floor mounting type and shall be provided with double hinged doors with padlocking arrangements.

All door panels, removable covers shall be gasketed all round with neoprene gaskets. All louvers shall have screen and filters. Vent opening shall be covered with mesh and so arranged that hot gases or other material shall not be discharged, injuring operating personnel or surrounding apparatus and cables.

Metal enclosure unit shall comprise of rigid welded structure frame enclosed completely by metal sheet of thickness not less than 2 mm. The sheet should be cold rolled with smooth finish, levelled & free from flaws. However, the structural frame & all load bearing members of the enclosures shall have a minimum thickness of 2.5 mm or more. All members shall be properly braced to prevent webbing.

Ring main design shall comprise full compartmental execution having separate vertical sections for each circuit having internal barriers. Compartment with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuit. The ring main cubical compartment shall be provided with hinged doors on the front with facility for padlocking door handles.

All corresponding components of circuit breaker / load break switch cubicles of same ratings shall be interchangeable with one another. The board shall be wired with the connection brought on to the terminal boards for remote operation. The equipment shall also be as compact as possible so as to occupy minimum space in the sub-station room. Such type of equipment will have preference. Temperature rise in the unit shall not exceed as prescribed in IS/IEC.

Minimum clearance between the phases and between live parts & grounded objects in the switchgear/ load break panels shall be in accordance with IEC.

Operating Mechanism:

Circuit breaker as well as load break switches shall be provided with suitably designed spring charged motor operated mechanism. It shall be possible to charge the spring manually, if required. The closing/ opening shall be through remote or through locally operated push button or operating

switch. It should be “trip free” mechanically under every method of closing (except during closing for maintenance).

The operating mechanism shall be such that the failure or any auxiliary spring will not prevent tripping. When the circuit breaker is already closed it shall not cause damage to the breaker or endanger the operator.

The breaker / load break switch shall also be hand operated, if so required.

Electrical as well as mechanical indicator shall be provided to show open & close positions of the breaker / load break switches. It shall be located in a position where it will be visible to a man standing on the ground with the mechanism housing closed. An operation counter shall also be provided with each breaker / load break switch.

Working parts of the mechanism shall be of corrosion resisting material. Bearings, which require grease, shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or required adjustment with repeated operation of the breaker / load break switch. The mechanism shall be maintenance free.

The closing mechanism should be able to be operated by one man standing on the ground & direction of rotation of the handle for charging / closing shall be clearly defined.

Arrangement shall be made to de-couple/ trip the motor in case of failure of limit switch to cut out motor when the springs are fully charged and annunciation for this shall be provided.

The mechanism shall be complete with opening spring, closing spring, auxiliary contacts & all other necessary accessories to make mechanism a complete operating unit. A continuous sequence of closing and opening operation shall be possible.

Besides the requirements of auxiliary switches used by the manufacturer, at least 4

NO + 4 NC shall be provided for the use of the purchaser.

6. RMU TO BE MAINTENANCE FREE

The RMU's life and its operation must not be affected by environmental conditions such as foggy atmosphere, extremes of cold, seismic conditions such as corrosive / winds, 100% relative humidity (condensing type) with hot and humid environment, temporary flooding etc.

The equipment shall be of “fit & forget” type requiring little maintenance, (practically no maintenance), during its life.

RMU should have reliable switching devices and maintenance free drives.

7. INSULATING MEDIUM

The RMU shall comply with the requirements of IEC standard for “Sealed Pressure System”, for which no filling of gas is to be carried out during the life span of the switchgear. The SF6 gas shall be as per IEC-60376 / IS:13072 and shall be suitable for its application in the switchgear. It should continue to have high insulating and arc quenching properties throughout the switchgear life of 30 years. The SF6 gas shall be self-regenerating after the interruption of arc due to breaking load currents. The gas tank should have material in the tank to absorb the moisture from SF6 gas.

The use of organic seals on the equipment, grease and oil in the drives requiring periodic maintenance are not to be used.

8. SF6 GAS MONITORING & PRESSURE RELIEVING

SF6 gas in the RMU tank shall be constantly monitored through a gas pressure indicator, which should be duly temperature compensated. In case the pressure is not adequate it should block its operation and give a warning to isolate the RMU.

The pressure sensors shall feed a microprocessor based analyzing unit. By this system the gas pressure (temperature compensated) should be recorded to measure the dielectric strength of the gas in the compartment. A loss of gas should be signaled via two contacts one to initiate the low alarm of gas and second to trip the whole system.

If the gas pressure exceeds the permissible limit, such as during short circuit clearing, the pressure relief device should operate in the underside of the module. This area must be partitioned from the cable connection apartment.

9. VOLTAGE INDICATOR LAMPS, PHASE COMPARATORS AND MONITORING OF RMU BUS VOLTAGE

It shall be possible for each of the functions on the RMU to be equipped with a continuous voltage indication, to indicate whether or not there is voltage on the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp shall be provided to indicate live cables. Three outlets can be used to check the synchronization of phases with the use of an external device. This device shall be in compliance with IEC 1958 standard. Besides this the voltage monitoring of bus bar shall be provided continuously.

10. EARTHING OF RMU CIRCUITS

The cables in the RMU on the load break switch sides shall be earthed (only when these are dead) through integral earthing switch having the short circuit capacity of the RMU.

The earthing switch should be mechanically interlocked so that it can only be operated when the main switch is in open condition and circuit is fully de-energized. Necessary voltage monitoring device in such a case shall be provided.

The earthing switch shall be operated through the main circuit mechanism and manual closing shall be through a fast acting mechanism.

Mechanical interlocking system shall be provided to ensure that the switch is turned to 'OFF' position before being turned from 'ON' to 'EARTH' condition.

Cable box interlocking is to be provided to ensure that before the removal of the unit cable box cover, the unit earth is applied.

General Earthing Requirement:

All metal parts not intended for carrying current shall be connected to duplicate earthing system and suitable terminals shall be provided on each equipment or part of equipment in conformity with the relevant standards.

The earth continuity conductor shall be of tinned copper and shall have sufficient cross sectional area so as to afford a low resistance path for the full fault current corresponding to the circuit breaker ratings.

The size of earth continuity conductor shall be adequate, so as to restrict the temperature rise to the limit without causing any damage to the earth connection, while short circuit current flows through it for the short time rating of the equipment.

The size of earth continuity conductor shall be as large as possible to reduce to the barest minimum the potential rise of the metal frame of the circuit breaker.

No sweated / riveted joints in current conducting path shall be permitted.

11. CABLE END TERMINATION BOX

Cable-end termination box shall form an integral part of the equipment. The cables shall be convenient to install. There shall be elbow type connection for cable termination with insulating boots. The boots shall form part of supply.

Each Cable compartment shall be provided with three bushings to terminate the incoming and outgoing 33KV or 11kV, 3 Core or single core cables as the case may be. There shall be minimum 700 mm height from the base of the mounted switchgear so that the cables can be bent and taken vertically up to the bushings. The Cable termination shall be done by Heat shrinkable Termination method so that adequate clearances shall be maintained between phases for Termination.

The arrangement for earthing the termination point of cables shall form a part of supply and should be of adequate rating. The standard size of 33KV or 11 kV XLPE cable being used is as specified for load break switches as well as for the tee-off transformer.

The cable mounting arrangement on the load break switches shall be over the trench and no special arrangement is required for installation of the cables and their terminations. These shall enter directly from the cable trench through cable glands in gland plate to the load break switches. The ring type air insulated CTs shall be provided.

All of the cable boxes shall be air insulated suitable for dry type cable terminations. Compound filled cable boxes are not acceptable.

The cable boxes at each of the two ring switches suitable for accepting H.V. cables approaching from below or as per site requirement. The tee-off circuit breaker shall be suitable for either of the following termination arrangements:

Direct coupling to a transformer flange

Cable entry from below via a tee-off cable box

Cable entry from above via a tee-off cable box

The extended function shall be suitable for cable entry from either above or below only.

Double compression type, chrome, plated cable brass glands shall be provided in the gland plate, with necessary cable clamping and earthing arrangement.

Support frames shall be provided whose height shall be such that cable connections can be conveniently made after allowing for bending radius of cables.

Note: The XLPE, outgoing & incoming 12 kV or 24kV power cables to LBS are not in the scope of the RMU manufacturer. However, elbow type outer cone plug in insulating boots with trifurification kits suitable for class of bushing for these cables are included in the scope of supply.

Testing of Cables:

It shall be possible to test the core or the sheath insulation of the network cables while the RMU remains energized at rated voltage. It shall be preferable to carry out the phase by phase testing through a built-in-facility without necessity to have an access to cable compartment. The maximum test voltage shall be less than 26 kV DC for 10 minutes.

Any cable test access facility which requires the use of an additional loose device shall not be acceptable.

Any switching unit, load-break switch or circuit breaker, shall be able to receive a dedicated device for cable testing, allowing the cable test bench to be connected from the front of the cell without opening the cable compartment. This cable test device must be fully interlocked with the earthing switch.

12. BUSHINGS:

Bushing shall be homogeneous, free from laminations, cavities & other flaws or imperfection that might affect the mechanical or di-electric quality & shall be tough and impervious to moisture. Silicon type bushings shall be used.

Bushings shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be subjected.

When operating at normal rated voltage there shall be no electric discharge between the conductors & bushings, which could cause corrosion or injury to the conductors, insulators or supports by the formation of substances produced by chemical action.

All iron parts shall be hot dip galvanized (not less than 75 micron) & all joints shall be airtight. Surfaces of the joints shall be smoothened up. Bushing design shall be such as to ensure a uniform compressive pressure on the joints.

All current carrying contact surfaces shall be silver plated; silver plating shall not be less than 1 mil in thickness. The creepage distance of the bushings shall be suitable for condensing type humidity atmosphere. Bushings shall be tested for type tests & routine tests in accordance with stipulation of IS: 2099. Routine as well as type test reports in conformity with above IS shall be furnished to the purchaser.

13. CAUTION NOTICE:

Caution name plates shall be provided at all points where such safety requirements are to be met as per Indian Electricity Rules.

14. SAFETY INTERLOCKS:

Disengagement of a circuit breaker or switch shall not be possible unless it is in open position. Suitable interlocks shall be provided.

The position of the circuit breaker, whether in open or close position shall be indicated through suitably designed fail-safe mechanical indicators.

The operating position of circuit breakers or isolators, either on bus-bar side or for earthing, shall be clearly indicated by a reliable indicating device.

Integral earthing facility, when provided, shall be suitable to make earthing connections only when the associated circuit breaker is in tripped position. The current rating of earthing facility should be commensurate with the short circuit rating of the circuit breaker.

15. METERING, PROTECTION, INDICATION & AUXILIARY SWITCHES

General Requirements for Instruments:

Multifunctional Measuring instruments or tri vector meter, with an accuracy of 0.5S or better shall be of digital type, with minimum 3 line LED display and conforming to relevant IS / IEC & shall be of an approved type & design suitable for tropical climate and condensing type humidity. Measurement shall include voltage, current, pf, kW, kVA, kVAR and neutral current. It shall have RS 485 communication port.

All instruments shall be back connected and instruments cases shall be earthed. The instruments safety factor shall be equal to or less than 5.

Protection:

The protection on the circuit breaker shall comprise the following arrangement:

The Tee-off, Circuit breaker unit fitted with 3 protection CTS of suitable ratio and burden [considering power transformer rating], a low burden trip coil and auxiliary switch assembly allowing

the use of a self -powered, numerical relay with an open protocol having three over current and one sensitive earth fault elements. The relay should be housed within a cubicle box, accessible from the front. This relay shall also communicate with Feeder Remote Terminal Unit.

The protection curves and all other settings shall be adjustable in software through lap top, which when viewed from the front clearly show the unit settings. (Note DIL type switches are not acceptable). The protection setting range and minimum pick up current shall be in accordance with the protection of transformer rating. Typically the primary settings may be in the following range:

Overcurrent: 20A to 200A Earth Fault: 2A to 50A

The relay should give local indication of a fault operation and should differentiate between overcurrent and earth fault.

It should be possible for the relay to perform a self-check.

Other auxiliary relays to give trip / alarm [local as well as remote] in case of operation of transformer protections, gas leakage, ON, OFF & Earth status of RMU load break / breaker, spring charged etc. shall be provided.

Besides the requirements of auxiliary switches used by the manufacturer, at least 4

NO + 4 NC shall be provided for the use of the purchaser.

Instrument Transformers:

The instrument transformers required for the switchgear shall conform with the respective standards specification.

Voltage Transformers

The Voltage Transformers (VT) shall be of dry compound epoxy insulated. The VT shall be protected on their primary sides by current limiting fuses. On the secondary side, the circuit shall be protected by MCB's. Provision shall be so made that the primary fuses can be handled only in the drawn out position. The particulars of the voltage transformer are:

Type: Cast Resin.

Rated Voltage : 11000/110/rt3

Rated Voltage : 22000/110/110/rt3

Accuracy Class : 0.5s/1.0

Burden : 50 VA or as per system requirement.

Note: Contractor shall design the voltage transformer as per system requirements, and alternate arrangement, if any, shall also be considered.

Current Transformers:

The CT's shall be cast resin ring type, suitable for metering and protection requirements, air insulated and shall be able to withstand the thermal, dynamic and mechanical stresses resulting from the maximum short circuit and short time current rating of the switchgear. CT should be suitable for continuous operation at 130% of its rated current.

CT's shall have polarity marks engraved on each transformer and at the associated terminal blocks. Facility shall be provided for short circuiting and earthing the CT secondary at the terminal blocks by the use of shorting type terminals.

CT ratio, burden, accuracy 0.5s for metering and 5P10 for protection and other requisite parameters shall be suitable for the self-powered relay. CT calculations in this regard shall be submitted.

16. CONTROL OF THE RMU AND CSS

Remote & local operation of the RMU's line switches and Circuit breaker should be provided using motors fitted to the operating mechanism.

The provision of the motors to the mechanism must not in any way impede or interfere with the manual operation of the switches or Circuit breaker.

The Contractor shall provide all necessary equipment for remote control and monitoring of the RMU including other important equipment items in CSS.

17. FAULT CIRCUIT INDICATOR

To pinpoint the faulty section between a number of series connected, load break switches, of RMU's a Fault Circuit Indicator (FCI) shall be provided with each RMU. This indicator shall operate for earth faults and phase to phase short circuits between any two RMU's.

The indicator should be suitable for use on 12 kV & 33KV RMU's in an open ring main system. In case of fault in a cable section between two RMU's. It shall be possible to pin point the faulty section and communicate with Feeder Remote Terminal Unit for automatic faulty cable isolation and supply restoration.

The FCI supplied should be complete in all respects, with all the necessary components e.g. LED lamp, Fault Indicator Unit, CTs cabling etc. and shall form part of RMU. It shall be with display to indicate current loading & type of fault.

Since RMU's shall be SCADA compatible, the FCI indications shall also be displayed on the central control room. Therefore these FCI's shall have additional provision for remote indication besides local indication.

FCI shall be of proven type and in the manufacturing range of RMU supplier.

18. FEEDER REMOTE TERMINAL UNIT (FRTU) FOR RMU

FRTU must be integral part of RMU & is recommended to be of same make as that of RMU supporting IEC 61850/DNP 3. It shall have peer to peer communication and with the remote switchgear / SCADA at the controlling substation through fiber optic cable to initiate the required switching operations.

Main Requirements:

FRTU cubicle shall be equipped to meet the following main requirements for compact substation. It shall be possible to mount it on wall if required.

- Monitoring and control of 33KV or 11kV LBS and VCB feeders
- In conjunction with FCI, detection and isolation of faulty cable for phase to phase and phase to earth cable short circuits and automatically ensure supply restoration in less than 60 seconds.
- Multifunction measurements.
- Transmit data to the remote control centre.
- The system shall have necessary redundancy in communication.
- To incorporate self-healing grid logic for faster restoration of supply even in the absence of control centre SCADA.
- Data storage.
- Provision for Maintenance
- FRTU shall be capable to monitor and control 3 Way / 4 ways RMU.
- Chronological time stamped event recording.

- Data storage, in the event of mains failure, shall be for at least 8 hours. The minimum storage shall be for about 40000 events.

Control unit:

Control Unit shall perform all the required control and monitoring functions as isolated unit or as part of Compact Substation and shall be equipped with a remote and local control mode switch on its front panel.

Operation in Local Mode:

- Transmission of data for remote measurements and time-stamped events shall not be disturbed.
- Opening and closing operation after validation.
- Inhibition of opening / closing from remote.
- Operation in Remote Mode:
- Transmission of measurements and time stamped events.
- Local electrical control shall get blocked.
- Opening and closing operation from remote control centre.

All data shall be available locally on the front panel of the enclosure and remotely from the control centres. LBS / breaker open and close status can be had from the front mimic of FRTU respectively with the green / red LED indication. It shall be possible to retrieve and display the time-stamped events recorded at the enclosure locally as well as at the remote control Centre on a lap top computer.

Power Supply:

Compact, built in sealed for life 12V battery with a long life and no maintenance of any kind for 5 to 7 years or more along with charger [to be supplied 230 V, 50 Hz from CSS and in case of stand-alone RMU supply arrangements shall be made by manufacturer] is to be provided in the unit. The supply shall be conditioned to provide power at required voltage for motor operation and communication for local and remote SCADA. The transmission output shall be able to supply a conventional radio [without battery power of RTU] to inform the remote control centre of a battery failure. Power from the unit shall be sufficient to supply control power to all the switch cubicles in the CSS, radio and the electronics in the enclosure. The standby power unit shall be with a minimum autonomy of at least 8 hours for 10 opening and closing cycles. The battery shall be checked at regular intervals by the slave station and an alarm shall be generated and transmitted to the remote control centre in the event of a fault. The unit shall be protected against overvoltage and over loads.

Time-tagged data archiving:

All the archived data shall be retrieved locally and remotely by means of the configuration and operating software supplied with the control unit. The data shall also be downloaded locally or remotely to a PC as a .CSV file.

Event and measurement time-stamping shall be accurate to one millisecond [ms] and the discrimination between two events shall be 10 ms.

Communication with the remote control center

FRTU shall have IEC 61850 protocol to transfer information to control center SCADA and Modbus protocol to communicate with field MFM [Multifunction Meters] on RS485. The Modbus protocol shall be open. Security & communication package provider shall only lay the fibre optic cable for the same and further connections, repeaters, boosters and any other communication equipment shall be included in the scope of supply.

It shall be possible to configure each measurement to be transmitted spontaneously to the remote control center with 100% redundancy. Failure of one channel should have an automatic changeover to second channel. Data shall be configured using a PC connected to the control unit via an Ethernet and / or USB port. It shall also be possible to configure data remotely.

Software

The Relay software shall not require a special license and it can be used and copied freely.

Indications. The slave stations shall process at least the following information for remote indication and for local display purposes:

- Open / closed position of each LBS
- Earth status
- Absence of AC voltage,
- Local / remote control operating mode,
- Detection of phase-to-phase or earth fault current flow,
- Load current measurement
- Charger fault
- Battery fault
- motor drive DC supply fault
- Internal fault
- Detailed diagnosis of the status of the uninterruptible power supply (charger, batteries).
- Indications for LT side status of switches, alarms as required.
- Erection / construction / Operating Tools and Tackles

Each RMU will be provided with operating lever and other such equipment which are necessary for the normal operation of the equipment. It should also include any spring charging handles for the manual charging of closing springs. The tenderer shall separately list out in the tender in the given schedule, sets of tools required for initial erection/construction and subsequent maintenance. The price of those should be included in the cost of equipment. An anti-reflex mechanism on the operating lever shall prevent any attempts to re- open immediately after closing of the switch or earthing switch. All manual operations will be carried out on the front of the switchboard.

The effort exerted on the lever by the operator should not be more than 250 N for the switch and circuit breaker. The overall dimensions of the RMU shall not be increased due to the use of the operation handle. The operating handle should have two workable positions 180° apart.

19. MIMIC DIAGRAM:

The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

Labels and Marking of Connections:

All apparatus, control gear and the apparatus mounted thereon shall be clearly labelled, indicating where necessary, their purpose and the 'ON' 'OFF' and 'EARTH' position. The labels shall be clearly lettered on enamelled surface or other approved materials. Brass should not be used for labels. Each phase of alternating current and connections shall be coloured to distinguish phases, neutral and earth. The colouring shall be red, yellow, blue, black and green respectively.

Bus Bars:

Bus bars shall be of uncoated tinned conductor grade electrolytic copper.

The tenderer shall furnish calculations establishing thermal and dynamic adequacy of bus bar sizes with reference to its short circuit ability. The bus bar shall be integrated completely into the gas filled compartment including the coupling chambers between two adjacent modules.

The insulating ability of the entire bus bar system should be monitored along with the gas filled cladded compartment of the module. The bus bar size shall be so chosen so as to limit the current density to within permissible limit and if the fault current restricts the current density less than that, then lesser density shall be used. Calculations shall be submitted for this purpose.

Temperature rise:

The temperature rise and the maximum temperature on any part of the equipment when in service at site under continuous full load condition or under short circuit shall not exceed the permissible limit as per relevant IEC or IS: 13947. This shall not be exceeded when corrected for the difference between the ambient temperature at site and the ambient temperature specified in the relevant standard.

RMU Indications

Indication of spring charge, ON, OFF trip etc shall be provided by means of LED which shall be fed from control supply arrangement designed by contractor. If LED's are provided, the indicating lamps shall have covers of following colours.

Red	closed position of breaker/ load break switch
Green	open position of breaker /load break switch
Blue	spring charge condition of breaker / load break switch
Amber	auto tripped position of breaker
Yellow	Earth position

Terminal boards and Secondary Wiring

Connection to switchgear, operating mechanism indicating relays and all instruments shall be deemed to form a portion of equipment of panel.

Panel connections shall be insulated and shall be healthy and securely fixed to back of the panel. The wiring must run on porcelain or non-rusting metal cleats or metal flexible tubes as may be approved by engineer. All wiring in the vicinity shall insulate and shall run in non-rusting flexible tubes from terminal boards conveniently situated. All control connections instruments and relay wires shall be provided with numbered ferrules at each terminal and the numbering shall be in accordance with an approved system. All wiring diagrams shall be clearly marked with the numbers corresponding with those on the ferrules of the individual cores. Each set of current and voltage transformer secondary connection shall be complete and shall be earthed at one point only. Each such earthing shall be made through links which can be opened for insulation testing.

All the internal control wiring shall be through fire-resistant tinned stranded copper wires of 1.5 mm² and for CT circuits these shall be with 2.5 mm². The strands in the copper wire shall not be less than 48.

The CT circuits shall be provided with isolating type of links, to check the current in the CT circuits during testing. Similarly it shall be possible to isolate PT's without disconnecting wires to check & test the meters. All CTs must have provision for shorting through link.

The air insulated control cabinet shall have provision for lighting.

As the equipment is to be installed in a tropical and humidity zone, the air insulated control cabin shall be provided with suitable space heater of PTC type.

20. TYPE AND ROUTINE TESTS

All the routine and type tests shall be carried out as per relevant IEC / Indian Standard. For type test certificates Engineer may consider test certificates at its absolute discretion. All the routine tests on the switchboard shall be witnessed by the Site Engineer or its authorized representative.

The following type & routine test certificates shall be supplied / carried out on the RMU:

- Impulse withstand test
- Temperature-rise test
- Short-time withstand current test
- Mechanical operation test
- Checking of degree of protection
- Switch, circuit breaker, earthing switch making capacity.
- Switch, circuit breaker breaking capacity.
- Internal arc withstand test.
- Checking of partial discharge on individual components.

In addition, for switches, test reports on rated breaking and making capacity shall be supplied. For earthing switches, test reports on making capacity, short-time withstand current and peak short circuit current shall be supplied.

The routine tests carried out by the manufacturer shall be backed by test reports signed by the factory's quality control department. They shall include the following:

- Conformity with drawings and diagrams,
- Measurement of closing and opening speeds & times
- Measurement of operating torque
- Checking of filling pressure
- Checking of gas tightness
- Checking of partial discharges on individual components
- Dielectric testing and main circuit resistance measurement

All of the major type tests shall be certified by an independent authority and an internationally acceptable test house for the tests carried outside the country of manufacture.

21. CONFIGURATION OF RING MAIN UNIT

Each non / extendable ring main unit shall comprise of three or four configuration, with a continuous bus bar, SF6 insulated, sealed for life, CTs and PTs as per requirement, pad locks for locking with a universal key, complete in all respects.

The main items of RMU are given below any other item not specifically mentioned but required for the successful operation of the equipment shall be deemed to be included without any financial liability to purchaser.

Each load break switch panel shall be equipped with rating of 24kV or 12 kV, 630

Amps. 20kA / 3s, Gang operated, SF6 insulated, manual / motor operated, fault making, load breaking switch, along with associated bus bars, CTs, PTs [as required] and the same shall consist of the following main items:

- Metal clad in door type weather proof housing.
- kV, 630 Amps, fault making, .load breaking, manually / motor operated, self-aligning, gang operated.
- One set of 630 Amp, bus bar as specified.
- Isolating plug & socket for main & auxiliary contacts if required.
- Mechanical interlocks to prevent switching on with cable in earthed position.
- One set of triple pole gang operated cable earthing contacts.
- Load Current measurement.
- Air Insulated cable box for Cable end termination suitable for 3 core, 24kV or 12 kV, XLPE armoured cable of specified size, with AL conductor, along with glands, suitable Gland plate and Cable support.
- Mechanical On/Off/Earth/Test Indicators.
- Cable Testing Sockets
- Capacitive Voltage indicator lamps.
- Cable clamps
- Feeder Remote Terminal Unit [FRTU]
- Fault Circuit Indicator along with CTs.
- Indicating lamps & auxiliary contacts.
- Auxiliary relays (if required).
- Interlocked earthing arrangement.

Tee-off Circuit Breaker Panel, with SF6 insulation, suitable for transformer feeder shall be equipped with minimum 24kV or 12 KV, upto 400 Amps, 20 kA, for 3 sec rated circuit breaker with associated C.Ts, PTs, spring operated mechanism, bus bars, compete with instruments, relays, terminal blocks. It shall comprise of the following main items:

- Metal clad / indoor type weather proof housing
- Vacuum circuit breaker, trip free
- One set of 630 Amps. Bus bars (integral part with load break bus bar).
- CTs for protection & Metering to match the transformer – 3 Nos.
- 3-overcurrent & one earth fault IDMT relays, direct operating.
- Termination suitable for connection to 11/0.433 kV transformer of specified rating.

Multifunction meter

- P.T. 22000/110/rt3 or 11000/110/110/rt3, as required.
- On/Off indicator
- Mechanical interlocks
- Tripping, closing coils.

- Indication lamp & spare auxiliary NO/NC contacts.
- Auxiliary relays for alarm and trip for transformer protections
- Earthing arrangement duly interlocked.
- Mechanism with spring charging motor.

The common system for the above shall consist mainly of:

- Channels, nuts, bolts, glands, gland plates, inter connecting arrangement of tee- off breaker with transformer, cable termination kits & supporting arrangement of cable, with the load break switches etc.
- Cable termination kits to be included for each RMU.
- Gas monitoring device for sealed gas unit.
- Pad locks for locking the panels.
- Handles for normal operation, spring charging & other tools required for normal operation.
- Arrangement of control supply for breaker / load break closing / tripping, motor charging indications etc.
- All the necessary indicating lamps.
- SF6 pressure monitoring unit.
- Analysis unit for dielectric monitoring of SF6 gas.
- Any other item not included above but required for the operation shall be deemed to be included though specifically not mentioned, without any financial liability to purchaser.

Two sets of cable termination and jointing tools for all the substations at various locations. Any other item mentioned in text or any other item required for successful operation but not included here shall be deemed to be included.

SECTION 4: TECHNICAL SPECIFICATION FOR COMPACT SUBSTATION

1. SCOPE

This specification covers the design, engineering manufacture, Shop testing packing, transportation to site, site storage, installation, testing and commissioning of a SCADA operated, prefabricated, factory assembled and fitted, Compact Sub Station [CSS] consisting of following main components.

- 12 kV, non-extendable, metal clad SF6 insulated switchgear, sealed for life, Ring

Main Unit (RMU)

- Dry type 11/0.433kV distribution transformer
- LV switch board.
- Prefabricated weather proof enclosure.
- SCADA connection for remote control and monitoring.

All termination and connections to high voltage and low voltage side of distribution transformer, earthing and any other work to complete the works in all respects whether specifically mentioned or not in this specification.

Portable Fire extinguishers for electrical fires

Complete Documentation

Training to Owners personnel

The CSS is to be totally free from any external deposit (dust, condensation etc.) and suitable to operate in highly humid, hot environment without any preventive maintenance, cleaning etc. It shall be of “fit and forget” type. All nut bolts, frames etc. shall be rust proof, typically of stainless steel or materials not prone to rusting, in site environmental conditions.

CSS can be placed indoor or outdoor as per detail design and requirement. Scope shall also include design, engineering of all the civil and all other related site works so as to complete the works in all respects. The prefabricated substation unit is required for fast installation, to be maintenance free and with life expectancy of thirty years under site conditions.

2. CLIMATE AND ISOMETRIC CONDITIONS

For KIMC Project, the electrical equipment selected shall be such so as to give trouble free operation during the life of the equipment, under the most stringent atmospheric conditions prevailing at site.

3. BASIC DESIGN CRITERIA

The CSS shall be designed with the following design criteria:

- For design purpose maximum ambient temperature of 50° C shall be considered.
- It shall be factory built and tested and preferably transported as such so that it is ready for site installation. Only external connections need to be done at site.
- Design to comply with latest version of IEC 62271- 202.
- Maintenance free Ring Main Unit [RMU] with SF6 insulation sealed for life as per IEC standard.
- Dry type, epoxy insulated transformer with HV side metering.
- LV Switchboard with Capacitor bank for automatic power factor correction [APFC].
- Enclosure to have independent compartments for RMU, transformer and LV Board with suitable entry doors.

The electrical equipment including the enclosure, its supporting structure etc. is to be rust and corrosion proof throughout its life. In case there is no alternative to items such as mild steel sheet, and other structural items, the same shall be hot dip galvanized [minimum 610 gm zinc /m²] and epoxy painted. Nut, bolts, washers and other similar items shall be of rust proof material such as stainless steel.

Cables shall be mostly in trenches of concrete, as per site conditions.

The Enclosure consisting of High Voltage switchgear, Low Voltage switchgear & Transformer of the Unitized substation shall be designed to be used under Indoor or outdoor service condition.

4. QUALITY OF MATERIAL:

All material used shall be new and of best quality and of class most suitable for working under the conditions specified herein without distortion or deterioration.

Galvanization of steel shall only be done by hot dip process after the parts are ready for the purpose of assembly. Alternatively stainless steel of the quality suitable for site shall be used.

5. DESIGN AND STANDARDIZATION

The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to withstand sudden load variations due to short circuits and other fault conditions.

The design shall incorporate every reasonable precaution and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the switchgear.

All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All Connections and contacts shall be of ample section and surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum. Cast iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.

All apparatus shall be so designed and constructed as to obviate the risk of short circuits of the live parts by reptiles, rodents etc. Metal cubicles, housings and covers shall be 100% weather / vermin proof.

All parts shall be manufactured in accordance with relevant standard specifications. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.

All apparatus, connections and cabling [FRLS type] shall be designed and arranged to minimize the risk of fire and any damage, which might be caused in the event of fire.

Design should take into consideration that equipment is to be operated under rainy, hot and humid atmospheric conditions, and surroundings with reptiles and rodents.

Certification offering evidence for the satisfactory operation under such environmental conditions shall be provided.

Technical Data for CSS

S. No.	Description	Technical Data
1	Applicable Standard	IEC 62271-202
2	Design Ambient Temperature	50 Deg C
3	Type of Ventilation for Normal Condition	Natural
4	Compartmentalized	Yes
5	Rated temperature enclosure class	10
6	Degree of protection for All Compartment	IP54
7	Location	Indoor / Outdoor
8	Rated HV	12kV, RMU, with metering
9	Transformer	≤1250 KVA, Dry Type
10	Nominal rated voltage rating on LV	415V
11	LV Board	Incomer ACB + Outgoing MCCB
12	Enclosure material	Resistant to rusting
13	Thickness of sheet (minimum)	2mm for CRCA enclosure.

S. No.	Description	Technical Data
14	Base	4mm hot-dip galvanised
14	Enclosure Paint	Epoxy, RAL 7032
15	SCADA system / Remote Control	yes

6. PAINTING

Since the local environment is harsh, even galvanized steel will rust after a few years. Therefore, paint of suitable quality to protect the equipment is of utmost importance.

All sheet steel work shall be phosphated in accordance with IS: 6005 'Code of practice for phosphating iron and steel, through seven tank process. Oil, grease, dirt shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed with the application of two coats of ready mixed zinc chromate primer. The first coat may be air dried while the second coat shall be stove dried. Panels shall be painted with epoxy paint of superior quality. ALTERNATIVELY, the panels

shall be painted with electrostatic epoxy powder coating process to have paint of hard coating. Necessary details shall be provided to Engineer in this regard for prior approval.

Paint Thickness

The final finished thickness of paint film on sheet shall be approximately 60 to 80 micron. The finished painted surface of panels shall present aesthetically pleasing appearance free from dents and uneven surfaces. Paints shall not scale off or wrinkle or be removed by abrasion due to normal handling. The colour for finishing paint shall be Siemens grey as per RAL 7032. Unless otherwise desired the same shall be got confirmed from the Engineer before taking up painting. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting.

Spare Paint

A small quantity (one litre per board) of finishing paint shall be supplied for minor touching up required at site after installation of the panel.

7. DRAWINGS AND MANUALS

The contractor shall furnish all drawings & manuals as called for and given below and also those which are not specifically included but are necessary for proper operation and maintenance.

- Complete assembly drawing of the Packaged & Ring Main Unit showing plan, elevations, side & typical sectional views giving complete dimensions.
- Assembly drawings & weight of main component parts.
- Foundation drawings showing the load on the foundations.
- Schematic control & wiring diagram in accordance with BIS / IEC practice.
- Bushing drawings & their specification.
- Cable termination details & drawings along with terminal connection drawings.
- General arrangement drawing of the complete panels showing CTs, PTs together with dimensions.
- Maintenance Manual.

- Graph indicating short circuit Vs number of tripping for Vacuum Circuit Breaker.
- Permitted mechanical opening and closing operations.
- Besides above drawings, the contractor shall submit type test certificates, leaflets & instruction manuals.

Within 60 days after contract award, the contractor shall furnish to the engineer three sets of following drawings for approval. No manufacture of equipment shall commence until the drawings are approved:

- General arrangement drawing of complete assembly of packaged & individual RMU including giving dimensions & their salient features.
- Schematic wiring diagram.
- Foundation drawings.
- Locations of cables slots, cable terminations, CTs, PTs & terminal connections.
- Any other necessary detail.
- Instruction manuals for erection/construction, maintenance and operation.
- Height of centre line of HV and LV connectors of transformers from the rail top level as well as from the roof of enclosure.

8. 12KV RING MAIN UNIT

Specifications same as mentioned as above “Technical Specifications for Ring Main Unit”

9. DRY TYPE TRANSFORMER

General

The distribution transformer in CSS shall be indoor Dry Type Transformer, complete with all accessories / fittings and spare parts as specified herein. Three-phase transformers shall be with cast resin type, class F insulation system with natural(AN) cooling for indoor installation, for use in three-phase HV/LV distribution systems.

Specific Technical Requirements (Standard Value)

• Rated KVA	:	Up to 1250kVA
• Number of phases	:	Three
• Type of installation	:	Indoor
• Frequency	:	50 Hz
• Cooling medium	:	AN Rated Voltage
• High voltage winding	:	11 kV (DELTA)
• Low voltage	:	0.433 kV (STAR) with Neutral

Highest Continuous System Voltage

• High Voltage	:	12 kV
• Low Voltage	:	0.433 kV

Method of System Earthing

- High Voltage : Unearthed
- Low Voltage : Solidly grounded
- Type of tap changer : OFF CIRCUIT GANG OPERATED
- Range of tapping : +5% to -5% with 5 steps of 2.5% on 11 kV side
- Impedance at rated KVA : As per relevant IS at 75°C
- Insulation and level : HV LV
- Type of insulation : Uniform Uniform
- One minute power : 28 3 Frequency withstand test voltage (kV)
- Impulse withstand : 75 8 Test voltage (kVp)
- Winding Connection : Delta (HV) Star (LV) Material Aluminium
- Vector group : Dyn-11

Terminal details

- HV Termination : Suitable for tee-off Breaker of RMU
- LV Termination : Suitable for phase and neutral connection

between transformer and LT board through an insulated copper bus bar or a sandwiched copper bus bar enclosed in a non-segregated bus duct. The size of the neutral bus shall be same as phase bus.

- LT Neutral earthing : A separate Neutral point to be provided for earthing.
- Minimum Clearance in Air : 11 kV 0.433 kV Phase to phase (mm) As per IEC
- Phase to earth (mm) : As per IEC Design Ambient temperature : 50°C
- Maximum Temperature Rise of winding over an ambient of 50°C and 1000m altitude, not to exceed 90°C.
- Maximum Temp of insulation : 150°C
- Over load capacity : As per IEC
- Noise level at rated voltage & frequency : As per NEMA Pub. Tr-1

Transformer Losses

The guaranteed losses of the transformer shall not exceed as given in the Energy Conservation Building Code [ECBC], as per latest guidelines of the Bureau of Energy Efficiency [BEE] for the required rating of distribution transformer or as per the Bureau of Indian Standards [BIS] for transformers having energy efficiency level-3. Transformers not complying with BEE / BIS loss guidelines shall not be accepted. The guaranteed values of no load losses and load losses shall be stated in the bid and these shall be firm.

Performance

Transformer shall be capable of withstanding for two seconds the short circuit at its terminals as per requirements of IS-2026 without any damage. Source short circuit power on the primary of the 33

or 11/0.433 kV transformer shall be assumed as 500MVA for the short circuit capability of the transformer. The thermal ability withstand due to short circuit shall be demonstrated by calculation.

The maximum flux density in any part of the core and yoke at normal voltage and Frequency shall be such that the flux density under 10% over voltage condition shall not exceed 1.9 Tesla.

Transformer shall, under exceptional circumstances, due to sudden disconnection of the load, be capable of operating at the voltage approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal for a period of 5 seconds.

The transformer may be operated continuously without danger on any particular tapping at the rated KVA $\pm 10\%$ of the voltage corresponding to the tapping.

Miscellaneous

Complete hardware for fixing the transformer as a part of packaged RMU substation shall be provided whether specifically mentioned or not.

Delivery

The equipment shall be delivered, erected and commissioned at site as a part of the packaged RMU substation.

Conflict in Clause

In case of any conflict between the Specific Technical Requirements and General Technical Requirements, the requirements indicated as Specific Technical Requirement shall prevail over the General Technical Requirements

9.1. ENVIRONMENT: CLIMATIC, ENVIRONMENTAL AND FIRE RESISTANT REQUIREMENTS

As the equipment is to be installed in humid atmosphere the equipment and material provided must resist the corrosion likely to occur in any case.

Further the transformer must comply to the following class requirements of clause 13 of IS 2026-11 / IEC 60076- 11.

Class C1: Operation, transportation and storage at ambient temperature as low as - 5°C

Class E2: Frequent condensation combined with high pollution.

Fire Class F1: Limited flammability, Self-extinguishing of the fire and to be free from halogens, emission of toxic gases, and minimum of thick smoke.

The above classes will be indicated on the rating plate.

Note: The manufacturer must produce a test report, complying to above clauses as per test procedure of IEC-60076-11. Test report shall be from an accredited laboratory acceptable to Engineer, for a transformer of the same design.

Name Plate

Transformer rating plate in English and Hindi language shall contain the information as given in Clause 15 of IS: 2026 (Part-I) / IEC 60076-11. The details on rating plate shall be finalised during the detailed engineering.

9.2. GENERAL TECHNICAL REQUIREMENTS

Dry type transformer will be manufactured in accordance with a quality system in conformity with ISO 9001 and complying to latest version of IEC 60076-11

Environmental management system is to be in conformity with ISO 14001, which shall be certified by an independent recognized organization acceptable to Engineer.

9.3. CODES & STANDARDS

The design, material, fabrication, inspection, testing before dispatch, erection/construction, testing, commissioning and performance of distribution transformers shall comply with all currently applicable statutory regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility.

Transformers shall conform to the latest applicable standards and codes of practice as given below.

S. No.	Standard Number	Description
1	IS: 5	Colour for ready mixed paints and enamels.
2	IS: 104	Ready mixed paint, brushing, zinc chrome Priming
3	IS: 2026- [Part 1 to 11]	Transformers
4	IS: 1180	Outdoor type three phase distribution transformer
5	IS: 1271	Thermal evaluation and classification of Electrical Insulation
6	IS: 1363	Hexagon head bolts, screws and nuts of Product grade C
7	IEC: 60076-11	Dry Type Transformers
8	IS: 2016	Plain washers
9	IS: 2026 (Part I to IV)	Specification for Power Transformers
10	IS: 2071	Method of high voltage test techniques
11	IS: 2074	Ready mixed paint, air drying, red oxide-zinc chrome, primary
12	IS: 2099	High voltage bushing for alternating voltage above 1000 V.
13	IS: 2633	Methods for testing uniformity of coating of zinc coated articles
14	IS: 2932	Enamel, synthetic, exterior (a) undercoating (b) Finishing
15	IS: 3043	Code of practice for earthing
16	IS: 3347	Dimensions for transformer Bushings
17	IS: 3639	Fittings and accessories for power transformers
18	IS: 4257	Dimension for clamping arrangements for porcelain transformer bushings
19	IS: 5216	Guide for safety procedures and practices in electrical work

S. No.	Standard Number	Description
20	IS: 5561	Electric power connectors
21	IS: 7421	bushing for alternating voltage upto and including 1000 V.
22	IS: 10028	Code of practice for selection, installation and maintenance of transformers.
23	IS: 12360	Voltage bands for electrical installation including preferred voltages and frequency.
24	C.B.I.P. Publication	Manual on Transformers

The equipment complying with other internationally accepted standard may also be considered if they ensure performance superior to the Indian Standards.

9.4. DRAWINGS

The contractor shall furnish, within fifteen days after issuing of Letter of Intent, the following drawings / documents incorporating name of project and transformer rating for approval.

Detailed overall general arrangement drawing showing front and side elevations and plan of the transformer and all accessories including external features with details of dimensions, spacing of wheels in either direction of motion, net weights and shipping weights, crane lift for un-tanking, size of lugs and eyes, bushing lifting dimensions, clearances between HV and LV terminals and ground etc.

- Foundation plan showing loading on each wheel and lifting lugs.
- GA drawings / details of bushing and terminal connectors.
- Name plate drawing with terminal marking and connection diagrams.
- Wheel locking arrangement drawing.
- Transportation dimensions drawings.
- Interconnection diagrams both on HV & LV sides.
- Over fluxing withstand time characteristic of transformer.
- Technical leaflets of major components and fittings.
- As built drawings of schematics, wiring diagram etc.
- Setting of winding temperature indicator.
- Completed technical data sheets.
- Details including write-up of tap changing gear.
- H.V. bushing.
- Bushing Assembly.
- B-metallic connector for connection to specified conductor / bus-bar /in bus-duct.
- Assembly.
- Two earthing terminals & core earthing

- Thermometer pockets
- Inspection cover

All drawings / documents, technical data sheets and test certificates / results / calculations shall be furnished. Any approval given to the detailed drawings by the Engineer shall not relieve the contractor of the responsibility for correctness of the drawing and in the manufacture of the equipment for the packaged substation.

9.5. GENERAL CONSTRUCTIONAL FEATURES

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 without distortion or deterioration or the setting up of undue stresses which may impair suitability of the various parts for the work which they have to perform.

Similar parts, particularly removable ones, shall be interchangeable.

Screws, studs, nuts and bolts used for external connections shall be as per the relevant standards. Bolts and nuts exposed to atmosphere shall be of stainless steel.

Exposed parts shall not have pockets where water can collect due to moisture or otherwise. Labels, indelibly marked, shall be provided for all identifiable accessories. All label plates shall be of in-corrodible material.

All internal connections and fastenings shall be capable of operating under overloads allowed as per specified standards without injury. Transformer and accessories shall be designed to facilitate proper operation, inspection, maintenance and repairs. No patching, plugging, shimming or other such means of overcoming defects, discrepancies or errors will be accepted. The galvanizing if required shall be of minimum 610 gm zinc per square meter and it should be hot dip galvanized.

9.6. PAINTING [AS APPLICABLE]

The structural steel work shall be cleaned of all scale and rust by shot-blasting. 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 a glossy oil and weather resisting non fading, paint of shade No. 631 as per IS: 5.

Metal parts not accessible for painting shall be made of corrosion resistant material.

All paints shall be carefully selected to withstand heat, rain, hot humid atmosphere and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting shall be supplied by the contractor.

9.7. UNDER CARRIAGE

The transformer shall be supported on non- corrosive steel structure with forged steel flanged wheels suitable for moving the transformer completely. Wheels shall be provided

with suitable bearings which will resist rust and corrosion and shall be equipped with fittings for lubrication.

9.8. MAGNETIC CORE

The magnetic circuit shall be constructed from prime quality high grade cold rolled, non- ageing, grain oriented silicon steel lamination. The manufacture shall submit the following documents to prove only Prime quality Core are used:

Invoice of the supplier Mill's test Certificate Packing list

Bill of loading

Bill of entry certificate to custom

The manufacturers shall indicate whether they have in-house core cutting facilities or not, if not, they shall indicate place of cutting. To reduce the noise produced by the magnetic core, it is to be equipped with noise-damping devices. To reduce the no-load losses, the magnetic core is to be stacked using overlapping- interlocking technology.

The laminations shall be free of all burns and sharp projections. Each sheet shall have an insulating coating. The insulation structure for the core to bolts and core to clamp plate shall be such as to withstand a voltage of 2000 V for one minute.

The completed core and coil shall be so assembled that the axis and the plane of the outer surface of the core stack shall not deviate from the vertical plane by more than 25 mm.

All steel sections used for supporting the core shall be thoroughly shot or sand blasted, after cutting, drilling and welding.

The finally assembled core with all the clamping structures shall be free from deformation and shall not vibrate during operation.

The core clamping structure shall be designed to minimize eddy current loss.

The core shall be carefully assembled and rigidly clamped to ensure adequate mechanical strength. The core shall be provided with lugs suitable for lifting the complete core and coil assembly. The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angle to the plane of the lamination which may cause local heating. The construction is to be of 'core' type.

9.9. INTERNAL EARTHING

All internal metal parts of the transformer, with the exception of individual laminations, core bolts and their individual clamping plates shall be earthed.

The magnetic circuit shall be connected to the clamping structure at one point only and this shall be brought out. A dis-connecting link shall be provided on transformer to facilitate disconnections from ground for IR measurement purpose.

Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connections.

9.10. WINDING

LV windings

The LV winding shall be of aluminium foils in order to cancel out axial stress during short circuit. This foil will be insulated between each layer using a heat-reactivated class F pre- impregnated epoxy resin film including the ends of the winding. The whole winding assembly is to be polymerized at suitable temperature to ensure high level of resistance environment and to have excellent dielectric strength.

HV windings

HV winding shall be separated from the LV winding to give an air gap between the MV and

LV circuits for easy maintenance.

HV winding shall have linear potential gradient from top to bottom to have low stress between adjacent conductors, with high dielectric strength and low partial discharge.

HV winding shall be of Aluminum wire with class F insulation cast in vacuum with fire proof / flame retardant epoxy resin. The interior and exterior of the windings will be reinforced with a combination of glass fibre or similar material to provide thermal shock withstand.

HV winding support spacers

Winding support spacers are meant to provide sufficient support in transport, operation, short circuit and earthquake conditions. These spacers will be circular in shape for easy cleaning. They will give an extended tracking line to give better dielectric withstand under humid or high dust conditions. These spacers will include an Elastomer cushion that will allow it to absorb expansion as per load conditions. This Elastomer cushion will be incorporated in the spacer to prevent it being deteriorated by air or UV.

HV Connections

The connections shall be of copper and made from the top to give a safe and neat connection. A terminal plate shall be provided.

The HV connections will be made from the top connection bars. Each bar will be drilled with a hole for connection of cable lugs on terminal plates. The HV connection bars will be in rigid copper bars protected by heat shrinkable tubing. HV connections in cables are not allowed, in order to avoid all risk of contact, due to cables flapping. Depending upon the design of the manufacturer the arrangement shall be approved by the Engineer.

LV Connections

The LV connections with copper bars will be made from top of coils on the opposite side to the HV connections.

Connection of the LV neutral will be directly made to the LV terminals between the LV phase bars. There shall be a separate earth point connected to neutral.

Depending upon the design of the manufacturer the arrangement shall be approved by the engineer.

9.11. TRANSFORMER THERMAL AND OVERLOAD PROTECTION

PTC type sensors [minimum 6] shall be placed in the winding to measure the winding temperature. The transformer shall be equipped with an overload and thermal protection device with sensors to continuously monitor the LV and HV winding temperature for each phase. Digital monitoring thermometers shall be installed locally in the CSS on LV Board, with a provision for monitoring the temperatures at remote SCADA. Necessary alarms and trip contacts along with warning LEDs shall be provided to protect the transformers from high temperature.

Sensors shall be so placed that it shall be possible to replace the same very easily. All sensors along with enclosures, digital thermometers, transducers, sensing relays, connecting leads, etc. complete in all respects shall be in the scope of supply. For this purpose Security & Communication contractor shall lay a fibre optic cable from CSS to SCADA control Centre, termination of which to such devices shall be in the scope of contractor. Provision shall be made that In case of fire the transformer circuit breaker should be tripped.

9.12. OFF CIRCUIT TAP CHANGER

There shall not be a bolting arrangement for selecting the taps and shifting the copper bars. Instead the off circuit tap changer shall be operable by means of an operating handle / ring brought outside the tank operable from ground level. It shall be equipped with an indicating device to show the tap in use and shall be provided with a locking arrangement to lock the switch in position. The arrangement shall be such that an operator can change the tap while standing at ground level with complete ease. There shall be separate cover for tap changer.

9.13. SAFETY OF PERSONNEL

Transformer shall be properly fenced / protected in case the maintenance personnel are likely to come near the live parts while carrying out normal maintenance or monitoring activities near the transformer.

9.14. FITTINGS

The following fittings shall be provided on the transformers: Separate LV neutral point, with two joined points for double earthing of neutral along with tinned copper strip compatible to transformer short circuit current rating for earthing.

9.15. ONE DANGER PLATE

Temperature indicating device, sensors etc. Complete in all respects with contacts for remote/ local indication. Lifting eyes or lugs for the top cover, core and coils and for the complete transformer. Platform lugs / haulage lugs on under carriage.

9.16. MARSHALLING BOX

Rating and connection diagram plate.

Two numbers earthing terminals on opposite sides, associated nuts, bolts and tinned copper earth strip of suitable section for connections to purchaser's grounding strip.

4 bidirectional rollers.

Thermal and overload protection devices and equipment, along with necessary transducers, sensors etc. for local and remote SCADA indication, Alarm / trip contacts, LED indicators complete in all respects

Note: The fittings listed above are indicative and any other fittings which are generally required for satisfactory operation of the transformer are deemed to be included in the quoted price of the transformer.

9.17. RADIO INTERFERENCE AND NOISE LEVEL

Transformers shall be designed with particular care to suppress at least the third and fifth harmonic voltages so as to minimise interference with communication circuits. Transformer noise level, when energised at normal voltage and frequency shall be as per NEMA stipulations.

9.18. MANDATORY SPARE PARTS

The mandatory spare parts shall be included in the bid along with costs. These shall be considered in evaluation.

9.19. RECOMMENDED SPARE PARTS

Contractor shall provide a list of recommended spare parts for 5 years operations. The cost of these spare parts shall not form part of contractor proposal.

9.20. TESTS

The Transformers shall be completely factory tested before dispatch in accordance with the standards and with such other tests as may be necessary to ensure that the equipment is satisfactory and is in accordance with this specification.

Routine Tests

Transformer routine tests shall include tests stated in latest issue of IS: 2026 / IEC 60076-11. These tests shall also include but shall not be limited to the following:

- Measurement of winding resistance.
- Voltage ratio on each tapping and check of voltage vector relationship.

- Impedance voltage at all tapping.
- Magnetic circuit test
- (After routine tests, each core shall be tested for 1 minute at 2 kV between all bolts, side plates and structural steel work. Immediately prior to the dispatch of the transformer, the magnetic circuit shall be pressure tested for 1 minute at 2 kV A.C. between the core and the earth).
- Load losses.
- No load losses and no load current.
- Absorption index i.e. insulation resistance for 15 seconds and 60 seconds (R60/R15) and polarization index i.e. Insulation Resistance for 10 minutes and one minute (R10 mt/R1 mt).
- Separate source voltage withstand test (applied potential).
- Induced voltage test.
- Measurement of partial discharges.
- Partial discharges less than or equal to 10 pC at 1.30 Un, or
- Partial discharges less than or equal to 5 pC at 1.30 Un (Special test)
- Measurement of acoustic noise level.
- Measurement of Zero sequence impedance.

All routine and type tests should be done free of cost. When transformers are equipped with a protection enclosure, these shall be tested in their enclosure. Moreover, in addition to the routine tests, the transformer shall be subjected to the following type tests:

Lightning Impulse Test

This test shall be carried in accordance with clause 12 of the latest issue of IS: 2026 (Part-III). The contractor shall include price for lightning impulse test on HV and LV windings. (one limb only).

- **Temperature Rise Test**

The temperature rise test shall be carried out in accordance with IS: 2026 /IEC-60076. The

Temperature rise shall not exceed the values as in the IS: 2026 / IEC 60076-11

- **Noise Level Test:**

It shall be carried out as per IEC-60076-10

- **Environmental and Firefighting tests**

Certificates for tests carried out for Compliance to Class C1, E2 and F1 as per IEC 60076-11.

- **Short Circuit Test**

It shall be carried out as per IEC 60076-5. Alternatively employer at its discretion can ask for calculations instead of actual test.

- **Test Waiver, Procedures and Costs**

The Engineer, at his option, may waive impulse tests, provided type test reports of impulse tests, carried out on essentially identical units in their factory in India or at an accredited lab overseas, during the last three years are furnished by the manufacturer and are acceptable to Engineer. No load losses and exciting current shall be measured at rated voltage, rated frequency and at 90% and 110% of rated voltage, both before and after the lightning impulse tests. The method of test loading shall be described in the test report for determination of both average and hottest spot temperature. Where

the winding temperature equipment are specified, data shall also be included for calibration of hottest spot temperature indicator.

Resistance of each winding of each phase shall be measured at principal and at all the taps and corrected to 750C.

Impedance voltage shall be measured at principal and at all taps. No load Loss Measurement at 415 Volt.

The contractor shall indicate separately the cost of each of the following type tests: Lightning impulse test separately for HV and LV winding.

Temperature rise test.

Test on Associated Equipment

Bushings, Transformer thermal and overload protection devices, sensors, digital thermometers, OFF LOAD tap changer, control devices, and other associated equipment shall be tested by the contractor in accordance with relevant IS or IEC. If such equipment are purchased by the contractor, he shall have them tested to comply with these requirements.

Test Measurements

Certified test report and oscillograms shall be furnished to the Engineer for evaluation as per the schedule of distribution of documents. Manufacturer's Test Certificates in respect of all associated auxiliary and ancillary equipment shall be furnished.

The contractor shall state in his proposal the testing facilities available at his works. In case full testing facilities are not available, the contractor shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing.

Witnessing of Tests

The Clients' Engineer reserves the right to witness any or all tests. If required, visits can be made to the works of manufacturer to ensure that the approved quality ensuring program is being followed. In this regard all the necessary facilities shall be arranged by manufacturer at his end and cost borne by the contractor.

Site Tests

After the transformer is installed, the following pre-commissioning tests and checks shall be done before putting the transformer in service.

Visual checks for connections etc.

Dry out test

PI / Resistance measurement of windings

Ratio test

Tap changer test

Temperature Indicators & alarms

Magnetising current

Earth connections are made.

Rejection

The Engineer can reject any transformer if during tests or service any of the following conditions arise:

No load loss exceeds the guaranteed value. Load loss exceeds the guaranteed value.

Impedance value exceeds the guaranteed value by 10% or more.

The difference in impedance values of any two phases during single phase short circuit impedance test exceeds 2% of the average value guaranteed by the vendor.

Winding temperature rise exceeds the specified value. 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.

9.21. INSTRUCTIONS MANUAL

Six sets of the instruction manuals shall be supplied at least four (4) weeks before the actual dispatch of equipment. The manuals shall be in bound volumes and shall contain all the drawings and information required for erection/construction, testing, operation and maintenance of the transformer. The manuals shall include amongst others, the following particulars:

Marked erection/construction prints identifying the components, parts of the transformer as dispatched with assembly drawings.

Detailed dimensions, assembly and description of all auxiliaries.

Detailed views of the core and winding assembly, winding, connections and tapping's, tap changer construction etc. These drawings are required for carrying out overhauling operation at site.

Salient technical particulars of the transformer. Copies of all final approved drawings.

Detailed O&M instructions with periodical check lists etc.

9.22. COMPLETENESS OF EQUIPMENT

All fittings and accessories, which may not be specifically mentioned in the specification but are necessary for the satisfactory operation of the equipment, shall be deemed to be included in the specification. These shall be furnished by the contractor without extra charges. The equipment shall be complete in all details, whether such details are mentioned in the specification or not. All deviations from this specification shall be separately listed under the requisite schedules, in the absence of which it shall be presumed that all the provisions of the specifications are accepted by the contractor.

Tools & Tackles

All the necessary tools and tackles required for the normal operation shall be supplied by the bidder.

10. LV SWITCHBOARD FOR COMPACT SUB-STATIONS

10.1. GENERAL

The LV switchboard for CSS shall be indoor 3-Phase, 4-wire, 440 V, 50 HZ, neutral solidly grounded, complete in all respects including base channels, foundation bolts and other hardware for various packaged RMU distribution sub-stations.

10.2. STANDARDS

The equipment covered in these specifications shall conform to the latest revisions / replacements of the following Indian Standard Specifications.

The equipment complying with other internationally accepted standards shall also be considered, if they ensure performance equivalent to or superior to Indian Standards.

S. No.	Standard Number	Description
1	IS: 5	Colours for ready mixed paints & enamels

S. No.	Standard Number	Description
2	IS: 722	AC Electricity Meters
3	IS: 1554	PVC insulated (heavy duty) electric cables
4	IS: 2147	Degrees of protection provided by enclosures for Low- voltage switchgear and control gear
5	IS: 2419	Dimensions for panel mounted electrical indicating & recording electrical instrument
6	IS: 2551	Danger notice plates
7	IS: 2633	Methods for testing uniformity of coating of Zinc coated articles
8	IS: 2705	Current Transformers
9	IS: 3156	Voltage Transformers
10	IS: 3231	Specification for electrical relays for power system protection
11	IS: 4237	General requirements for Switchgear & Control gear for voltage not exceeding 1000 volts.
12	IS: 4794	Push buttons
13	IS: 5082	Wrought aluminium and aluminium alloy bars rods, tubes, sections plates, sheets for electrical application
14	IS: 5578	Guide for making of insulated conductors
15	IS: 6005	Code of practice for phosphate coatings of iron and steel (First Revision)
16	IS: 6875	Control switches (switching devices for control and auxiliary circuit including contractor relays) for voltages up to and including 1000 V AC and 1200 V DC
17	IS: 8623	Low voltage Switchgear and Control gear assemblies
18	IS: 8828	Electrical accessories circuit breakers for over current protection for home load and similar installations.
19	IS: 9000	Basic environmental testing procedures for electronic and electrical items
20	IS: 10580	Service conditions for electrical equipment
21	IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
22	IS: 13703	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC
23	IS: 13942	Low voltage switchgear and control gear
24	SP: 39	Guide for insulation coordination within low voltage system
25	IEC -60364 IEC: 60664	Low Voltage Electrical Installations [All applicable series of IEC-60364] Insulation coordination within low voltage system including clearance and creepage distance for equipment.

IEC: 60664 Low Voltage Electrical Installations [All applicable series of IEC-60364]

Insulation coordination within low voltage system including clearance and creepage distance for equipment.

10.3. SYSTEM DETAILS

The L.V. Distribution Board shall be a part of a packaged RMU substation having transformer rating as in the single line diagram for that location and technical data as given under Specific Technical Requirements. Only the standard size of transformer shall be selected. Broadly the LV distribution board shall have the following configuration:

Connection to LV side of Transformer

Connection to LV side of distribution transformer shall be through insulated, three phase, four wire tinned Copper bars. Alternatively tinned Copper bars may be considered with a non-segregated three phase four wire bus duct, or with sandwiched bus bars, conforming to relevant IS Standard as per current requirements.

Incomer and Board Bus bar

Incomer shall be Air Circuit Breaker, draw out type, electrically operated, equipped with microprocessor based electronic trip units, complete with CTs & metering. It shall be possible to operate this breaker from remote through SCADA also. Transformer incomer rating shall be same as that of bus rating. LV Bus bars shall be three phase, 4wire, and of tinned copper. Size of neutral conductor shall be same as of phase bars. The LV Board shall be designed for fault level as given in the Specific Technical Requirements.

Outgoing Feeders

No HRC fuses are envisaged. All the outgoing feeders shall be equipped with Moulded Case Circuit Breakers of appropriate rating.

External Cabling

The external, three phase, four core, LV cables of required size shall be terminated to the outgoing terminals of LV switch board. Necessary cable supports shall be provided in the cable alley of the board.

10.4. DESIGN AND STANDARDIZATION

10.4.1. GENERAL

The equipment shall be designed to ensure satisfactory operation of the system in which continuity and quality of service is the first consideration. It shall also be designed to withstand sudden load variations due to short circuits and fault conditions or for any other reason.

All mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and have sufficient surface area for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless steel bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.

Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.

All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards, vermin's etc. Metal cubicles, housing and covers shall be 100% weather / vermin proof and shall be able to provide the degree of protection IP-54 in accordance with latest version of IS-2147.

All parts shall be manufactured in accordance with relevant standard specifications of IEC / I.S. Corresponding parts of similar equipment and apparatus shall be mutually interchangeable.

All apparatus, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage which might be caused in the event of such an eventuality.

10.4.2. SPECIFIC TECHNICAL PARTICULARS

The standard technical particulars (which must be modified considering the climatic conditions as given in relevant standards) for the LV Switchboard, are given below:

- AC System : 3 phase, 4 wire, solidly earthed
- Transformer secondary Voltage : 433V
- System Nominal Voltage : 415 volts $\pm 6\%$
- Frequency : 50 Hz $\pm 5\%$
- Combined variation in absolute sum of Voltage & frequency Bus bar : $\pm 10\%$

Electrolytic Copper, tinned, Continuous rating [as per transformer rating]

- 250 KVA : 800 A
- 500kVA : 1200 A
- 800kVA : 1600 A
- Short time (1 Sec) : 50 kA rms

One Minute Power Frequency / Impulse Withstand Voltage

- Power circuits : 2.5 kV (rms)
- Control circuits : 2.5 kV (rms)
- Basic Insulation Level, kVp : 8

Flush Mounted Moulded Case Circuit Breaker (MCCB, TPN) with rotary handle AC

- Voltage : 3-Phase, 415 V (-6 to +9%)
- Frequency : 50 Hz
- Short Circuit Performance : P2
- Short Circuit Capability : 50 kA (rms) for 1 Sec.
- Making capacity : 50 kAp
- Operating Mechanism : Manual, trip free
- Temperature rise : As per IS: 2516
- Mechanical : As per IS: 2516
- Auxiliary contacts : 4 No., 4 NC
- Current Rating : As per Single Line Drawing

Multi-function Meters

- Accuracy class : 1
- One Minute Power : 2 kV (rms)

Frequency Withstand Voltage

Current Transformers

- Type : Cast resin, Bar primary
 - Secondary circuit : 1 Amp.
 - Voltage class and Frequency : 1100 v, 50 Hz
 - Class of insulation : E or better Accuracy :
 - Accuracy class & VA : Class 1, 10 VA
- of metering CT
- Accuracy class of VA : 5 P 15, 10 VA
- of protection CT
- Short time current rating : 50 kA (rms) for 1 sec.
 - Dynamic rating : 120 kA (peak)
 - One Minute Power : 2.5 kV (rms)

Frequency Withstand Voltage

Voltage Transformers

- Type : Cast resin
- Rated voltage :
- Primary : 415 V / $\sqrt{3}$
- Secondary : 110 V / $\sqrt{3}$

Accuracy class and VA burden

- Metering : 1.0, 25 VA
- Protection : 3 P, 25 VA

Method of connection

- Primary : Star
- Secondary : Star
- Rated voltage factor : 1.1 continuous, 1.5 for 3 sec.
- Class of insulation : E or better
- One minute power : 2.5 kV (rms)

Frequency withstand voltage Relay

- One Minute Power : 2.0 kV (rms)

Frequency withstand Voltage

Cubicle Color Finish

- Interior : Glossy White
- Exterior : Grey shade No. 631 of IS: 5

Accessories

- Plug point with MCB.
- Space heater PTC type.
- Name plate on front & rear

- Danger plates.
- Cubicle
- Minimum thickness of CRCA sheet steel : 2 mm
- Base Frame channel : 100mmx50mmx6mm
- Degree of protection : IP-54
- Rubber mat between Panel & base : 15mm

10.4.3. DRAWINGS AND LITERATURE

Four sets of tentative G.A., Schematic drawings and detailed literature of equipment shall be submitted with the tender clearly giving the scope of supply and bill of material to enable the Engineer to scrutinise all aspects of design including arrangement and support of cable

Accessibility for maintenance work and future additions, cable connections, general appearance etc. In addition, the contractor shall submit drawings & literature are to be furnished by successful tenderer / bidder within 2 weeks after the award of contract, which shall include the following:

Complete assembly drawings of the boards, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.

Foundation plan, embedment channel frame with associated holes and suitable size of bolts for fixing to channel frame.

Wiring diagrams including terminal wiring design and cable schedule.

Schematic control diagram, details of relays, instruments, space heaters, cubicle illumination and receptacle etc.

Bill of material of each LV board. Layout plan of each LV board.

10.4.4. BOUGHT OUT ITEMS

All bought out items such as switches, MCCBs, MCB's meters, terminal blocks, cables etc. shall be of reputed make. Engineer reserves the right to accept only materials of proven make at its sole discretion.

10.4.5. DETAILS OF L.V. SWITCHBOARD

Constructional Details

The Switchboard shall be made of cold rolled sheet steel of 2 mm thick having different compartments for bus-bars, cable alley and instrumentation. The board shall be floor mounted, self-supporting.

The bus-bars shall be rectangular, of tinned electrolytic copper and of approved size for current rating for phases as well as for neutral. The bus bars shall be suitably supported on non-hygroscopic insulators to withstand forces arising from short circuits in the system. These shall be suitable for harsh environmental conditions.

The switch boards shall be of compact design. All doors and covers shall be fully gasketed. Individual feeder compartments shall be provided with stainless steel hinged doors, bolted type doors shall not be acceptable. Indicating instruments shall be of 96x96 mm.

The interconnections between bus-bars and MCCBs unit shall be solid insulated, tinned copper strip permanently bolted with the bus-bars and MCCBs. The bus-bar joints shall be given a thin coating of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact area and the contact

pressure is maintained permanently. The bus-bars / tee off shall be insulated with heat shrinkable sleeve tapes with red, yellow, blue colours for 3 phases and black for neutral. All the bus-bar tapping & markings shall be in accordance with relevant IS.

The gland plate shall be of Aluminium minimum thickness of 3 mm and detachable type. A strong supporting channel of 100 x 50 x 6 mm shall be provided beneath the switchboard shell besides anti-vibration rubber gasket of 15 mm thickness.

The connection from 11/0.433 kV transformers to the LV switchboard shall be through a LV non-segregated bus duct [alternatively sandwiched bus duct] or through insulated copper bus bars as per requirement.

The bus-bars shall have non-hygroscopic support insulators. The bus bar shall be insulated with heat shrinkable insulating kits. The short circuits withstand capacity of all the bus-bars and tap-connection shall be 50 KA for one second.

Details of Circuits

Each switchboard shall have the following circuit arrangement.

Incoming

1 no. 3 phase, 4 wire incomer four pole air circuit breaker, electrically operated with microprocessor based trip circuit release. The breaker shall conform to IEC 61439.

It shall be withdrawal type. The control supply can be provided from a line connected PT from the LV connection from the transformer or any other arrangement given by contractor can also be considered during detailed engineering.

3 Nos. – Metering CTs of required ratio, 10 VA Class 0.5s, with ISF less than 5.

3 Nos. – Protection CTs

The incomer breaker shall have numerical relay having three over currents of setting 50% to

100% of 1A rating with IDMTL; current Vs time characteristics. Short circuit instantaneous trip shall be included. Alternatively the built in microprocessor based trip units having Overload protection [IDMTL, IEC characteristics], short circuit trip [time delayed], Instantaneous short circuit protection, Ground Fault Protection can also be considered.

1 no. 96 x 96 mm flush mounted multi-function meter. Meter shall measure unbalanced neutral current also along with three phase currents simultaneously.

1 no. digital bus voltmeter scale 0-500 V with three line reading.

If required, 1 no. Automatic Power factor controller [APFC], connected to y-phase metering CT, with SCADA communication, and five steps to switch on capacitor banks for power factor improvement to 0.95.

Note: Number of steps is tentative and shall be finalised during detailed engineering.

LED type lamps to indicate breaker closed, open, auto trip, protection operation, spring charged etc. indications.

Outgoing feeders

3 phase, 4 wire, outgoing cable circuits are envisaged from the switchboard and each circuit shall have the following items, indicating instruments, terminal connectors etc.

4 pole withdrawable type Moulded Case Circuit Breakers of appropriate, rating as indicated in the single line diagrams.

Earth leakage relay

3 nos. metering current transformers of secondary rating 1A & 1.0 accuracy class having primary current as per SLD.

1 no. 96x96mm flush mounted multifunction meter as per CT rating. Termination points for 4C XLPE, Al. Armoured cables with lugs.

The LV board must have sufficient space of not less than 100 mm between two termination points for external cables.

Cable alley along with necessary clamping arrangement for the outgoing feeder cables. Indicating LED lights – red, yellow and blue for the supply.

10.4.6. CAPACITOR BANK & AUTOMATIC POWER FACTOR CONTROLLER [APFC] (IF REQUIRED)

Considering the transformer capacity and load power factor as 0.85, a suitable size of switched capacitor bank shall be mounted inside the LT compartment to improve the power factor to 0.9. Necessary calculations, number of steps and switching details shall be provided for approval.

Capacitor units shall be fuse-less, with loss not exceeding 0.5W / kVAR, with metallised polypropylene film, double casing insulation, self-healing feature, non-flammable and with nontoxic material. Reactors shall be non- resonance, dry type resin embedded. Capacitor unit shall with automatic operation steps as required, built in discharge resistor and mounted on stainless steel frame. APFC shall also be supplied by the same manufacturer. APFC shall have LCD display, programmable, with monitoring of all parameters locally as well as at remote SCADA on mod bus via fibre optic cable. It shall be with built in cabinet placed in the cubicle of LV board with easy access doors.

It is being advised to inform 0.95 & above Power Factor to be maintained by each of the Plot owner adhering to Local DISCOM Guidelines while designing there own distribution system

10.4.7. EARTHING

The LV switchboard shall be provided with two separate earthing terminals at the ends. With minimum rated for 50kA for 3 sec running in the board. All metal parts, enclosure, transformer and neutral have to be interconnected and ready for connection to the external earthing arrangement.

The earthing terminals shall be identified by means of proper embossed sign marks adjacent to the terminals.

In the cable gland area provision shall be made at cable gland for armour earthing and then connecting it to main earth bar in a proper way. There shall be a continuous tinned copper earth bus bar in the board. The size of the earth bus bar shall be suitable to carry 50 kA for 3 second. The bus bar shall not be visible or removable from outside the switchboard. The earth bus bar shall have necessary holes, nuts & bolts including washers for making earth connection of cable glands / armouring of the cables.

10.4.8. SWITCHBOARD LIGHTING & HEATING

A lamp holder with a 11 W LED lamp and operated by an internal SP-MCB shall be fitted for internal illumination. In addition, a 3 pin 6A/25A socket shall also be provided with a separate SP-MCB. Space heater of suitable rating of PTC type, and with SP MCB shall also be provided to avoid any moisture condensation inside the switchboard.

10.4.9. DANGER NOTICE PLATES

An enamelled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the middle upper front of the switchboard.

Test

All tests as required in relevant Indian standard shall be carried out on the LV switchgear. Engineer shall witness the tests at the works of the manufacturer.

Type Tests

The purchaser may ask the manufacturer to conduct the following type tests on one of the AC Boards.

Verification of temperature rise limits test

Verification of rain test to determine the degree of protection against rain. Verification of dielectric properties.

Necessary type tests as per IS on all the individual items such as ACB's, MCB's, MCCB's, instruments, links etc.

Short circuit test

The Engineer, at its option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / approved testing laboratory are furnished by the manufacturer.

Routine Tests

The switchboard shall be subjected to all the routine tests as per Indian Standard [IS] and witnessed by the Engineer. For power frequency voltage the test voltage to be applied shall be for a period of one minute. Insulation tests with 500 volts megger before and after the high voltage test shall be carried out on the switchboard.

Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's, MCBs, meters etc.

Verification of wiring & earth continuity

Voltage test on auxiliary circuits.

Tests for mechanical operation, control & interlocks.

Commissioning Site Tests

Necessary site tests at site shall be carried out to ensure its satisfactory operation after installation at site.

10.5. AIR CIRCUIT BREAKER (ACB)

415 V four pole air circuit breakers shall be withdrawal type with manually / electrically operated mechanism. It shall be supplied for controlling the LV side of the 11/0.433 kV, distribution transformer. Air circuit breakers shall have symmetrical short circuit rating of 50 kA for 1 sec. The circuit breaker shall be fitted with direct acting microprocessor based electronic release. It shall be provided with instantaneous and adjustable short circuit trip. The adjustment of the setting should be possible without disrupting the supply. The releases shall be ambient temperature compensated type. The release shall have IEC IDMTL characteristics. The breaker mechanism should be robust, quick making quick breaking and trip free. It should be possible to close and trip the breaker without opening the compartment & door. It shall have auxiliary contacts for indications along with spare contacts.

The detailed specifications of Air Circuit Breaker shall be as under:

- No. of poles : Four
- Service voltage : 415 Volts
- Normal current : As per design calculation
- Frequency : 50 Hz Rated

- Symmetrical Breaking
- Capacity at 415 V AC/50 Hz : 50 kA for 1 Sec.
- Making current : 120 kA
- Rated insulation voltage : 1000 V Max
- Breaking time : 30 ms Max
- Making time : 80 ms
- ACB Connection to Transformer

The air circuit breakers shall be suitably earthed with the main earth bus. The air circuit breakers of the LV board shall be connected to the LV side of the distribution transformer as specified. In case bus duct is provided the connections at both the ends shall be through proper clamps preferably bimetallic. Suitable arrangement shall be provided in the bus duct to take care of the expansion.

LV Moulded Case Circuit Breaker

All the LV outgoing underground feeders from the sub-station shall be controlled by 4 pole draw out type moulded case circuit breakers, provided in the LV switchboard.

The moulded case circuit breakers shall be of robust construction and shall comprise of switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact moulded case and cover. The insulating case and cover shall be made of high strength, heat-resistance and flame-retardant thermo-setting insulating material.

The switching mechanism shall be quick-make / quick break type, and should be trip-free. The arc extinguishing device shall comprise of a series of grid plates mounted in parallel

between supports of insulating material. The arc shall be drawn from the moving contact into the divide chamber and extinguished.

The moulded case circuit breakers shall have a thermo-magnetic type tripping mechanism, where the heating effect and the electromagnetic effect of current are made use of to provide protection against overload and short-circuit conditions respectively. The heated-bimetal strip in each phase of the MCCB shall actuate the tripping system following on inverse-time-current characteristics depending upon the severity of the overload current. During short-circuits, the system shall trip instantaneously. The tripping element provided on each pole of the MCCB shall operate on a common trip bar, thereby preventing single phasing in the event of fault occurring on any of the phases. The tripping device shall be ambient temperature compensated type.

The MCCB shall have a minimum Ics rupturing capacity of 50 kA. Positive indication about the position of the MCCB i.e. whether 'ON' 'OFF' or TRIPPED shall be provided.

The short circuit breaking capacity and operation mechanism of the MCCB shall be supported by test certificates.

All the MCCBs used in LV switchboards for controlling the outgoing feeders shall have a

Thermal current setting of 50 to 100% of its rated current and magnetic setting of 500% to 1000%

The rated currents given are provisional and shall be finalized during detailed engineering. The detailed specifications of the MCCBs shall be as under:

- No. of poles : 4 pole
- Service voltage : 415 Volts

- Normal current [In] : As per SLD
- Frequency : 50 Hz Service [Ics]
- Breaking capacity at
415V AC, 50 Hz : 50 kA
- Making current : 120 kA

MCCB shall be provided with rotary handle for manual operation.

Internal Wiring

The LV AC distribution boards shall be supplied with complete internal wiring. The central wiring shall be of 1100 V grade, FRLS, PVC insulated. Stranded tinned (not less than 48 strands) copper conductor cables of 1.5 mm² size shall be used for control circuits and 2.5 mm² for CT circuits. 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 and suitable for 500 V and of recommended make. Terminals shall be adequately rated for the short circuit current. Typically terminals of 'Phoenix' make shall be provided which shall be approved by Engineer during detailed engineering. For CT circuits, shorting type terminals shall be provided. It shall be possible to measure the CT current through clip-on-ammeters.

10.6. PRE-FABRICATED ENCLOSURE FOR PACKAGED RMU -SUBSTATIONS

10.6.1. GENERAL

The enclosure for the compact substation also includes the base frame/ channels and all the necessary fixing hardware accessories required at site. The enclosure shall be compartmentalized and house RMU, dry distribution transformer, LV distribution board with capacitor bank and their interconnections both external and internal. Engineer at its sole discretion may also consider the alternate designs given by the contractor, if the same are found to be better or equivalent to the ones given hereunder.

10.6.2. STANDARDS

The equipment shall conform (but shall not be limited) to IEC 6227-202 standard. The requirements of standards for necessary clearances, ventilation etc. shall also be complied with.

10.6.3. SPECIFIC TECHNICAL REQUIREMENTS

- Typical size : 2 x 2.5 m (5 m²) with 2 m height
[Contractor may quote its own size, if different]
- Construction : Self- standing on concrete base
- Steel base frame : 4mm thick base [hot dip electro-galvanized steel, with epoxy paint]- suitable for local e
- Lifting eyes : 4 Nos from the bottom.
- Housing enclosure : 2 mm corrosion resistant Zinc / Aluminium alloy coated sheet steels
- Degree of Protection : HV Compartment : IP-54
- Transformer Compartment : IP-23

- LV Compartment : IP-54
- All hinges, supports Nuts,
washers etc. : Stainless steel
- Paint : Epoxy
- Roof Design Load [min] : 250 Kg/m²
- Roof Design : Slanting on the sides
- Top of Roof : Removable
- Ventilation : With louvers (no exhaust fans shall be used)
- Sound Level : 60 dB
- Standard Applicable : IEC 62271-202
- Number of earths : Two (at opposite ends)
- Compartments : Three with independent doors

10.6.4. CONSTRUCTION

General

The enclosure shall be self-standing on a concrete base. Necessary civil requirements to be satisfied for the concrete base shall be provided by the contractor. The levelling of ground and construction of the concrete base and associated civil works shall also be in the scope of the contractor.

The compact substation is completely self-contained, mounted upon a 4 mm thick galvanised steel base frame, epoxy painted, factory assembled in a totally enclosed, aesthetically acceptable metal cladding, vandal-proof and weatherproof housing ready for placing into position upon a concrete base.

The lifting arrangement should be with four lifting eyes from the bottom of the enclosure & not from the top.

The structure of the substation shall be capable of supporting the gross weight of all the equipment & the roof of the substation compartment shall be designed to support adequate loads. In case of relocation of the Package Substation, the entire substation should be capable of getting lifted and placed as a Single Unit without dismantling of any of the major equipment inside the enclosure. The complete housing assembly with four lifting eyes should be easy to lift and position the whole unit at the site by the use of crane. The substation can be lifted without damage or distortion. The transformer is located in the middle of the substation while the HV and LV compartments are located at both ends of the substation adjacent to the corresponding bushings of the transformer. The arrangement is subject to the approval of the Client or site Engineer.

There shall be adequate ventilation inside the enclosure so that hot air inside enclosure is directed out by help of duct. Louvers apertures shall be provided so that there is circulation of natural air inside the enclosure. The Package Substation should be designed & engineered to have natural cooling & ventilation only. No forced cooling / ventilation is acceptable.

The enclosure must be weather proof installation with proper measures against rusting.

The enclosure must also be vermin proof to prevent the entry of rodents, reptiles, & flying insects, which are prevalent in the area.

The enclosure should be pre-fabricated such that fire from one compartment MUST NOT spread to other compartments.

It should have easy access to all the equipment inside the enclosure, viz RMU, transformer, LV switchboard, capacitor bank, connections, and terminations of HV & LV cables.

The metal base and all supporting channels shall be hot dip galvanized. These should ensure rigidity, ease in transportation to sites and installation.

The outdoor panel envelope may be made of electro-galvanised mild steel with nominal thickness of not less than 3 mm. The housing of the enclosure shall be made of 2 mm corrosion resistant Zinc / Aluminium alloy coated steel sheets.

All hardware such as hinges, supports, screws, nuts, bolts, washers etc. should be made of stainless steel. All locking bolts shall be accessible from inside to prevent the unauthorised dismantling.

All the enclosures shall be or of similar type & design.

The colour of the enclosure shall be decided by Engineer during detailed engineering, if different from the one given. The last finish coat shall be of epoxy paint.

The roof of the substation enclosure shall be designed to support loads up to 250 kg/m². The roof shall be sloped on the sides so that the rain water cannot stay on roof during rainy days.

The pre-fabricated roof of the enclosure shall be removable whenever required. The locking nuts, bolts to allow the removal of roof shall be only accessible from inside the enclosure.

Covers & Doors:

Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors in normal operation have been opened. The doors shall open outward at an angle of at least 90degrees & be equipped with a device able to maintain them in an open position. Proper padlocking facility shall be provided for doors of each compartment. Transformer compartment doors must be open from both the sides.

Door closing shall be by means of a three point linkage arrangement (i.e. Centre, top and bottom) and controlled by a centrally located stainless steel operating handle. Pad locking facilities along with Master pad locks shall be provided. Master pad locks shall be operated by a master key for all the substations.

The outer doors of the enclosure shall be wide and provided with heavy duty hinges to prevent distortion and misalignment. A robust door restraint shall be provided to hold each door in the 950 open positions. The restraint shall be of a captive design so that it cannot be easily removed and shall be self-strong when the door is closed such that it cannot rattle. With the door in this position, operation of LV and HV switchgear shall be possible without endangering operator's hands, etc.

When doors are closed, they are firmly locked; as such entry of dust, vermin and rainwater is completely prevented. Neoprene gaskets are to be used.

The HV doors are provided with a drawing pocket to keep drawing inside. A weatherproof nameplate shall be provided on the door.

The edges of the doors are bended at both sides to assure they fit properly so that the door jams and misalignment is prevented.

The transformer, low voltage and HV compartments are completely separated by steel sheet. The barrier between the HV switchgear and the transformer is provided with pressure relief flaps.

All compartments are individually accessible by their own doors from outside.

Labyrinthine louvers form the sidings of the transformer room to assure free entry and exhaust of air, as such the inside temperature is kept within limits. Openings located at the lower and upper sides of the slanted roof shall allow air circulation as part of the ventilation design.

No exhaust fans shall be used. Ventilation louvers shall be required to provide sufficient ventilation.

All compartments are equipped with internal lighting consisting of 25 watts LED lamps controlled by their respective door micro switches. MCB shall be provided to control the supply.

Space heaters shall be provided to control condensing type humidity.

Labels for warning, manufacturer's operating instructions etc. & those according to local standards & regulations shall be pasted / provided inside and shall be durable & clearly legible.

The substation forms a complete metallic structure bolted together and each compartment is to be provided with tinned copper, grounding bus-bar. Bonding and interconnection of the grounding buses shall be made of 70 mm² bare stranded copper tinned conductors. The ring main unit shall have 25x8 mm grounding bus while the low voltage switchgear shall have 30 x 10 mm tinned copper grounding buses to which connection to the grounding system at site can be made. At least two grounding points for bolting to ground conductor shall be provided on opposite ends.

All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include :

The enclosure of Unitized / prefabricated substation.

The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose.

The metal screen & the low - high voltage cable earth conductor. The transformer tank or metal frame of transformer.

The frame &/or enclosure of low voltage switchgear.

- **Dimensions**

The overall typical dimensions of the enclosure may be around 2.5 m x 2.0 m (or 5m²) having height of about 2 m. To achieve necessary clearances, contractor may propose alternate size of the enclosure depending upon the dimensions of the equipment supplied.

- **Enclosure Requirements**

The enclosure must be totally safe to the personnel in the populated areas as the packaged substation shall be established in the residential townships.

The equipment in the enclosure must be accommodated with necessary clearances, easy access to the RMU, and transformer, LT switchgear and capacitor bank for testing, maintenance, removal and normal operation (including operation with normal switchgear handles).

There shall be unhindered access to the transformer, operation of OFF load tap changer and other normal operating requirements. Similarly termination & removal of cables, withdrawals of ACB from LV board should be easy & comfortable.

It shall be the sole responsibility of the contractor to satisfy all the statutory clearances and to provide safety measures against all possible hazards to the equipment in the enclosures, such as internal arcing faults in the enclosure considering environmental conditions existing at site.

Failure within the unitized substation due either to a defect, or mal-operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the unit shall be tested for Internal Arc fault test to the tune of at least 20KA for 1 second as per latest IEC 62271-202 standard. The enclosure must be so designed that internal arc faults are directed away from places where personnel or public may be present. Test certificates from a recognised national/international test house [acceptable to Engineer] shall be supplied for internal arc.

Testing of incoming & outgoing cables and use of testing equipment for the same shall not entail the dismantling the sides or the roof of the enclosure.

There shall be sufficient space for termination & removal of cables from Load Break Switches & also from the LV board.

Sufficient clearance must be kept between the top of any equipment installed in the pre-fabricated substation and the roof of the substation for ventilation and operational purposes.

- **Interconnection**

The equipment inside the enclosure shall be interconnected as follows:

The RMU shall be directly coupled by VCB feeder to distribution transformer through insulated copper bars or cables as per manufacturer standard.

The LV side (three phases plus one neutral conductor) of distribution transformer shall be connected to LV incomer Air Circuit Breaker via flexible insulated copper bars or through a four conductor sandwiched insulated bars or with bus duct enclosure.

The HV termination to Load Break Switches shall be from 11 kV, Al. armoured XLPE cables, fitted with termination kits, for the ring system.

The earthing of pre-fabrication station shall be provided at two opposite ends for connection to the outside earth rods. It shall be a bolted connection.

- **Drawings**

The following drawings shall be submitted with the tender.

- The detailed sketch of the enclosure indicating general view, position of louvers etc.
- The drawing showing the layout of HV, transformer & LV switchgear along with interconnections.
- Size & position of doors in the enclosure.
- Fixing details of the enclosure including civil foundations (if any)
- Safety Measures

The enclosure shall have the following safety measures:

- Electric shock treatment chart duly framed shall be fixed in a conspicuous position inside the enclosure.
- Danger notice in English/ Hindi/ Kannad language conforming to IS: 2551 shall be fixed on all the four sides of the enclosure.
- Electric insulated rubber mat (non-skid type) with flouted top and plain border end,
- 12 mm thick to withstand 12kV di-electric strength shall be provided in front of
- HV/LV boards where people have to work.
- Two number portable fire extinguisher typically 2 litre, suitable for transformer / cable and other electrical equipment fires shall be placed & fixed in a suitable location in the enclosure, away from the place where fire is expected.

- **Tests**

The following tests shall be carried out on the enclosure as per IEC standard at the works of the manufacture:

- The complete prefabricated substation unit will be tested at full load for temperature rise. The maximum temperature rise on any part of the equipment placed inside the enclosure shall not exceed the value as specified in IEC 62271-202.
- Test to verify the sound level of the pre-fabricated substation, which shall be less than 60 db.
- Test to verify the degree of protection of enclosure for various compartments.

For the internal arc fault test on the enclosure the following need to be observed and tested as below:

Internal Arc Fault tested to 20 kA 1 sec.

- Test to accessibility of Type “B” that is with unrestricted accessibility including that of the general public (Annex. AA.2 IEC). Although test to accessibility of Type “A” is not required, tenderers shall also provide adequate measures to have any hot gases directed away from the operator during switching with the door open.
- Arc initiation is made inside the SF6 gas compartment of the RMU (Annex. AA.3 IEC)
- Assessment of the internal arc fault test is based on the fulfillment of all 6 criteria as stated in Annex. AA.6 of IEC.

Other Checks

- Inspection of conformity with the specification & approved drawings.
- Inspection of devices locking out and interlocks.
- Inspection and checking electrical continuity of metallic frame and earthing system.
- Dielectric tests of M.V. and L.V. bus bar.
- Provision of two earths as per Indian Electricity Rules.
- Tests as per IEC standard.

SECTION 5: SYSTEM DETAILS FOR INDOOR SWITCHGEAR PANEL BOARDS (33KV GIS PANELS)

33 KV GIS systems shall be with solid grounding; therefore, switchgear shall be suitable for such an operating condition.

MV Switchgear Boards shall be of single bus bar type. The breakers shall be of fixed type on the floor and equipped with earth switches to earth the externally connected cables. The switchboard shall be installed in the switchgear room of the Main Control Room. Detailed SLD shall be prepared by EPC Contractor for complete system understanding.

The two incoming feeders on the boards shall not run in parallel and shall be feeding the loads on the respective bus sections.

The substation where the indoor switchgear shall be installed and shall be suitable with conventional local operation as well as remote controlled through SCADA on IEC 61850 Protocol. For metering all the feeders at the respective board shall be operated on MODBUS for remote indications.

EPC Contractor shall submit CT/ PT parameter calculations.

1. GENERAL DESIGN AND CONSTRUCTION REQUIREMENTS

The Switchboard shall have following features:

Gas insulated Metal clad switchgear shall be complete with all the accessories for efficient and trouble free operation. The equipment offered shall be safe, reliable and compact to install. The workmanship shall be high order. The circuit breaker, switches and protective device etc shall be latest design so as to ensure rapid and efficient interruption of fault current low arc energy, small arcing time and freedom from fire hazards.

The GIS shall be designed, manufactured and tested in accordance with the best international engineering practices under strict quality control to meet the requirement stipulated in the technical specification.

Adequate safety margin with respect to thermal, mechanical, dielectric stress, dynamic short circuit fault and insulation coordination be maintained during design, selection of raw material, manufacturing process etc. so that the GIS provides long life with least maintenance. The complete switchgear shall be designed to manage the risks associated with it such that there shall not be any safety hazard to the employees in normal service and during inspection and maintenance.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

The switchgear panel shall be fully arc proof, free standing, floor mounted, fully compartmentalized, metal enclosed construction complying requirements of IEC 62271-200. Each circuit shall have a separate vertical panel with required compartments for circuit breaker, cable termination, main bus-bars and auxiliary control devices.

The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch (by human/animal) of any of its constituent live parts.

The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The Service Class Continuity of Switchgears shall be LSC-2 (as per IEC 62271-200), LSC 2B-PM (as per IEC 62271-200) will be preferable.

All necessary equipment required for Gas handling at site (if any), shall be arranged by the supplier at their own cost during commissioning and further servicing in GP.

All louvers (if provided), shall have very fine brass or GI mesh screen. Tight fitting gasket / gaskets are to be provided at all openings in relay compartment. Relays shall be draw out type fully flush mounted on the switchgear panels at a suitable height from operator point of view.

Switchgear shall have an Internal Arc Classification of IAC-A-FLR 25 KA, 1 sec. (as per EI guidelines all switchgear shall be at least 1.2 meters away from wall) The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Gas Pressure relief device/Explosion Vent/Pressure relief duct shall be provided for each SF6 gas compartment, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device/Explosion Vent/Pressure relief duct shall not however reduce the degree of protection of panels under normal working conditions.

The switchgear shall be cooled by natural air flow.

Total height of the switchgear panels shall be finalized during detail engineering in line with building design. The height of switchgear panel shall not be less than 2600 mm.

Suitable interlock & Indications shall be provided to prevent opening of any HT compartment doors, in case the incoming HT supply is ON.

Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the

insert plates shall be in Bidder's scope. The bidder may offer panels with built in base frame ready for dispatch and suitable for installation on indoor cable trenches.

The switch board shall have the facility for extension on both sides. (The facility of extension for additional breakers (to existing set up) in case of future expansion shall be provided.)

The manufacturer shall give guarantee for maximum leakage rate of SF6 gas will be lower than 0.1 % per year. SF6 gas leakage rate should not exceed 0.1% per annum after guarantee period. In case of Gas Leak the GIS should have the capability to withstand di-electric strength at 1bar pressure. Separate gas monitoring sensors should be available for all the gas filled chambers.

The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of it's constituent live parts Thermostatically controlled space heater with common MCB shall be provided for various compartments.

The panel complying ingress protection IP 65 for HV live part and IP 4X for LV compartment shall be constructed from corrosion-resistant stainless steel sheet of min 3 mm thickness, filled with SF6 accommodating the primary switching devices (VCB and Three position disconnecter cum earthing switch) and all live parts.

The interconnection of individual panels shall not require any gas work neither for installation at site nor for extension of the panel board. It shall be possible to extend the panel board on either side.

All the mechanical parts shall be surface treated to prevent corrosion.

The panels must be suitably treated and powder coated with 60-70 micron thickness, to achieve indoor worthiness and corrosion protection and should pass salt spray test for not less than 500 Hrs .

It shall be with pressure relief device with controlled direction of flow of the hot gasses generated in rare event of internal arc

The panel board with minimum gas pressure shall withstand the rated highest system voltage.

In case gas refilling is required, same shall be possible at site. A gas refilling kit comprising gas cylinder, manometer, reduction valve adopter, pressure measuring device, connecting and filling hose, etc shall be also be supplied under the scope of work.

In case gas handling at site is required as per the manufacturer standard minimum following tools shall be supplied for each switchboard at free of cost.

- Gas Handling DILO Machine
- Handheld gas detector
- Moisture Detection Meter
- SF6 Bottle

Temperature compensated gas density monitor shall be provided on the front side to monitor SF6 gas and for interlock purpose.

No any special tools shall be required for installing the equipment.

The design of the panel should be such that no permanent or harmful distortion occurs either when being lifted by eyebolts or when moved into position by rollers.

Paint shade of Indoor Switchgear shall be 694 as per IS: 5.SF6 gas pressure and density should maintained as per relevant IS and IEC, if gas pressure or density goes below specified limits, breaker should go in lockout mode.

2. BUSBAR AND INSULATORS

- 1) 33 kV busbar shall be housed in SF6 gas chamber only.

- 2) Busbar shall be made of electrolytic high grade Copper of adequate size and bus bar size calculation / supporting type test report shall be submitted for approval (current density of copper shall not exceed more than 1.6 Amp/sq.mm). They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.
- 3) Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators.
- 4) Bus bar cross-section shall be uniform throughout the length of switchgear board. Bus bars shall be in SF6 gas insulated compartment.
- 5) All piping for SF6 gas including their fittings shall be made of non-magnetic stainless steel housings.
- 6) Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. In case of organic insulator partial discharge shall be limited to 50 pico coulomb at rated Voltage $\times 1.1/\sqrt{3}$
- 7) All busbars shall have suitable phase identification. Bus switching scheme shall be as per Single Line diagram attached with bidding documents.
- 8) The temperature of the busbars and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of relevant Standards, duly considering the specified ambient temperature (50 deg C).
- 9) Clearances between phases and between phase and earth shall be kept liberally so as to obtain high reliability. However minimum clearances for 33 KV as shown below shall be kept.

Sr. No.		For busbar Chamber	For breaker Chamber
1.	Phase to Phase	127 mm	127 mm
2.	Phase to earth	77 mm	77 mm

- 10) If any special insulating material is proposed to achieve the effect of above clearances details of the same shall be furnished in the technical offer.
- 11) Test certificate of bus bar for rated STC rating shall be submitted, along with offer, otherwise necessary confirmation shall be given in the offer for submitting the same for approval of competent authority prior commencement delivery.

3. CIRCUIT BREAKER

- 1) SF6 circuit breaker shall be used for 33 KV GIS. It shall comprise of three single pole interrupting units or 3-pole interrupting unit, operated through a common shaft by a sturdy operating mechanism.
- 2) Circuit breaker shall be re-strike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. Anti-pumping features shall be provided for each breaker. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable. (No parallel interrupter)
- 3) Circuit breaker shall be provided with two trip coils.
- 4) Suitable indicators shall be provided on the front of panel to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring, SF6 gas density monitor for all gas compartments.

- 5) The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil shall operate satisfactorily at all values of control supply voltage between 80-120% of the rated voltage. The trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 70-120% of the rated voltage. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by indicating lamps and trip coil supervision relay.
- 6) The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor, a continuous sequence of closing and opening operations (CO) shall be possible. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the supply voltage is anywhere between 80-120% of rated voltage. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 55 deg. C ambient air temperature. The motor shall be provided with over load protection.
- 7) Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.
- 8) Tripping time < 40 ms Closing Time < 50 ms
- 9) Manual Spring Charging shall be provided. All the basic mechanical ON/OFF of Circuit Breaker, Disconnecter & earth switch operation, manual spring charge of Circuit Breaker must be possible without opening the door to ensure the operator safety
- 10) Breaker operations (Mechanical Endurance) as per relevant IS/IEC amended up to date.
- 11) The circuit-breaker has to control at least 10,000 Make-Break cycles without maintenance. The mechanical life and operating cycles of the vacuum interrupter shall confirm relevant IS/IEC amended up to date.
- 12) Tripping coil, closing coil and motor mechanism shall be easily accessible for maintenance purpose.

4. DISCONNECTOR AND EARTHING SWITCH

- 1) Each Switchgear panel shall be provided with three (3) position disconnecting-cum-earthing switch of required rating.
- 2) It shall be possible to control these switches from front of the panel & remotely from SCADA /PMS through IED.
- 3) Necessary indication shall be provided on the front of the panel for Close/Open status of the three position switches.
- 4) The safe, positive and foolproof interlocks shall be provided for personnel safety and equipment safety.
- 5) Key interlocks shall be provided for local manual operations.
- 6) Mechanical interlocks shall be provided for following conditions
- 7) Three position disconnecter cum earth switch cannot be operated when circuit breaker is closed.
- 8) The operating handle /lever cannot be removed until the switching operation has been completed.

- 9) Earthing shall be additionally secured against "de-earthing" by providing a padlock.
- 10) The cable compartment cover can only be opened if the panel is earthed.
- 11) In addition to above, relevant all electrical interlocks shall also be provided.
- 12) (Disconnecting switches shall be motor operated where SCADA is implemented) Isolators or isolators combined with earthing switches (3 position switches) shall be motor operated. In cases of emergency, manual operation must be possible.
- 13) The earthing position for all 3 phases must be visible via a mechanical position indicator (MIMIC) directly connected to the drive shaft on panel front Fascia. The mechanical operation of isolator / 3 position disconnect switch must be possible with door closed for operator safety.
- 14) The large view ports to be provided to make it easy to visually check the switching position and to ensure safety of operations thereof.

5. CONTROL AND INTERLOCKS

- 1) The circuit breaker shall normally be controlled remotely from PMS SCADA system through closing and trip coils. However, it shall also be designed to control locally from Indoor Switchgear panel. Suitable mimic on Panel shall be provided.
- 2) Facilities shall be provided for mechanical tripping of the breaker in an emergency. Facility shall also be provided for manual charging of the stored energy mechanism for a complete duty cycle.
- 3) Necessary mechanical & Electrical interlocks shall be provided between CB, Isolator & Earth switches for safe operation.
- 4) Each CB, Isolator & earth switch shall have 6 NO + 6 NC Auxiliary spare of good quality (corrosion free and easy for making connection) for future use by owner. It should be located at accessible position in panel.

6. EARTHING AND EARTHING DEVICES

- 1) The grounding system for GIS shall be designed and provided as per IEEE-80-2000 and CIGRE-44 to protect operating staff against any hazardous touch voltages and electro-magnetic interferences.
- 2) The earth busbar made of electrolytic high grade copper with cross sectional area of minimum 240 sq mm shall be provided at the bottom in all the panels and interconnected with adjacent panels in the panel board through a connecting link to form a common earth busbar for the entire panel board ready to connect to the substation earthing grid. It shall be welded to the framework of each panel and each breaker earthing contact bar. The earth bus shall have sufficient cross section (minimum 240 sq mm) to carry the momentary short-circuit and short time fault currents to earth without exceeding the allowable temperature rise.
- 3) Suitable arrangement shall be provided at each end of the earth bus for bolting to station earthing grid. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.
- 4) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.
- 5) All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth by independent stranded copper wires of size not less than 2.5 sq. mm. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable.

However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

- 6) PT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.
- 7) The panel shall have Voltage Presence Indicator (VPI) to warn the operator against earthing of live connections.
- 8) All hinged doors shall be earthed through flexible earthing braid.
- 9) Separate earthing for switchgear and C&R panel shall be provided.

7. INSTRUMENT TRANSFORMERS

- 1) All current transformers shall be ring type (epoxy/cast resin) whereas voltage transformers (PT) shall be cast resin insulated type.
- 2) Instrument transformers shall be suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.
- 3) All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules.
- 4) The parameters of instrument transformers specified in this specification are indicative and shall be finalized by the Employer during detailed engineering, considering the actual burden of various relays and other devices finally selected. In case the Bidder finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings without any cost implication.
- 5) All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.
- 6) All voltage transformers shall have suitable MCB on secondary sides.
- 7) The voltage transformers shall be inductive metal-enclosed transformers.

8. ENCLOSURE AND SEGREGATION

The bus bar system shall be designed with either one three phase or three single phase bus bar compartments.

Each cubicle shall be divided into at least under listed metal enclosed compartments with the following insulating medium:

- Busbar : Gas insulated
- Three position isolating switch : Gas insulated
- Circuit breaker : Gas insulated
- Connecting bushings for power cables : Gas insulated
- Cable compartment : Air insulated
- Low voltage compartment : Air insulated
- Drive Mechanism : Air Insulated

9. METERING, PROTECTION, INDICATION & AUXILIARY SWITCHES

General Requirements for Instruments

10. SCADA COMPATIBILITY

The panels shall be fully SCADA compatible

11. NUMERICAL PROTECTION RELAYS (IEDS)

Indoor switchgear panels shall have communicable numerical protection relays (IEDs) complying with IEC-61850 on all feeders which shall be networked on Ethernet to communicate with PMS SCADA system on IEC-61850. These IEDs shall also be used for control & monitoring the switchgear from PMS. In addition to status of devices (CBs/Isolators/Earth Switches) and equipment alarms, Metering data shall also be made available to PMS SCADA station from protection IEDs. Further, multifunction meters with IEC-61850 protocol are also envisaged, which will be connected in daisy-chain-link to communicate to station PMS. Modbus to Modbus TCP/.IP converters shall be provided for integration with PMS System.

The Bidder's scope shall include the followings:

1. Communicable Numerical Protection Relays (with IEC 61850 in each of the feeders & Bus-section/Bus coupler)
 - IED's / Numerical Relays shall have digital display, display to facilitate settings, relay operations and to view measurement, event and alarm etc.
 - Cat5e Ethernet cable for connection of Numerical Relays (IEDs) to Ethernet switches and Optical cable between Ethernet switch (for indoor switch gear IEDs) and ring/ redundant network of Substation LAN switch shall be used.
 - Required number of Ethernet switches mounted in Indoor Switchgear panels for communication with IEDs on IEC 61850 / protocol.
 - The PMS SCADA system has been envisaged as part of main substation. Bidder shall facilitate in successful Integration of Numerical Relays to the PMS SCADA system through Ethernet switches.
2. All Numerical relays shall be of proven design for the application satisfying requirements specified elsewhere and shall be subject to Employer's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity for the intended application.
3. All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Heavy duty binary output contacts of IEDs to be used for breaker close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays.
4. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal-operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.
5. All IEDs shall have freely programmable optically isolated binary inputs and potential free binary output contacts as per approved scheme. These I/O points shall be used for wiring of status of devices (CB/Isolator/Earth switch) and equipment alarms etc.

6. Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
7. Relays shall have event recording feature with Date & time stamping. Event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data. Relay shall have disturbance recorder.
8. All Numerical relays shall have features for electrical measurements of current.
9. Directional numerical relays shall have provision of both current (CT) and voltage (PT) inputs as required for protection & measurement purposes using protection cores.
10. All numerical relays shall have built-in key pad / keys to allow relay setting from relay front. Resetting of relay shall be possible from remote SCADA.
11. Relays shall have suitable output contact for circuit breaker failure protection (LBB: Local Breaker Backup) logic.
12. Relays shall have self diagnostic feature on display with continuous self check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.
13. Contractor shall submit applicable Type Test reports for Numerical relays as per IEC including report for IEC 61850 protocol from accredited lab.

12. CONTROL & PROTECTION SYSTEM

All numerical relays shall communicate to station SCADA / PMS on IEC- 61850 communication protocol. It is envisaged that these protection IEDs shall be used for CB control & monitoring of bay equipment's. The type test reports along with communication protocol shall be submitted as per relevant IS/IEC amended up to date.

13. NUMERICAL TRANSFORMER PROTECTION RELAY

1. The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements with standard inverse characteristics (1.3 and 3 Sec) IDMT.
2. The over current element should have the minimum setting adjustable between 20 -200% of CT secondary rated current with increment/decrement by 1 % and high set setting 100-2000%.
3. The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current (IDMT) and high set 100-1000%.
4. The relay shall have selectable directional & non-directional feature.
5. For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0 sec to 3 sec. in step of 0.01 s
6. The relay shall allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.
7. Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips etc. (as applicable) shall be wired independently to separate binary inputs of the relay and shall be configured to issue trip command to the breaker. Similarly alarm points shall be wired separately to binary inputs of the relay.
8. Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

14. NUMERICAL LINE PROTECTION RELAY

1. The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements with standard inverse characteristics (1.3 and 3 Sec) IDMT.
2. The over current element should have the minimum setting adjustable between 20- 200%(in step of 1%)of CT secondary rated current.
3. The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.
4. The relay shall have selectable directional & non-directional feature.
5. Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

15. NUMERICAL BUS COUPLER/BUS-SECTION PROTECTION RELAY

1. The relay shall have instantaneous as well as time delayed three over current (50) and one earth fault (50N) protection elements.
2. The over current element should have the minimum setting adjustable between 20-200 % (in step of 1%) of CT secondary rated current.
3. The earth fault element of relay shall be suitable for detection of earth fault currents in the range of 5% to 80% of the CT rated current.
4. No bus volt signal shall be configured in the relay for use in control logics and other Protections and Control functions in the Relays.
5. Trip circuit supervision shall be provided to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

16. OTHER CONTROL AND PROTECTIONS FEATURES

1. Control of breakers, three position Isolators & Earth switches shall be carried out from the station HMI of PMS/SCADA system through the LAN and the numerical relays.
2. The station HMI shall have a graphical dynamic Plant Key Single Line Diagram to view the complete system status. This shall include the status of the switchgears, measurement values, operation counters, graphical alarm representation, etc. Spontaneous changes of a state, typically opening of a circuit breaker from a protection, shall have a specific colour code. All the Breakers with the status shall be clearly displayed along with values of currents, voltages, and frequency, active and reactive powers etc.
3. Schematics requiring auxiliary relays / timers for protection function shall be part of numerical relay. Timer functions shall be configurable for on & off delays as per requirement.
4. The numerical relay shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a Date & time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
5. At least 100 time tagged events / records shall be stored with date & time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
6. Automatic testing, power on diagnostics with continuous monitoring shall be provided in the IED to ensure high degree of reliability. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be available on the user interface
7. The alarm/status of each individual protection function and trip operation including measurement values shall be communicated to the PMS SCADA system.

8. Sequence of events shall have 1ms resolution at device level.
9. It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.

17. ETHERNET SWITCH

1. Ethernet switches shall be 'substation hardened & managed type', and shall comply with IEC61850 for communications with IEDs. The Ethernet switches shall be of managed type with two (2) No. of Fiber optic cable ports and sufficient number of Copper ports (with 30% Spare) to achieve the LAN configuration. More no. of switches or higher ports switch can also be supplied to meet all IEDs & Multi-function meters requirements for the LAN. The Ethernet switches shall have features to support the redundant rings. These switches shall be mounted in the switchgear Panels. The FO ports shall be Single-mode 1000 Mbps ports. Copper ports shall be 10/100 Mbps ports.
2. Necessary network management software for configuration and real-time network monitoring shall be provided along with the Ethernet switches.

18. CONTROL WIRING

1. All wiring shall be carried out with 1100 volts grade with ISI mark single core, multi strand flexible tinned copper wires with non flammable, fire resistant PVC insulation. The conductor size shall be 4 sq mm for CT's and 2.5 sq mm (minimum) for other circuits. Wiring trough may be used for routing the cables. Wire numberings and colour code for wiring shall be as per IS:5578/1984. The wiring diagram for various schematics shall be made on thick and durable white paper in permanent black ink and same should be encased in plastic cover, thermally sealed. It should be kept visibly in a pocket of size 350 x 400 mm of MS sheet of 1 mm thickness, on the interior surface of the door of C & R Panel.
2. Internally mounted items including MCBs shall be provided with individual identification labels. Labels shall be mounted directly below the respective equipment and shall clearly indicate the equipment designation.
3. Further it shall be ensured that any control wiring if at all routed through the H.T chamber is properly insulated and provided with metallic barriers to prevent damages due to heat.

19. WIRING AND CONTROL WIRING TERMINALS

1. Terminal blocks shall be of clip-on design made out of non-trackable insulating material of 1100 V grade. All terminals shall be stud type, with all current carrying and live parts made of tinned plated brass. The studs shall be of min 4 mm dia tin plated brass. The washers, nuts, etc. used for terminal connectors shall also be of tinned plated brass.
2. The terminal connector/blocks shall be disconnecting type terminal connectors with automatic shorting of C.T. secondary terminals shall be provided in CT secondary circuit. All other terminal connectors shall be Non- disconnecting type. Terminal should be shock protected in single moulded piece. Terminal block should have screw locking design to prevent loosening of conductor.
3. At least 20% spare terminals shall be provided. All terminals shall be provided with ferrules indelibly marked or numbered and identification shall correspond to the designations on the relevant wiring diagrams. The terminals shall be rated for adequate capacity which shall not be less than 10 Amps for control circuit. For power circuit it shall not be less than 15 Amps.
4. All front mounted as well as internally mounted items shall be provided with individual identification labels. Labels shall be mounted directly below the respective equipment and shall clearly indicate the equipment designation. Labeling shall be on aluminum anodized plates of 1 mm thickness, letters are to be properly engraved.
5. All fuses used shall be of HRC type. The fuse base and carrier shall be plug-in type moulded case kitkat of bakelite/DMC. All current carrying and live parts shall be of tinned/nickel plated copper.

No fuse shall be provided on DC negatives and AC neutrals. Tinned copper links shall, however, be provided on DC negatives and AC neutrals and easily accessible for changes.

6. All MCBs as per IS:8828/1993 (amended up to date) of adequate rating shall be used of ISI marks.

20. SURGE ARRESTER

Surge arrester shall conform all the requirements and type test reports as per relevant IS/IEC (IEC-99-4 and ISS-3070 (part-III) amended up to date and as per technical specifications of UPCL.

21. LV COMPARTMENT

1. The panels shall be with low voltage compartment consisting control switches ,indication and metering instruments, protection relays and other secondary equipment's. The dynamic mimic shall be provided on the front fascia and not on the LV chamber.

2. The front side shall have Mimic as per single line diagram with control switches and mechanical and electrical 'Position indicators' circuit breakers, disconnectors and earth switches

3. Control switches/Push buttons shall be provided adjacent to respective equipment position indicators in Mimic for ON-OFF operation of circuit breakers, disconnectors and earth switches.

4. The SCADA compatible Multifunction Meters (MFM) shall be provided and to be integrated with substation Automatic System (either RS232 or RS 485)

5. Live line Indicators: - Capacitive voltage indicators shall be provided on feeder side in outgoing feeders, on bus side & feeder side in incoming feeders and on both the sides in Bus coupler to indicate the voltage presence in each phase and to prevent the closing of earth switch in case the part is live. It shall have sufficient output contacts for substation Automation System and interlock purpose.

6. Panel interlocking wiring cables shall be supplied with panels

7. End termination required for cables should be touch proof type, EURO mould.

22. SYSTEM PARAMETERS:

1	Nominal System voltage	33 KV
2	Highest System voltage	36 KV
3	Rated Frequency	50 Hz
4	Number of phases/ poles	Three
5	System neutral earthing (As per requirement)	As per Vector Group of transformers
6	One minute power frequency withstand voltage	70
7	1.2/50 microsecond Impulse withstand Voltage	170 kV (peak)
8	Short time rating for bus bars, CB, CT and switchgear Assembly.	25 kA (rms) for Three 3 Sec
9	Dynamic withstand rating	62.5 kA (peak)
10	IAC Rating	25 KA ,1.0 sec
11	Control supply voltage:	
a	Trip and closing coils	As per station DC Supply
b	Spring charging motor	As per station AC supply
12	Maximum ambient air temperature	50 deg. C

13	Degree of Protection	
a	HV-live parts	IP65
b	Low voltage compartments	IP4X

A. CIRCUIT BREAKER

1	Rated Voltage	33KV
2	CB rated Current	
A	Incomer Breaker	As per Design
B	Outgoing feeder Breaker	As per Design
3	Short circuit breaker Current:	
A	A.C. component	25kA for 3 sec
B	D.C. component	As per IS:13118 or IEC62271
4	Short Circuit making current	62.5kA(peak)
5	Out of phase breaking Current capacity	As per IEC
6	Rated line/cable charging Interrupting current at 90° Leading power factor Angle	As per IEC
7	Maximum allowable switching voltage under any switching Condition	As per IEC
8	Rated small inductive current Switching capability with over Voltage less than 2.3 Pu	As per IEC
9	First pole to clear factor	1.5
10	Operating Duty	O-0.3 Sec-CO- 3 Min-CO
14	Max. difference in the instants of closing/opening contact between poles at rated control Voltage and rated operating and quenching media pressures	As per IEC
15	Auxiliary contacts	6NO + 6NC for future use besides scheme requirement
16	Operating Mechanism	Motor wound Spring charged stored energy type as per IEC- 62271

B. CURRENT TRANSFORMER (Incomer and Bus coupler Feeder)

1	Rated primary voltage	33 KV
2	Rated primary current	800 A or as per detailed design
3	Type of CT	1-Phase
4	Max temp rise	As per IEC:60044-1

5	Class of Insulation	Class E or better
6	One minute power frequency withstand voltage between secondary terminal & Earth	3 kv
7	No. of Secondary cores	3

C. CURRENT TRANSFORMER (Line Feeder)

1	Rated primary voltage	33 KV
2	Rated primary current	400 A or as per detailed design
3	Max temp rise	As per IEC:60044-1
4	Class of Insulation	Class E or better
5	One minute power frequency withstand voltage between secondary terminal & Earth	3 kv
6	No. of Secondary cores	2

D. CURRENT TRANSFORMER (LT Transformer Feeder)

1	Rated primary voltage	33 KV
2	Rated primary current	100-50/5-5 A
3	Max temp rise	As per IEC:60044-1
4	Class of Insulation	Class E or better

E. VOLTAGE TRANSFORMERS:

1	Rated primary voltage	33 KV
2	Type	1-phase
3	Voltage ratio (kV)	$(33/\sqrt{3})/(0.11/\sqrt{3})$
4	Rated voltage factor	1.2 continuous and 1.5 for 30 seconds
5	Nos. of Secondary cores	2
6	Accuracy of Secondary core	0.5s
7	Class of insulation	Class E or better
8	Rated output burden (Minimum) or to cater all connected burdens of meters & relays.	50 VA or cater to connected burden as per clause no.11.4

23. ANNUNCIATOR

Annunciator facia units shall have translucent plastic windows for each alarm point.

Annunciator facia plate shall be engraved in black lettering with respective alarm inscription as specified. Alarm inscriptions shall be engraved on each window in not more than three lines and

size of the lettering shall be about 5 mm. The inscriptions shall be visible only when the respective facia LED is glow.

Annunciator facia units shall be suitable for flush mounting on panels. Replacement of individual facia inscription plate and LED shall be possible from front of the panel.

Each annunciator shall be provided with 'Accept', 'Reset' and 'Test' push buttons, colored red, yellow and blue respectively. Special precaution shall be taken by the supplier to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels.

In case 'RESET' push button is pressed before abnormality is cleared, the LEDs shall continue to glow steady and shall go out only when normal condition is restored.

Any new annunciation appearing after the operation of 'Accept' for previous annunciation, shall provide a fresh audible alarm with accompanied visual, even if the process of "acknowledging" or "resetting" of previous alarm is going on or is yet to be carried out. Provision for testing healthiness of visual and audible alarm circuits of annunciator shall be available.

Mounting	Flush
No. of facia windows	8
No. of windows per row	4
Supply voltage	30 V DC
No. of LEDs per window	2
Lettering on facia plate	Properly engraved

12 Window Annunciation Scheme to indicate following functions for Incomer 1, Incomer 2 and Bus coupler		
1	Main protection (O/C) Trip for incomer 1	1 no.
2	Main protection (E/F) Trip for incomer 1	1 no.
3	Main protection (O/C) Trip for incomer 2	1 no.
4	Main protection (E/F) Trip for incomer 2	1 no.
5	Main protection (O/C) Trip for Bus coupler	1 no.
6	Main protection (E/F) Trip for Bus coupler	1 no.
7	Spare (low gas pressure)	1 no
8	Spare (Fault passage Indicator)	1 no
9	Spare	1 no
10	Spare	1 no
11	Spare	1 no
12	Spare	1 no
20 Window Annunciation Scheme to indicate following functions for Power Transformer.		
1	Protection (O/C) Trip	1 no.
2	Protection (E/F) Trip	1 no.
3	Spare (low gas pressure)	1 no.
4	Spare (Fault passage Indicator)	1 no.
5	Transformer Differential Relay Trip	1 no.
6	Transformer Buchholz Relay	1 no.
7	Transformer Buchholz Relay Trip	1 no.
8	Transformer WTI Trip	1 no.
9	Transformer WTI Alarm	1 no.

10	Transformer OTI Alarm	1 no.
11	Transformer OTI Trip	1 no.
12	Transformer PRV Trip	1 no.
13	OLTC Buchholz Relay Trip	1 no.
14	Transformer MOG Alarm	1 no.
15	Spare	1 no.
16	Spare	1 no.
17	Spare	1 no.
18	Spare	1 no.
19	Spare	1 no.
20	Spare	1 no.

12 Window Annunciation Scheme to indicate following functions for Outgoing Feeder 1,2,3 & 4

1	Main protection (O/C) Trip for feeder 1	1 no.
2	Main protection (E/F) Trip for feeder 1	1 no.
3	Main protection (O/C) Trip for feeder 2	1 no.
4	Main protection (E/F) Trip for feeder 2	1 no.
5	Main protection (O/C) Trip for feeder 3	1 no.
6	Main protection (E/F) Trip for feeder 3	1 no.
7	Main protection (O/C) Trip for feeder 4	1 no.
8	Main protection (E/F) Trip for feeder 4	1 no.
9	Spare	1 no.
10	Spare	1 no.
11	Spare	1 no.
12	Spare	1 no.

12 Window Annunciation Scheme to indicate following functions for Outgoing Feeder 5,6,7 & 8

1	Main protection (O/C) Trip for feeder 5.	1 no.
2	Main protection (E/F) Trip for feeder 5.	1 no.
3	Main protection (O/C) Trip for feeder 6.	1 no.
4	Main protection (E/F) Trip for feeder 6.	1 no.
5	Main protection (O/C) Trip for feeder 7.	1 no.
6	Main protection (E/F) Trip for feeder 7.	1 no.
7	Main protection (O/C) Trip for feeder 8	1 no.
8	Main protection (E/F) Trip for feeder 8.	1 no.
9	Spare	1 no.
10	Spare	1 no.
11	Spare	1 no.

12	Spare	1no.

24. TYPE TESTS

Type tested as per relevant latest IEC standards 60056, 62271-102, 60265, 62271-200, 62271-105, 60529 and 60694 following type test reports shall be submitted with the technical bid. These tests must have been conducted on the offered item in the NABL approved laboratory within last seven years prior to date of validity of the offer.

Sr.No	Name of Test
A	Switchgear Panel (With Circuit Breaker installed)
i.	Short Circuit Duty test
ii.	Short time and peak withstand current test
iii.	Power frequency withstand test
iv.	Lightening impulse withstand test
v.	Temperature rise test
vi.	Internal Arc test as per IEC 62271-2009 for 1 second)
vii.	Measurement of resistance main circuit
viii.	Test to verify pressure relief operation of the panel (During internal arc test)
ix.	Cable charging test
x.	Short circuit withstand test of earthing device
xi.	Dielectric test
xii.	Capacitor bank current switching test
xiii.	Single phase making and breaking test
xiv.	Humidity Test
B	Circuit Breaker
i.	Mechanical Endurance Test
C	Current Transformer
i.	Short time current test
ii.	Temperature Rise test
iii.	Lightning impulse withstand test
D	Potential Transformer
i.	Temperature Rise test
ii.	Lightning impulse withstand test
E	Switchgear panel Degree of protection
i.	IP 4X test b) IP 65 for HV live Part
F	Tri vector Meter The Tri vector meter shall conform all the requirements and type test reports as per relevant IS/IEC amended up to date and as per technical specifications of UPCL.
G	Protection Relays The Protection Relays shall conform all the requirements and type test reports as per relevant IS/IEC amended up to date and as per technical specifications of UPCL.

H	Surge arrester Surge arrester shall conform all the requirements and type test reports as per relevant IS/IEC (IEC-99-4 and ISS-3070 (part-III) amended up to date and as per technical specifications of UPCL.

1. All the equipment's offered shall be fully type tested as per the relevant standards, amended up-to-date. The supplier shall furnish the type test reports and certificate of accreditation issued by the testing authority along with the offer. These tests must not have been conducted earlier than five years from the date of opening of bids.
2. In case these type tests are conducted earlier than seven years, all the type tests as per the relevant standards shall be carried out by the successful bidder in the presence of purchaser's representative at free of cost before commencement of supply. The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for rejection.
3. The Purchaser reserves the right to demand repetition of some or all the type tests in the presence of his representative. For this purpose the supplier may quote unit rates for carrying out each type test.

25. INSPECTION

1. The inspection may be carried out by the purchaser at any stage of manufacture. The successful Tenderer shall grant free access to the purchaser's representative/s at a reasonable notice when the work is in progress. Inspection and acceptance of any equipment under this specification by the purchaser, shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.
2. The supplier shall keep the purchaser informed in advance, about the manufacturing program so that arrangement can be made for stage inspection.
3. The purchaser reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The supplier shall keep the purchaser informed, in advance, about such testing program.

26. FACTORY ACCEPTANCE & ROUTINE TESTS:

1. All acceptance and routine tests of equipment given in bill of material as per relevant IS/IEC standards shall be carried out by the supplier in the presence of purchaser's representative without any extra cost to the purchaser. (Note:- All measuring/testing equipment's shall be of appropriate class of accuracy and shall have valid calibration certificates which shall be produced to the Inspecting Officer for verification.)
2. After finalization of the program of type/acceptance/routine testing, the supplier shall give three weeks advance intimation to the purchaser, to enable him to depute his representatives for witnessing the tests.
3. The following Factory Acceptance Tests shall be carried out during inspection
 - a) Withstand Voltage at power frequency
 - b) Measurement of resistance of main circuit
 - c) Partial discharge test
 - d) Withstand voltage on the auxiliary circuits
 - e) Operational checks as per schematics
 - f) Operations of interlocks, signaling devices and auxiliary devices

- g) Operation of VCB and three position Disconnecter cum earth switch
- h) Verification of wiring
- i) Visual inspection

27. QUALITY ASSURANCE PLAN

The tenderer shall invariably furnish information along with his offer, failing which his offer shall be liable for rejection. Information shall be separately given for individual type and current rating of circuit breaker/CTs/PTs/Panel mounting & accessories.

Statement giving information about names of sub-suppliers, list of testing standards, list of tests normally carried out in presence of tenderer's representative and copies of test certificates in respect of following items of raw-materials.

Contact material : Porcelain

Information and copies of test certificates in respect of bought out accessories.

List of areas in manufacturing process, where joint stage inspections are normally carried out by the tenderer/purchaser for quality control and details of such tests and inspections.

Special features provided in the equipment to make it maintenance free.

List of testing equipment's available with the tenderer for final testing of breakers vis-à-vis. the type, special, acceptance and routine tests specified herein. The limitations in testing facilities shall be very clearly brought out in schedule-E i.e. schedule of deviation from specified test requirement.

The successful tenderer shall, within 30 days of placement of order, submit following information to the purchaser.

List of raw materials as well as bought out accessories and the names of sub-suppliers selected from those furnished along with the offer.

- a) Type test certificates of the raw material and bought out accessories.
- b) Quality assurance plan (QAP) with hold points for purchaser's inspection. The quality assurance plan and purchaser's hold points shall be discussed between the purchaser and supplier, before it is finalized.

The successful tenderer shall submit the routine test certificates of bought out accessories at the time of routine testing of the fully assembled breaker for the goods manufactured within purchaser's country. The supplier shall also submit the central excise passes for the raw material at the time of routine testing of the fully assembled breaker.

28. PERFORMANCE GUARANTEE:

The equipment's offered shall be guaranteed for satisfactory performance for a period of 66 months from the date of receipt of complete equipment at destination store/site in good condition or 60 months from the date of satisfactory commissioning of equipment whichever is earlier. The equipment's found defective/failed within the above guarantee period shall be replaced/repared by the supplier free of cost within one month of receipt of intimation. If the defective/failed equipment's are not replaced/repared as per the above guarantee clause, the company shall recover an equivalent amount plus 15 % supervision charges from any of the supplier's bills.

29. DOCUMENTATION:

All drawings shall conform to international standards organization (ISO) 'A' series of drawing sheet/Indian Standards Specification IS 656. All drawings shall be in ink and suitable for micro filming. All dimensions and data shall be in System International Units.

DRAWINGS:

The tenderer shall furnish four sets of relevant descriptive and illustrative published literature/pamphlets and the following drawings for preliminary study:

- a) General outline drawings showing outside dimensions, shipping dimensions, weights, and quantity of insulating media air receiver capacity and such other prominent details.
- b) Sectional views showing the general constructional features of the circuit breaker including operating mechanism, arcing chambers, contacts, with lifting dimensions for maintenance.
- c) Schematic diagrams of the scheme for control, supervision and reclosing.
- d) Structural drawing, design calculations and loading data for support structures.
- e) Foundation drilling plan and loading data for foundation design.
- f) Technical specifications of equipment and special tools explaining construction features, principle of operation, special features etc.
- g) Comprehensive QAP,GA,SLD/BOQ ,Gas schematic diagram, technical brochures, building requirements, earth mat design, list of recommended spares, special tools or fixtures, O&M manuals, environmental guide for handling SF6 gas & decommissioning, estimated time schedule for installation & commissioning & operation of complete GIS
- h) Type test reports of circuit breakers along with a separate list showing all the tests carried out with date & place of test.
- i) Test reports, literatures and pamphlets of bought out items and raw materials.

SECTION: 6 TECHNICAL SPECIFICATION FOR 11KV, VCB SWITCHGEAR PANELS (AIS) – INDOOR

1. SCOPE

- a) The section covers the specification of metal clad indoor vacuum type switchgear unit with horizontal draw out circuit breaker as per IS 13118 [1991] / IEC 62271-100/ IEC 62271- 200 or latest amendment thereof. The equipment offered shall be of high quality, sturdy, robust and of good design and workmanship complete in all respects and capable of performing continuous and satisfactory operations in the actual service conditions at site and shall have sufficiently long life in service as per statutory requirements.
- b) All equipment shall be suitable for satisfactory operation in tropical climates and hot and humid atmosphere prevailing in the location where it shall be used against the Contract. The equipment shall be able to withstand a wide range of temperature variations in the required location.
- c) The equipment offered shall be complete with all parts necessary for their effective and trouble-free operation. Such parts shall be deemed to be within the scope of the supply irrespective of whether they are specifically indicated in the commercial order or not.
- d) All the plant / apparatus / equipment supplied shall comply in all respect with the requirement of Indian Electricity Act 2003 and Indian Electricity Rule 2003/IS and latest amendment thereof during the execution of contract where-ever applicable.

2. SYSTEM CONDITIONS

- a) The switchboard shall be metal enclosed, floor mounting, single front self supporting cubical type suitable for indoor. The switchgear shall be easily extendable in future.
- b) The switchgear assembly shall be designed for the power system having the following parameters.

- Nominal system voltage : 11KV
- Highest system voltage : 12KV

- Number of phases : 3
- Frequency : 50 Hz + 3%.
- System earthing : Solidly earthed neutral

3. SERVICE CONDITIONS:

Short Current Rating : 25kA for 3 seconds

Maximum altitude above sea level	400m
Minimum ambient air temperature	50°C
Maximum daily average ambient air temperature	45°C
Minimum ambient air temperature	36° C

4. STANDARDS:

The circuit Breaker shall confirm to the latest revision with amendment available of relevant standards, rules, and code. Some of which are listed herein for ready reference.

Sl. No.	Standard	Item
1	IEC- 62271-100/200 / IS-13118 (1991)	High Voltage Alternative current circuit breaker.
2	IS-2705 (1992)	Current Transformer
3	IS-3156 (1992)	Voltage Transformer
4	IS-3231 (1987)/IEC 60255 (All parts) IEC 61850 Ed-II	Numerical Relays
5	IS-1248	Ammeter & Voltmeter
6	IS-375	Arrangement of Breakers Bus Bars main connection and auxiliary wiring.

5. GENERAL TECHNICAL/CONSTRUCTIONAL REQUIREMENTS

5.1. GENERAL REQUIREMENTS

a) The switchgear shall be of CRCA steel / corrosion proof aluminum-zinc construction with sheet not less than 3 mm thickness for load bearing section and not less than 2mm thickness for non-load bearing and shall totally dust and vermin proof. However, if vendor has standardized the thickness of enclosure other than above mentioned and it meets the performance requirements and the design has been established through type test, the same shall be accepted. The panels shall be rigid without using any external bracings. The switchboard panels should comply with relevant IS / IEC and revision thereof and shall be designed for easy operation maintenance and further extension. Each circuit shall have a separate vertical panel with distinct compartments. Bus bar, metering, circuit breaker chamber, cables and cable box chamber should have proper access for maintenance and proper interlocks should be provided. All instruments (Except the Relays) shall be non-draw out type and safe guard in every respect from damages and provided with mechanical indicator of connection and disconnection

position. The switchgear shall be completed with all necessary wiring, fuses, auxiliary contacts, terminal boards etc.

b) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction, comprising of row of freestanding floor mounted panels. The adjacent panels shall be completely separated by steel sheets except in busbar compartments where insulated barriers shall be provided to segregate adjacent panels. The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED, TEST or removed, and all doors and covers closed. All doors, removable covers and glass windows shall be gasketed all round with synthetic rubber or neoprene gaskets.

c) The arcing contacts and bus bar should be rated for 25KA faults for 3 seconds for 11kV system. Bus bars shall be capable of connecting one switchgear panel to other through proper insulated arrangement. The panels shall be modular in design.

d) The breakers should be able to be drawn out in horizontal position at ground level [with vertical/horizontal isolation]. When breaker is drawn out in horizontal position none of the live components inside the 11KV switchgear panel should be accessible. The safety shutters shall be robust and shall automatically cover the live components when the breaker is drawn out. The switchgear shall have complete interlocking arrangements at the fully inserted and fully drawn out and test positions. Withdrawal of the breaker should not be possible in ON position, it should not be possible to close the circuit breaker in service unless the entire auxiliary and control circuit are connected.

e) Circuit breaker shall be vacuum; draw out type housed in a separate cubicle of the switchboard and shall be enclosed from all sides. A sheet steel hinged lockable door shall be at the front. It shall be possible to withdraw the circuit breaker to 'Test' and "Isolated" position with the door closed. Door interlock shall be provided such that the door can only be opened after withdrawing the breaker to 'Isolated' position and the

f) breaker cannot be racked into the 'Service' position unless the door is closed. A visual indication as to show when the breaker is in 'Service', 'Test' or 'Isolated' position shall be provided in front of the door.

g) Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

h) The breaker and the auxiliary compartments provided on the front side shall have strong hinged doors, busbar and cabling compartments provided on the rear side have bolted compartment covers with self retaining bolts. Breaker compartment doors shall have locking facility.

i) Built-in / separate trolley mounted earth switches for incomer (busbar earth) and outgoing (feeder cable earth) shall be provided.

j) All the high voltage compartments must have pressure discharge flap for the exit of gas due to internal arc to insure operator safety. All the HV compartment design shall ensure conformity to IEC-60298 and must be type tested at 26.3 kA for 1 second for IAC classification and duration as per IEC As per IEC 62271-200 clause A. 4.5 (AFLR).

k) Two separate earthing terminals shall be provided in each panel and shall be connected to the earth bus within the panel. The earth bus shall be of copper and shall have adequate cross sectional area.

l) The bus PT/relay compartments shall have degree of protection not less than IP:52 in accordance with IS:2147. However, remaining compartments can have a degree of protection of IP:42. All louvers if provided shall have very fine brass or GI mesh screen, IPH-2 degree of protection as per IS: 3427 to all live parts shall (whether isolated or removed from panel) even when the breaker

compartment door is open. Tight fitting garments / gaskets are to be provided at all openings in rely compartment.

m) Total height of the switchgear panels shall not exceed 2600 mm. The height of switches, pushbuttons and other hand-operated devices shall not exceed 1800 mm and shall not be less than 700mm.

n) Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and levelled when the flooring is being done, welding of base frame to the insert plates shall be as per approved installation drawings.

o) The switchboard shall have the facility of extension on the both sides of Adapter panels and dummy panels required to meet the Busbar.

5.2. BUS BARS AND CONNECTORS

a) Bus bars and all other electrical connection between various components shall be made of electrolytic copper of rectangular / tubular cross sections, as per the type tested and ratified design. The bus bars section should have ample capacity to carry the rated current of minimum 2000 Amps in panel current rating at an ambient temperature of 40 deg C, continuously without excessive heating and for adequately meeting the thermal and dynamic stresses in the case of short circuit in the system up to full STC rating of 25kA for 3 sec. The Current density of 1.6Amps/sq. mm shall be considered for the bus bars.

b) All bus bars connections shall be firmly and rigidly mounted on suitable insulators to withstand short circuit stresses and vibrations. 'Self-supported busbar' design will be acceptable if the same is ratified by type tests for the specified rating and busbar support drawings approved during type tests shall be furnished with the offer.

c) All fasteners (Nuts Bolts) used for bus bar connections shall be of non-magnetic stainless steel. Only belleville type washers shall be provided for each nut bolt. If the fasteners used are not of stainless steel the bidder shall state in their offer the material used and confirm that the same is non-magnetic and is superior to stainless steel.

d) Adequate clearance between 11 kV point and earth and between phase shall be provided to ensure safety as per provision in Indian Electricity Rule 2003 and its amendment thereof and also in accordance with the relevant Indian standard specification and the same shall be capable of withstanding the specified high voltage tests as per IEC 62271-200 / IS 13118 and amendment thereof.

e) Sharp edges and bends either in the bus bars or bus bar connections shall be avoided as far as possible. Wherever such bends or edges are un-avoidable, suitable compound or any other insulation shall be supplied to prevent local ionization and consequent flashover.

5.3. CIRCUIT BREAKER:

a) The vacuum circuit breaker shall be draw out type suitable for installation in the switchgear cubicles (indoor). The breaker shall comply with IEC 62271-100 / IS- 13118 (1991) for circuit breaker and IEC 62271-200 for the switch gear and latest amendment thereof. Construction of breaker shall be such that the points, which require frequent maintenance, shall be easily accessible.

b) The circuit breakers shall be spring operated, motor/manually charging of the spring feature, manually released. VCB shall have spring closing mechanism for 3 pole simultaneous operation. The speed of closing operation shall be independent of the speed of hand operating level. The indication device shall show the OPEN and CLOSE position of breaker visible from the front of cubical.

c) The circuit breakers shall be type tested as per IEC 62271 for compliance with the following requirements :

- **E2 class:** The circuit breakers shall not require maintenance of the interrupting part of the main circuit during its expected operating life;
- **C2 class:** The circuit breakers shall have very low probability of restrike during capacitive current breaking.
- **M2 class:** The circuit breaker should require very limited maintenance and should be tested for endurance for 10,000 close – open operations.

d) The breakers shall be capable of making and breaking the short time current in accordance with the requirement of IEC 62271-100 / IS 13118 (1991) and latest amendment thereof and shall have three phase rupturing capacity of 25KA for 3 second at 11 KV. The continuous current rating of all current carrying parts of breaker shall be 2000 Amps for all items. The total break / make time shall be not more than 4 cycles for break and 6 cycles for make time for all breakers.

e) Circuit breaker shall be suitable for rapid reclosing cycle i.e. O-0.3 sec.-CO-30 sec.- CO.

f) The spring release coil for VCB close and VCB trip coil shall both be rated for continuous energization at the rated close / trip voltage. Trip and close coil shall be suitable for 110 V DC.

g) The vacuum circuit breakers shall ensure high speed extinction and adequate control of pressure during breaking of current and also designed to limit excessive over voltages.

h) Comprehensive interlocking system to prevent any dangerous or inadvertent operation shall be provided. Isolation of circuit breaker from bus bar or insertion into bus bar shall only be possible when the breaker is in the open position.

i) Vacuum Circuit Breaker shall have completely sealed interrupting units for interruption of arc inside the vacuum. The vacuum interrupter sealed for life.

j) Vacuum interrupter should have an expected life of 30000 operations at rated current and should be capable for operating at least 100 times at rated short circuit current.

k) Vacuum interrupter technical data sheets & outline drawing particularly provided by the manufacturer should also be provided with Bid.

l) The circuit breaker shall be provided with motor for spring charging operation. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC and 110 V DC Supply.

m) All circuit breakers shall have mechanical ON/OFF indicator and spring charge indicator. These shall be visible from the front without opening the panel door. Also there shall be provision for mechanical (manual) tripping and also for manual charging of the springs.

5.4. CURRENT TRANSFORMERS:

a) The requirement of ratio, VA capacity, class or accuracy, limit factor etc. for resin cast CTs installed in different type of units are tabulated below:

Item	Core / CT	Ratio	VA Burden
IncomingPanel	Metering	800/1A	2.5
	Protection	800/1A	10
	Protection	800/1A	10
OutgoingPanel	Metering	400-200/1A	2.5
	Protection	400-200/1A	10

- b) Primaries shall be wound or bar or window type, rigid, high conductivity grade copper conductor. Unavoidable joints on the primary conductor shall be welded type, preferably lap type. The current density at any point shall not exceed 1.6 A/sq. mm.
- c) The Insulation level of all the CTs shall be : 12/28/75 kV and the Class of Insulation shall be "E".
- d) Short time current rating of CTs shall correspond to 25KA faults for 3 seconds of 11kv system. CTs shall be triple / double core and dual ratio. Instrument safety factor for metering core shall not exceed 2.5.
- e) The designed accuracy should be available even at the lowest ratios.
- f) The secondary terminal of the current transformers shall be such that effective and firm wire terminations are possible. Shorting links of adequate capacity shall be provided at the terminal blocks for sorting of the leads from secondary terminals of current transformers. The secondary terminal of the CTs shall be earthed at one point.
- g) CTs shall conform to IS 2705 with latest amendment and relevant IEC standard, if any in all respect and will be subjected to all routine and type test specified in the IS/IEC.
- h) The CTs shall be resin/epoxy cast. Contact tips on primary terminals shall be silver plated. Correct polarity shall be invariably marked on each primary and secondary terminals.
- i) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be atleast 10 mm.

5.5. POTENTIAL TRANSFORMERS

- a) 1 No. 3 phase resin cast, draw out type, bus bar connected, potential transformer of 5-limb construction, ratio 11000/110 volts, class 0.5 accuracy at 50 VA output per phase, complete with HT HRC fuse and Triple Pole & Neutral MCB, rated 1 Amp, with monitoring contacts on PT LV circuit. Primary and secondary neutrals of the PT must be brought out and earthed. If required, the busbar connected P.T. may be housed in a separate cubicle. PT mounted on top of the panel will not be acceptable.
- b) H.V side shall be connected in star formation and L.V. side in star/open delta formation.
- c) PT may be provided in a separate compartment. The primary and secondary contacts (moving & fixed type) shall have firm grip while in service. Service position locking mechanism shall be provided and indicated by bidder in relevant drawing. Rigidity of primary stud point with earth bus in service position shall be confirmed.
- d) Contact tips of primary/secondary contacts shall be silver plated. Correct polarity shall be distinctly marked on primary and secondary terminal
- e) Secondary terminal studs shall be provided with at least three nuts, two plain and two spring washers for fixing leads. The stud, nut and washer shall be of brass, duly nickel plated. The minimum outside diameter of the studs shall be 6 mm. The length of at least 15 mm shall be available on the studs for inserting the leads. The space clearance between nuts on adjacent studs when fitted shall be at least 10 mm.
- f) Details of PTs
 - IS: 3156 and relevant IEC standard.

- Ratio: 11KV/ $\sqrt{3}$ /110V/ $\sqrt{3}$
- No. Of phases: 3 Phases / star - star connected.
- Insulation level : 12/28/75 kV
- Class of Insulation : Class E
- Rated voltage factor: 1.2 continuous & 1.5 for 30 Sec.
- Rated Burden : 100 VA per phase
- Class of accuracy: 0.5
- Purpose : Metering
- Primary wiring of the PTs shall be protected by suitable H.R.C. fuse.
- Each secondary core will be protected by suitable MCB.

Two sets of 11 KV/110V PT's shall be provided

5.6. PROTECTION RELAYS:

a) All relays shall conform to the requirements of IS: 3231 / IEC-60255/ IEC 61850. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. The relay for entire project shall be of same type. The relays shall be numerical protective & communicable type. Composite relay unit having O/C, E/F & directional element etc. shall be preferred. Relays should have USB / ethernet communication port and RS485 serial communication port for communication through IEC 61850 Ed II (with high-speed GOOSE communication and certified by KEMA/CPRI certificate level A for IEC 61850 compliance). Licensed version of the relay software should be provided as per user's requirement.

5.7. CIRCUIT BREAKERS CONTROL SWITCH:

- a) Circuit Breakers Control Switches should have finger touch proof terminals. For the convenience of maintenance, screw driver guide should be from top/bottom of the switch and not from the side. Terminal wire should be inserted from the side of the switch terminal.
- b) Terminal screws must be captive to avoid misplace during maintenance.
- c) Switch shall be with 48 mm x 48 mm escutcheon plate marked with Trip & Close.
- d) Circuit Breakers control switch shall be non- discrepancy type
- e) Trip-neutral-close, with pistol grip handle must be pushed in to spring return to either trip or close position from Neutral position for safety and not just turn to trip.
- f) One contact to close in each position of Trip and Close. Contact not required in Neutral position. Contact rating shall be 12A at 110V DC

5.8. CUBICLE

- a) The switchgear cubicle (panel) shall be free standing floor mounting indoor type. There shall be sufficient reinforcement to have level surfaces resistance to vibration and rigidity during transportation & installation.
- b) Design & construction of the switchgear panel shall be of the highest order. All sheet steel work shall be treated as per the seven tank process before applying primary coating. For the final coat (stowed) epoxy paint color shade of RAL 7032 shall be used. All panel boards in the substation shall be in the same color. The panels after final painting shall present an aesthetically pleasing appearance, free of any dent or uneven surface.

- c) Power cable compartment shall be provided at the rear of the switchgear panels and shall be suitable for cable entry from the bottom cable trenches. Rear bottom plates of the cable compartment shall be fitted with removable gland plates of adequate size for fixing the cable glands.

5.9. AUXILIARY/CONTROL WIRING:

- a) All the secondary wiring in the panel shall be 1100 volts grade single core, multi-strand flexible tinned copper wires have high quality PVC insulation and the same shall have conductor size of not less than 2.5 mm² of copper. Colours of the secondary/auxiliary wiring should confirm to IS 375/1963 and latest amendment thereof if any. All wiring shall be neatly run and group of wiring shall be securely fixed by clips so that wiring can be checked without necessity of removing the clamps. Wiring between fixed and moving portion of the panel shall be run in flexible tubes and the same shall be so mounted to avoid any damage to them due to mechanical movements. Ferrules with number shall be provided on both end of the wiring.
- b) All front mounted as well as internally mounted items including MCBs shall be provided with individual identification labels. Labels shall be mounted directly below the respective equipment and shall clearly indicate the equipment designation.
- c) Terminal blocks shall be of screw type design made out of non-trackable insulating material of 1100 V grade. All terminals shall have all current carrying and live parts made of tinned plated brass. The washers, nuts, etc. used for terminal connectors shall also be of tinned plated brass.
- d) At least 20% spare terminals shall be provided. All terminals shall be provided with ferrules indelibly marked or numbered and identification shall correspond to the designations on the relevant wiring diagrams. The terminals shall be rated for adequate capacity which shall not be less than 10 Amps for control circuit. For power circuit it shall not be less than 15 Amps.
- e) All fuses used shall be of HRC type. The fuse base and carrier shall be plug-in type moulded case kitkat of bakelite/DMC. All current carrying and live parts shall be of tinned/nickel plated copper. No fuse shall be provided on DC negatives and AC neutrals. Tinned copper links shall, however, be provided on DC negatives and AC neutrals.
- f) All MCBs as per IS:8828/2006 (amended upto date) of adequate rating shall be used.
- g) Auxiliary supplies available at the various sub-stations are as follows: -

Rating:

1	A. C. Supply	240 volts with $\pm 10\%$ variation
2	D.C. Supply	110 V DC with +10% to – 15% variation
3	Frequency 50 Hz	with $\pm 3\%$ variation

5.10. MARKING OF PARTS:

For facilitating the erection, the several parts of the plant and equipment shall be suitably marked.

5.11. NAME PLATE AND DIAGRAM PLATES:

All equipment shall have weather proof and non-corrosive metal plates fixed in suitable position with full particulars engraved thereon with white letters against black background. The firm shall affix a name plate on each Switchgear panel having following information:

- Manufacturer's name and trade mark.
- Serial No.

- Type of Panel.
- CT Ratio.
- Rated Voltage.
- Rated Insulation Level
- Rated Frequency
- Rated Normal Current
- Rated Short Circuit Breaking Current.
- Weight
- Specification No.
- Order No. and Date
- Year of supply.
- Property of AKIC

5.12. PAINTING:

a) All metallic surface [except corrosion resistant aluminium-zinc material and enamelled and bright parts] exposed to weather shall be given suitable primer coat and two coats of first quality paint of approved colour. The supplier shall also supply adequate quantities of paints, varnish etc. for use of finished cost and for use of patching up any scratches received during transport, handling erection testing and commissioning.

b) Instead of above proper powder coating after proper pretreatment is acceptable and in that case earlier condition will not applicable.

5.13. ANNUNCIATION SYSTEM:

Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification i.e. 110 volts dc for new substation or as existing dc supply system of the utility audible annunciation for the failure of dc supply to the annunciation system shall be provided and this annunciation shall operate on 240 Volts ac supply. On failure of the dc supply to the annunciation system, a bell shall immediately sound. A separate push button shall be provided for the cancellation of this audible alarm alone but the LED lamp shall remain steadily lit till the supply to annunciation system is restored.

A separate dc supply operated relay shall be provided to monitor the failure of supply 240V ac supply to the scheme mentioned in Clause above. In case of failure of ac supply, this relay shall initiate visual and audible annunciation. This annunciation shall operate on annunciator DC and buzzer shall sound.

6. TESTS:

The equipment offered should have been successfully type tested at NABL accredited laboratories for following tests in line with the relevant standard and technical specification, within the last 5 (five) years from the date of offer.

The design of circuit breaker shall be proven through all the routine and in accordance with IEC 62271-100 / 200 / IS 13118: 1991 and any amendment thereof. Photocopy of all the test reports must be enclosed with the tender. Type test report earlier than 5 years from the date of tender opening shall not be acceptable. The bidder shall be required to submit complete set of the following type test reports along with the offer.

TYPE TESTS:

- a) Lightning Impulse Voltage withstand Test.
- b) H.V. dry 1 min power frequency withstand test.
- c) Short time and peak withstand current test.
- d) Short circuit test with basic duties.
- e) Single phase breaking capacity test.
- f) Temperature Rise test.
- g) Seismic Level Test.

Circuit Breaker:

Each circuit breaker shall be fully type tested as per IEC 62271 - 100/200, including the following tests:

- a) Short time and peak withstand current test.
- b) Short circuit breaking capacity and making capacity.
- c) Capacitive current switching test: Cable charging current breaking test (U_r less than or equal to 52 kV).
- d) Dielectric test i.e., power frequency with stand and impulse withstand test.
- e) Temperature rise test.
- f) Mechanical Endurance Test at ambient temperature.
- g) Measurement of resistance of the main circuit.
- h) Internal arc test (ALFR).

Current Transformer:

- a) Short Time Current Test.
- b) Impulse Voltage Withstand Test.
- c) Temperature Rise Test

Potential Transformer

- a) Impulse Voltage Withstand Test
- b) Temperature Rise Test

Switchgear Panel

- a) IP 4X Test

7. INSPECTION:

The inspection may be carried out by the purchaser at any stage of manufacture. The contractor/manufacturer shall grant free access to the purchaser's representative/s at a reasonable notice when the work is in progress. Inspection and acceptance of any equipment under this specification by the purchaser shall not relieve the supplier of his obligation of furnishing equipment in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective.

The supplier shall keep the purchaser informed in advance, about the manufacturing program so that arrangement can be made for stage inspection.

The purchaser reserves the right to insist for witnessing the acceptance/routine testing of the bought out items. The supplier shall keep the purchaser informed, in advance, about such testing program.

8. PERFORMANCE GUARANTEE:

All equipment supplied against this specification shall be guaranteed for a period of 66 months from the date of receipt at the consignee's stores centers or 60 months from the date of commissioning, whichever is earlier. However, any engineering error, omission, wrong provision, etc. which do not have any effect on the time period shall be attended to as and when observed/pointed out without any price implication.

DRAWINGS & DOCUMENTATION

1. The successful tenderer shall submit 3 sets of complete drawings along with detailed bill of materials for approval. If any modifications are required on these, the same will be conveyed to the supplier who shall modify the drawings accordingly and furnish final drawings for approval.

a) List of drawings to be submitted along with the offer are as under:

- GA of indoor 11 panel Switchgear.
- Typical single line diagram for 11 panel Switchgear.
- Sectional view of incomer, bus coupler & feeder panels.
- GA of Circuit Breaker truck.
- GA of Current Transformer
- GA of Potential Transformer.
- A. Drawing for Control Desk.
- Bill of material for complete switchgear.
- Technical particulars of Switchgears.

b) Successful tenderer shall furnish all above drawings and following additional drawings for approval before commencement of supply.

- Foundation details.
- Equipment door layout for incomer, bus coupler & feeder panels.
- Schematic Diagram for incomer bus coupler & feeder section of Switchgear
- Protection Circuit for incomer bus coupler & feeder section of Switchgear
- DC control circuit for incomer, bus coupler & feeder section.
- Metering circuit for incomers, bus coupler & feeder section.
- Annunciator and Alarm scheme.
- P.T. supply change over scheme.
- Terminal block details for incomer, bus coupler & feeder section.
- Cross section view for CTs.
- Name Plate & Connection diagram for CTs.
- Cross section view for PTs.
- Schematic Diagram for Control Desk.
- A. Drawing for Chair.

- G. A. Drawing for Sliding Door Unit.
- c) The manufacturing of the equipment shall be strictly in accordance with the approved drawings and no deviation will be permitted. All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawings shall be at the supplier's risk.
- d) After approval of the drawings and bills of materials, the suppliers shall submit detailed packing lists for approval. After approval, copies of these packing lists shall be forwarded to the respective consignees.
- e) Six set of final drawings, bill of materials, wiring schedules, technical literature and commissioning manuals shall invariably be forwarded to the consignee along with each panel consignment, and shall be listed out in the packing list when submitted for approval. All drawings shall preferably be of A3 size. In case the supplier fails to furnish contractual drawings and manuals even at the time of supply of equipment, the date of furnishing of drawings/manuals will be considered as the date of supply of equipment for the purpose of computing penalties for late delivery.

GUARANTEED TECHNICAL PARTICULARS FOR 11KV AIS Panel

The Bidder shall furnish the following technical details along with the relevant leaflets, test certificates etc.

Sl. No.	Description	Department Specifications	To be filled up by the Bidder
			12kV Switchgear
1.0	AMBIENT CONDITIONS		
1.1	Temperature (Design) :	50°C	
1.2	Max. Average relative humidity measured over one month	90%	
1.3	Climatic condition: High Seismic zone	Minimum type tested for Seismic Zone 4	
2.0	SWITCHGEAR ASSEMBLY		
2.1	Type	Metal-clad,	
2.2	Service/Installation	Indoor	
2.3	Reference standard	IEC62271-200	
2.4	Short Circuit rating		
	a. Interrupting Symmetrical short circuit current	25kA (11kV)	
	b. Short time for 3 Secs. KA rms	25kA (11kV)	
2.5	Insulation Level		
	a. Impulse withstand KVP	75(11kV)	
	b. 1 min. 50 Hz, voltage withstand KV ms	28(11kV)	
2.6	Metalclad construction	Required	
2.7	Degree of Protection	IP-4X For enclosure (switchboard)	
		IP5X for metering chamber. Within the cubicle IP – 2X	
2.8	Minimum thickness of sheet metal used	2 mm	

2.9	Earthing switch (cable side & bus Side) fault making type Note: BUS earthing switch only if BUSPT is in board.	Required	
2.10	Breaker chamber shutter class	PM (metallic)	
3.0	CONSTRUCTION		
3.1	Draw-out feature provided for :		
	a) Circuit breaker with service and test position	Horizontal drawout ,Horizontal isolation Required	
	b) Voltage Transformer	Required	
	c) Protective relays	Required	
3.2	Door lockable with breaker in test/isolated position	Required	
3.3	Automatic safety shutter for breaker chamber (PM class)	Required	
3.4	Short time withstand rating of the switchgear (r.m.s.) for 3 Sec.	25 kA (11kV)	
3.5	Making current	62.5 kA peak	
3.6	Design voltage of the switchgear buses	12kV	
3.7	Rating of the switchgear buses	11kV	
3.8	Internal arc test details – Relevant test report submitted for IAC 25kA/1sec _AFLR	To be submitted by the Bidder	
3.9	Compartmentalization of switchgear cubicle provided as per LSC2B	Required	
3.10	Limiting dimension: 1. Width 2. height	1. 600mm for rating upto 800Amps 2. 2300mm	
3.11	Extensible from both end	required	
3.12	Overall Dimensions of switchgear	To be submitted by the Bidder	
3.13	Weight of circuit breaker (with operating mechanism)	To be submitted by the Bidder	

3.14	Panel Approximate weight with Circuit Breaker		
3.15	Foundation frame	required	
3.16	Minimum and recommended clearance for the installation a) In front of cubicles to permit draw out of switchgear truck b) In front of cubicles with two switchgear rows facing each other c) Behind cubicles	To be submitted by the Bidder	
4.0	BUS BAR		
4.1	Material & Grade	Electrolytic Copper	
4.2	Reference standard	As per IS	
4.3	Self-supported busbar	required	
4.4	Momentary rating (peak)	As per IS	
4.5	Short time rating (rms) for 3 sec.	25kA (11kV)	
4.6	Temperature rise of the bus bar over the specified ambient at full load	As per IS/IEC	
4.7	Cross section of the bus bars	To be indicated by the Bidder	
4.8	One minute power frequency withstands voltage (rms)	28(11kV)	
4.9	Impulse withstands voltage 1.2 x 50 micro sec. wave	75(11kV)	
4.10	Continuous Current (at site condition, 50°C ambient and within cubicle)	800A(12kV)	
4.11	Minimum clearance of bare bus bar and connection		
	a) Phase to phase, mm	As per relevant standard/Type tested design	
	b) Phase to ground, mm	As per relevant standard/Type tested design	
4.12	Bus bar with		
	a) Insulating sleeve (full voltage, heat shrinkable type)	Required, Make: Raychem or any approved makes	
	b) Shrouds for joint	Required	
4.13	Bus joints Connections		
	a) Silver plated	Required	
5.0	CIRCUIT BREAKER		
5.1	Make		

5.2	Type	1. Vacuum 2. Horizontal draw out with Horizontal isolation 3. Floor rolling type.	
5.3	Reference Standard	Latest relevant Indian Standard/IEC 62271-100	
5.4	Rated Voltage, KV	12 kV	
5.5	Rated Frequency, Hz	50	
5.6	No. of Poles, No.	3	
5.7	Rated Currents		
	a) Continuous (at site condition, 50°C ambient & within cubicle) Amp.	800A (12kV)	
	b) Short-time current for 3 Sec. KA rms	25kA (12kV)	
5.8	De-rating factors for CB (In panel rating)	To be indicated by the Bidder	
5.9	Short circuit tests certificates or report number	To be indicated by the Bidder	
5.10	Type and material of inter phase Barriers between poles of the breaker	Encapsulated poles required, Poles in open is not acceptable	
5.11	Whether the circuit breaker is trip free	Required	
5.12	Type of closing mechanism	Motor Wound spring charged	
5.13	Method of closing a) Normal b) Emergency c) Anti-Pumping Relay provided	Electrical Manual Required	
5.14	Power at normal voltage for closing coils (watt)	200Watt	
5.15	Tripping mechanism		

A	Type of tripping mechanism	Shunt trip	
B	Power at normal voltage for tripping coils (Watt)	200Watt	
C	Spring charging motor details (for stored energy mechanism) i.Rating (KW) ii.Voltage (Volts) iii.Permissible voltage variation iv.Spring charging time (Second) v.Limit switch provided	i.350watt ii.110V DC iii.80% to 110% of rated voltage iv.less than 8 sec v.Required	
5.16	Breaker operation class	E2 M2 C2	
5.17	Rated operating duty	O-0.3sec-CO-3 min-CO	
5.18	a) Interrupting capacity at rated voltage and operating duty		
	a) Symmetrical, KA rms	25 KA (11kV)	
5.19	b) Rated making current, c) KA Peak	62.5 kA peak	
5.20	d) Insulation Level		
	a) Impulse voltage withstand with 1.2 x 50 micro sec. wave ... KV Peak	75(11kV)	
	b) 1-minute 50 Hz voltage withstand... KV rms	28(11kV)	
5.21	Minimum clearance in air, mm		
	a) Between poles	As per IS/Type tested design	
	b) Between live parts and ground	As per IS/Type tested design	
5.22	Closing Coil		
	a) Rating in wattage	200 watt	
	b) Permissible Voltage variation (%)	- 15% to + 10%	
	c) Rated for continuous energization at the rated Close voltage.		
	d) Control voltage	110 VDC	
5.23	Tripping Coil		
	a) Rating in wattage	200 watt	

	b) Permissible Voltage variation(%)	- 30% to + 10%	
	c) Rated for continuous energization at the rated trip voltage.	Required	
	d) Control voltage	110 VDC	
5.24	Breaker provided with the following		
	a) safety interlock	1. Closed CB cannot be racked out from service to test position. 2. Mechanical ON & OFF Push buttons provided. 3. CB can not be closed Mechanically or Electrically in intermediate Position	
	b) Emergency manual trip	Required	
	c) Mechanical ON-OFF indicator	Required	
	d) Operation counter	Required	
	e) Spring Charge/Discharge indication	Required	
	f) Manual spring charging facility	Required	
	g) Auxiliary switch with 4 NO + 4 NC contacts	Required	
5.25	Spring charging handle	Inbuilt part of breaker.	
5.26	Closing time	Less than 80ms	
5.27	Opening time	40 to 60 ms	
5.28	Max. Arcing time at 100% breaking capacity	10 to 15 ms	
5.29	Total break time at 100% breaking capacity	55 to 70 ms	
5.31	Rated Cable Charging Current	25A	
5.32	Type test report on identical breaker	Required	
6.0	CURRENT TRANSFORMER		
6.1	Make	ECS, Pragati, JSL, Gemini	
6.2	Type	Epoxy Cast Resin	
6.3	Reference standard	: As per relevant IS	

6.4	CT ratios	As per SLD/Spec	
6.5	Rated frequency	50 Hz	
6.6	Accuracy class of CT for -		
	a. Protection relays	5P 10/PS	
	b. Metering	0.5 , ISF<10	
6.7	Short Circuit Withstand		
	a. Short-time current for 3 Sec. KA rms	25kA (12kV	
	b. Dynamic current KA Peak	62.5kA peak	
6.8	Class of insulation	E or better	
6.9	Temperature rise over 50°C ambient	Within limit of relevant IS	
6.10	CT magnetization curve	Required	
6.11	V. A. burden	Suitable for connected load +20% margin. Calculation for the same must be submitted	
6.12	Continuous thermal rating (% of normal)	To be indicated by the Bidder	
7.0	POTENTIAL TRANSFORMER	ECS, Pragati, JSL	
7.1	Make		
7.2	Type	Epoxy Cast Resin	
7.3	Standards applicable	As per relevant IS	
7.4	Class of insulation	E or better	
7.5	Accuracy class	0.5	
7.6	Rated Voltage factor	As per specification	
7.7	Mounting	Line PT at rear side in cable chamber Bus PT in separate panel. Top mounted PT is not acceptable	
8.0	Numerical RELAYS		
8.1	Make	ABB, Siemens, Schneider, Alstom	
8.2	Type	Microprocessor based	
8.3	Drawout type with built in test facilities	Required	
8.4	Reference standard	As per relevant IEC 60255 & 61850	
8.5	KEMA CERTIFICATION LEVEL A FOR IEC COMPLIANCE FOR NUMERICAL RELAY	Required	
8.6	DI/DO	12 DI+10 DO exclude watchdog contact	
8.7	Fault record in Numbers	100 nos	
8.8	Event record in numbers	1000nos	

8.9	CT selectable 1A and 5A	Required	
8.10	INTEROPERABILITY Suitability OF NUMERICAL RELAY	Required	
8.11	Programmable LEDs for status indication	11 LEDs among that at least 8 should be programmable	
8.12	Setting group	5 no	
8.13	Optical arc sensor feature for HT compartments	Required	
9.0	Indicating METERS		
9.1	Make	Rishabh	
9.2	Type	Digital	
9.3	Reference standard	As per IS	
9.4	Size	96 mm x 96 mm	
9.5	Accuracy class	□ 1% on full scale	
10.0	HT STATIC ENERGY METER		
10.1	Make	Secure/ Schneider	
10.2	Type	Static	
10.3	Standard	As per latest IS	
10.4	Provision for RS 485 DLMS communication	Required	
11.0	SECONDARY WIRING		
11.1	Type and Insulation	PVC insulated FRLS	
11.2	Voltage grade	1100 V	
11.3	Conductor material	Copper	
11.4	Conductor size (minimum)		
	a. Potential & control circuit	1.5 mm ²	
	b. Current circuit	2.5 mm ²	
11.5	Wires identified at both ends with markers	Required	
12.0	Vacuum Interrupters		
12.1	Make	Panel OEM Tested & Certified	
12.2	Vacuum level	10-9 Bar	
12.3	No. of operation under short circuit condition	100 no	
12.4	Mechanical operation	30000 no	
12.5	Type of contact	Bidder has to specify	
12.6	Material of contact	Bidder has to specify	
12.7	Contact pressure at no load	Bidder has to specify	
13.0	TERMINAL BLOCK		
13.1	Make	Elmex / Phoenix / Connectwell.	
13.2	Type	1100V grade ,Screw type	
14.0	CABLE TERMINATION		
14.1	Cable entry	Bottom	

14.2	Thickness of removable gland plate	Minimum 2 mm	
14.3	Material	GI for 3 core cable AL for single core cable	
15.0	GROUND BUS		
15.1	Ground bus	Required	
15.2	Material	copper	
15.3	Cross section	240 sq mm(Minimum)	
16.0	SPACE HEATER		
16.1	Space heater details i.Voltage ii.Rating /Wattage iii.Numbers iv.Controlling	i.240V AC ii.Bidder has to specify iii.Bidder has to specify iv.Thermostat	
18.0	General Note		
18.1	Make of Relay, VI, VCB & Swgr	should be same	
18.2	manufacturing of VCB & swgr (Assembly)	In-house	
19.0	TESTS		
19.1	Routine tests to be performed on switchgear	As per relevant IEC/IS	
19.2	Following Type Test reports are to be furnished along with the offer:	Copies of Type Tests Report of similar type & rating of Switchgear to be furnished by the Bidder	
	a) Short time and peak withstand current test.	Required	
	b) Short circuit breaking capacity and making capacity.	Required	
	c) Dielectric test i.e., power frequency withstand and impulse withstand test.	Required	
	d) Temperature rise test.	Required	
	e) Circuit Breaker tested for M2,E2,C2	Required	
	f) Measurement of resistance of the main circuit.	Required	
	g) Internal arc test (ALFR) for 25kA/1sec	Required	
	h) Horizontal Acceleration due to seismic force (minimum zone 4)	Required	
19.3	Type test report validity	Not older than 7 years from tender opening result.	

SECTION 7: TECHNICAL SPECIFICATION FOR POWER AND CONTROL CABLES

1. SCOPE

This specification covers the design, manufacture, testing at manufacture's work before despatch, packing and transportation to site, laying, termination, testing and commissioning of HT, LT Power, control and instrumentation Cables required for various sub-stations.

All cables shall comply with relevant Indian standards.

2. MAKE

The cables shall be procured from experienced and reputed manufacturers (as are approved by purchaser), with proven experience in manufacture of cables for substations and having capability to develop, test and timely supply of cables as specified in the tender specification. The manufacturer shall have arrangements for carrying out all the routine, type and acceptance tests including special tests (such as flammability test, smoke generation test, HCL gas evaluation test) as per the standards specified and have furnished satisfactory test results.

3. DESIGN CRITERIA

Standards

The cables under this specification shall comply with the requirements of latest edition of the following standards including amendments:

S. N.	Standard Number	Description
1	IS: 1554 (Part-I)	PVC insulated (heavy duty) electric cables for working voltage up to and including 1100 V.
2	IS: 1753	Recommended current rating for PVC insulated and PVC sheathed heavy duty cables.
3	IS: 3961 (Part II)	Metal steel wires, strips and tapes for armouring of cables
4	IS: 3975	Methods for random sampling.
5	IS: 4905	PVC insulation and sheath of electric cables.
6	IS: 5831	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to & including 1100 V.
7	IS: 7098 (Part II)	Cross linked polyethylene insulated PVC sheathed cable for working voltage from 3.3 kV to 33kV.
8	IS: 8130	Conductors for insulated electric cables and flexible cords.

9	IS: 10418	Wooden drums for electric cables.
10	IS: 10810	Method of tests for cables.
11	ASTMD - 2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastic.
12	IEEE: 383	Standard for type test of IE class of electric cables.
13	IEC - 332 (Part-I)	Tests on electric cables under fire conditions.
14	IEC - 754 (Part-I)	Test on gases evolved during combustion of electric cables.
15	ASTMD – 2843	Test method for density of smoke from the burning on decomposition of plastic.

4. CABLE DESIGN

The cables shall be designed considering the following:

4.1. HT CABLES

HT cables shall be 33KV/11 kV of earthed grade suitable for use in solidly earthed system, stranded & compacted electrolytic aluminium conductor, extruded semi conducting screen over conductor, XLPE insulated, armoured or unarmoured as required, semi-conducting followed by copper tape screened, extruded PVC, Type ST–2 inner sheathed, overall FRLS, PVC outer sheathed, conforming to IS 7098 (Part II), IEC 60502 for constructional details and tests.

4.2. LT POWER CABLES

LT Power Cable shall be 1100 V grade, single / multi core, stranded electrolytic aluminium conductor, XLPE insulated, with PVC inner sheath, armoured and outer sheath made of FRLS PVC compound, generally conforming to IS-7098 (Part-II). The cables used for DC system shall be of two core type. Minimum conductor cross section of power cables shall be 10 mm² for aluminium cables and below 10 mm² it shall be copper conductor.

4.3. CONTROL CABLES

Control cables shall be 1100 V grade, multi core, minimum 1.5 mm² cross section, stranded copper conductor having minimum 7 strands, XLPE insulated, PVC inner sheathed / galvanised steel wire armoured, overall FRLS, PVC outer sheathed generally conforming to IS 1554 Part-I. In situations where accuracy of measurement or voltage drop in control circuit warrants, higher cross sections as required shall be used.

4.4. INSTRUMENTATION CABLES

The instrumentation cables shall be annealed, tinned stranded copper conductor, 0.5 mm², twisted into pairs, overall screened (L1 type) for digital signals, individual and overall screened (for L2 type) for low level analogue signals, individual triplet and overall screened (type L3), PVC insulated, inner PVC sheathed, GS wire armoured and overall sheathed with FRLS PVC. The insulation shall be strippable manually as well as by mechanical stripping devices without damage to the conductor.

4.5. LIGHTING WIRES

1100 V grade, single core, stranded, copper conductor, PVC insulated wires conforming to IS 694 / IEC 60227 Part 1 to 5 / IEEE-719. Minimum cross section of copper wires shall be 2.5 mm² for lighting circuits and 4 mm² for receptacle circuits.

These shall be suitable for installation in a monsoon area having 100% relative humidity, which is likely to accelerate rusting in steel. However, for reference the ambient temperature may be taken as -5° C (minimum) and 50° C (maximum) with RH of 100%. The galvanising of steel armour has to be of the highest quality for such ambient conditions.

The user shall consider the derating factor for the various conditions of installation including the following while choosing the conductor size.

Maximum ambient air temperature. Maximum ground temperature. Depth of laying wherever applicable. Grouping of cables.

The minimum size of all 22k, 11 kV and 415 V power cable shall be chosen considering the following:

- Maximum fault level
- Full load current of the circuit.
- Maximum permitted time as dictated by system protections, switchgear etc.
- The allowable voltage drop at the terminal of the connected equipment shall be maximum

5% at full load for LV and 10% for HV.

For PVC insulated cables continuous conductor temperature and allowable maximum conductor temperature during short circuit be taken as 70°C and 160°C and for XLPE insulated cables the corresponding values shall be 90°C and 250°C respectively.

Frequency variation $\pm 3\%$, voltage variation $\pm 6\%$ and combined frequency and voltage variation of $\pm 9\%$.

5. GENERAL TECHNICAL REQUIREMENT

The cables shall be suitable for laying in racks, ducts, covered trenches, conduits and underground buried installation with chances of flooding by water.

Cables shall be designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The aluminium / copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be of uniformly good quality free from defects. All aluminium used in the cables shall be of H2 grade.

The conductor of control cables shall be manufactured from plain annealed copper. The conductor shall be multi-stranded or solid as per data sheet.

Allowable tolerance on the overall diameter of the cables shall be + 3 mm maximum, over the declared value in the technical data sheets.

The cable cores shall be laid up with fillers between the cores wherever necessary. It should not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables shall have distinct extruded PVC inner sheath black in colour as per IS 5831.

The fillers and inner sheath shall be of non-hygroscopic. Flame retardant material shall be softer than insulation and outer sheath shall be suitable for the operational temperature of the cable.

For single core armoured cables, armouring shall be of aluminium wires. For multi-core armoured cables, armouring shall be of galvanized steel as follows.

Size & diameter of cable	Type of armour
Up to 13 mm	1.4 mm dia GS wire
Above 13 up to 25 mm	0.8 mm thick GS strip / 1.6 mm dia GS wire
Above 25 up to 40 mm	0.8 mm thick GS strip / 2.0 mm dia GS wire
Above 40 up to 55 mm	1.4 mm thick GS strip/2.5 mm dia GS wire
Above 55 up to 70 mm	1.4 mm thick GS strip/3.15 mm dia GS wire
Above 70 mm	1.4 mm thick GS strip/4 mm dia GS wire

The gap between armour wire/ strip shall not exceed one armour wire/strip space and there shall be no cross over/over-riding of armour wire/strip. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire/strip. Zinc rich paint shall be applied on armour joint surface.

Suitable chemicals shall be added to the outer sheaths of all cables to protect them from entry of water, UV light, rodent and termite attack. These chemicals shall not have any harmful effect on the human being.

The normal current rating of all PVC insulated cables shall be as per IS-3961 and should suit the duty requirements for which it is intended. Outer sheath shall be of PVC black colour for power cables and of grey colour for control cables.

In plant repairs to the cables shall not be accepted.

As far as feasible, separate cables shall be provided for circuits of different plant and auxiliaries, for circuits of different voltages, and for circuit used separately. Power, control and instrumentation circuit shall invariably be taken through different routes, which shall not be laid together on the same cable tray.

At least 20% cores shall be kept as spares in the multi core control cable.

6. IDENTIFICATION OF CORES

The insulated cores of HT and LT power cables shall be identified by colour code.

Cores of the cables of up to 5 cores shall be identified by colour of insulation with the following colour scheme.

No. of cores	Colour
1 Core	Red, Black, Yellow & Blue
2 Core	Red & Black
3 Core	Red, Yellow & Blue
4 Core	Red, Yellow, Blue & Black
5 Core	Red, Yellow, Blue, Black & Grey

For reduced neutral conductors the core shall be black

For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). The numbers shall be printed in Hindu-Arabic numerals on the outer surfaces of the cores. All the numbers shall be of same colour, which shall contrast with the colour of insulation. The colour of the insulation for all the cores shall be grey only.

The control cables shall have identification by means of indelible printing of numbers on its cores at intervals not more than 75 mm.

The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.

All HT and LT cable shall have embossing at interval of 1 meter for Owner's name, size /core type and length.

In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.

Cable voltage grade.

Sequential marking of length of the cable in meters at every one meter.

The embossing shall be progressive, automatic, on line and marking shall be legible and indelible.

7. COPPER CABLES

Copper cables shall be used for the following services. DC cables from batteries to DC boards

DC emergency lighting cables for main building Battery and battery chargers

Actuator motors, wherever provided.

All other essential system wherever necessary

8. CONSTRUCTIONAL REQUIREMENTS FOR HT CABLES

8.1. TYPE OF CABLE

The cable shall be multi core/ single core XLPE insulated type as specified.

8.2. CONDUCTOR

The cable conductor shall be made from stranded electrolytic Aluminium as specified to form compact conductor having a resistance within the limits specified in IS.8130.

All the cables of size 25mm² and above shall have sector-shaped conductors. The minimum number of strands in conductor shall be 7 (seven) except as otherwise specified. Power cables shall be of stranded Aluminum conductor with a minimum size of 10 mm² and the control cables shall be of stranded or solid copper (electrolytic) conductor with a minimum size of 1.5 mm² as specified.

8.3. CONDUCTOR SEMI-CONDUCTING LAYER

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation and the semi-conducting polymer shall be cross-linked for XLPE cables.

8.4. INSULATION

The insulation of the cable shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation. The insulation of the cables shall be of high standard quality. The minimum volume resistivity of the PVC insulation of all the PVC insulated cables shall be 1×10^{14} ohm cm at 27° C and 1×10^{11} ohm cm at 70° C.

8.5. INSULATION SHIELD

In XLPE cables to confine electrical field to the insulation, a non-magnetic semi-conducting shield shall be put over the insulation. The XLPE cable insulation shield shall be strippable.

Metallic screening, as given in this specification for the various power and control cables shall be provided.

The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.

The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper.

The copper screen shall be capable of carrying the single line to ground fault current for the duration specified for the protection employed. Vendor shall furnish calculation in support of selection of the size of copper screen.

8.6. INNER SHEATH

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded.

The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness.

The dimensions of the insulation, inner sheath and armour materials shall be governed by values given in Tables 2,3 & 4 (Method 3) of IS: 7098 Part-II).

8.7. ARMOUR

Armouring shall be provided wherever specified. Generally cables laid in say in underground ducts need not be armoured. For multi core cables, the armouring shall be by galvanised steel wire/tape. If armouring is specified for single core cables, the same shall be with hard drawn aluminium round wire of 2.5mm diameter.

The hard drawn aluminium wire for armour shall be of H4 grade, as per IS:8130 (having tensile strength above 150 N/mm²). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanised steel wire armour given in the relevant standard. All cables directly buried shall be armoured.

8.8. SERVING/ OUTER SHEATH

Extruded PVC serving as per IS:5831 or as specified otherwise shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All serving must be given anti-termite treatment.

The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of type ST2 compound of IS: 5831. The thickness of outer sheath shall be as per amendment no. I of table 5 of IS: 7098 Part-2 (Column 3 & 5 for both armoured and un armoured cables).

8.9. FILLERS FOR MULTI CORE CABLES

Cable shall have suitable fillers laid up with the conductors to provide a substantially circular cross-section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality. Workmanship shall be neat, clean and of highest grade.

9. CABLE TYPES

9.1. POWER CABLE

The cable shall be for 33KV/11 kV earthed system, heavy duty, three or single core, stranded Aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, aluminium armouring for single core, extruded PVC of Type ST2 outer sheathed, as per system requirement. The cables shall conform to IS:7098 (Part II).

9.2. 415V SYSTEM

The cable shall be 1.1 kV, grade, heavy duty, stranded Aluminium conductor, XLPE insulated as specified, 4 or 3 1/2 core, galvanised steel wire/strip armoured, extruded PVC type STI outer sheathed.

9.3. CONTROL CABLES

The cable shall be 1.1 kV grade, XLPE, heavy duty, multi core stranded (7 wires) tinned copper (annealed) conductor, PVC Type-A insulated, galvanised steel wire/strip armoured, flame retardant low smoke (FRLS) extruded PVC of type-STI outer sheathed. The following sizes shall be used.

Cable Size (mm ²)	1.5/ 2.5	4	6	16
No. of Cores	2,5,7,10,14,19,27	3,5	2,4	4

9.4. LV POWER AND CONTROL CABLES

LV power and control cables shall be XLPE, heavy duty type, 1100 V grade with electrolytic Aluminium conductor, PVC inner sheathed, armoured, if specified and overall PVC sheathed, as specified in bill of quantities.

Copper conductor for control cables shall be PVC insulated where as for power cables it shall be XLPE as given in bill of quantities.

The conductors shall be stranded. The minimum number of strands shall be 7 (seven) except as otherwise specified. Conductors of nominal area less than 25 sq. mm shall be circular only. Cables of nominal area 25 sq. mm and above may be circular or shaped. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS:1554 (Part-I).

Power cables shall be of stranded aluminium conductor with a minimum size of 10 mm² and control cables shall be stranded copper conductor with a minimum size of 1.5 mm².

If armouring is specified for multi core cables, the same shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm.

10. CABLE ACCESSORIES FOR HT CABLES

The termination and straight through jointing kits for use on the system shall be heat shrinkable type and suitable for the type of cables offered as per this specifications.

The accessories shall be supplied complete in all respects and should be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.

The kit shall include all stress grading insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.

The contents of the accessories kit including all consumables shall be suitable for storage without deterioration at a temperature of 50°C with shelf life extending more than 5 years.

A set of tools for making joints shall be provided (both for indoor and outdoor joints).

11. TERMINATION KITS

The heat shrinkable terminating kits shall be suitable for termination of the HT cables to an indoor switchgear or to a weather proof cable box of an outdoor transformer or to a 4 pole structure. For outdoor terminations whether shields/sealing ends and any other accessories required shall also form part of the kit. For RMU cable termination shall be with plug in type.

12. REQUIREMENT OF XLPE JOINTS & TERMINATION

The straight through jointing kit shall be suitable for installation on overhead trays, concrete lined trenches, ducts, and for underground burial with uncontrolled backfill along with possibility of flooding by water and chemicals. These shall have protection against any mechanical damage and suitably designed to be protected against rodent and termite attack. For ducts suitable man holes shall be provided for joints. Joint in cables shall meet the following requirements.

Conductivity of the jointed conductor shall not be less than that of the main conductor of the cable.

Joints between two conductors or conductor lugs shall have a mechanical strength not less than that of the conductor.

Adequate insulation level free from voids and impurities. Sufficient stress relief provision.

Adequate creepage paths to eliminate system tracking.

Ability to withstand electromagnetic thermal stress during flow of short circuit Current. Proper seals for water, dust and chemical fumes for checking their ingress under all conditions.

Inner semi-conducting layer with a smooth surface & good contacts and insulation. Outer semi-conducting layer to adhere firmly to the insulation.

Earth continuity connection of adequate size shall be a part of the kit.

Heat shrinkable technique shall be used for termination kits. This system shall be based on the use of heat shrinkable radiation vulcanised cross linked polyethylene tubes (semi-conducting and insulation grade) and skirts. These tubes shall be fitted to the cable and/or joints and set in position by shrink fitting by application of heat by a gas torch or kerosene blow lamp.

The heat shrinkable tubes, designed as stress control tubing, insulating tubing and screen tubing shall meet the requirements of temperature, flexibility, stress grading, long life, resistance to corrosion and chemical etc. Complete list of various items required for making various type of joints shall be furnished with the offer.

13. CABLE DRUMS

Cables shall be supplied in non-returnable wooden or steel drums of heavy construction in proper and suitable packing for shipment to site. For wooden drums the wood used for construction for the drum shall be properly seasoned, sound and free from defects. Wood preservative shall be applied to the entire drum.

Contractor shall indicate in the offer the standard length for each size of power and control cable which can be furnished on one drum. The cable length per drum shall be subject to tolerance of $\pm 5\%$ of the standard drum length agreed between purchaser and contractor.

Cable Joints shall be avoided as far as possible by use of proper cable lengths.

The Engineer shall have the option of rejecting cable drums with shorter lengths as the cable drums shall be selected so that through joints are eliminated.

A layer of water proof paper shall be applied to the surfaces of the drums and over the outer most cables layer. A clear space of at least 40 mm shall be left between the cables and the logging.

Each drum shall carry the manufacturer's name, the purchaser/ supplier's name and contract number, owner's name, address, item number, type, size, length of cable, net and gross weight stencilled on both sides of drum. A tag containing the same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wordings shall be marked on one end of the reel indicating the direction in which it should be rolled.

On the drum the number of cores, type of cable, voltage rating, code, direction of drum rotation, BIS certification mark and year of manufacture shall also be mentioned.

Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation handling and storage.

Both cable ends shall be sealed with PVC/ Rubber caps so as to eliminate ingress of water during transportation, storage and erection/ construction.

14. CABLE INSTALLATION

Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable. The cable drums shall be placed on jacks before unwinding the cable. Great care shall be exercised in laying cables to avoid forming kinks. Cable shall be laid in accordance with relevant Indian Standards.

14.1. LAYING OF CABLES ON CABLE TRAYS

The relative position of the cables, laid on the cable tray shall be preserved and the cables shall not cross each other. At all changes in direction in horizontal and vertical planes, the cable shall be bent smooth with a radius as recommended by the manufacturers. All cables shall be laid with minimum one diameter gap and shall be clamped at every meter to the cable tray. Cables shall be tagged for identification with aluminum tag and clamped properly at every 20M. Tags shall be provided at both ends and all changes in directions both sides of wall and floor crossings. All cable shall be identified by embossing on the tag the size of the cable, place of origin and termination.

All cables passing through holes in floor or walls shall be sealed with fire retardant Sealant and shall be painted with fire retardant paint up to one meter on all joints, terminations and both sides of the wall crossings.

14.2. LAYING OF CABLES IN GROUND

The minimum width of trench for laying single cable shall be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench shall be worked out by providing minimum one cable diameter gap between the cables, except where otherwise specified. There shall be clearance of minimum half a cable dia or 25mm whichever is greater between the end cable and the side wall of the trench. The minimum depth of the cable trench shall not be less than 750 mm for single layer of cables. When the cables are laid in more than one tier the depth of the trench shall be increased by 300 mm for each additional tier.

Excavation of trenches: The trenches shall be excavated in reasonably straight lines. Wherever there is a change in direction, suitable curvature shall be provided. Where gradients and changes in depth are unavoidable, these shall be gradual. The excavated soil shall be stacked firmly by the side of the trench such that it may not fall back into the trench. The bottom of the trench shall be levelled and shall be made free from stone, brick bats etc. The trench shall then be provided with a layer of clean, dry sand cushion of not less than 100 mm in depth. ***(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).***

Prior to laying of cables, the cores shall be tested for continuity and insulation resistance. The cable drum shall be properly mounted on jacks, at a suitable location, making sure that the spindle, jack etc. are strong enough to carry the weight of the drum and the spindle is horizontal. Cable shall be pulled over rollers in the trench steadily and uniformly without jerks and strains. The entire drum length shall be laid in one stretch.

However, where this is not possible the remainder of the cable shall be removed by 'Flaking' i.e. by making one long loop in the reverse direction. After the cable has been uncoiled and laid into the trench over the rollers, the cable shall be lifted off the rollers beginning from one end by helpers standing about 10 meters apart and laid in a reasonably straight line.

Cable laid in trenches in a single tier formation shall have a cover of clean, dry sand of not less than 150 mm. above the base cushion of sand before the protective cover is laid. In the case of vertical multi-tier formation after the first cable has been laid, a sand cushion of 300 mm shall be provided over the initial bed before the second tier is laid. Finally the cables shall be protected by second class bricks before back filling the trench. The buried depth of uppermost layer of cable shall not be less than 750mm *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures)*.

Back Filling : The trenches shall be back filled with excavated earth free from stones or other sharp edged debris and shall be rammed and watered, if necessary, in successive layers not exceeding 300 mm. Unless otherwise specified, a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench shall be left to allow for subsidence.

14.3. CABLES INSIDE BUILDING

Cables inside buildings shall be laid on the cable trays. All cables passing through walls shall run through GI Pipes sleeves of adequate diameter 50 mm apart maintaining the relative position over the entire length.

14.4. LAYING OF CABLES IN CONCRETE TRENCH

The minimum width of trench for laying single cable shall be minimum 350 mm. Where more than one cable is to be laid in horizontal formation, the width of the trench shall be worked out by providing minimum one cable diameter gap between the cables, except where otherwise specified. There shall be clearance of minimum half a cable dia or 25mm whichever is greater between the end cable and the side wall of the trench. The minimum depth of the cable trench shall not be less than 500 mm for single layer of cables. When the cables are laid in more than one tier the depth of the trench shall be increased by minimum 300mm for each additional tier. Cables shall be laid on FRP Cable trays supported by MS angles at intervals.

14.5. ROUTE MARKER

Route marker shall be provided along straight runs of the cables not exceeding 30 meters also for change in the direction of the cable route and underground joints. Route marker shall be of cast iron painted with aluminum paint. The size of marker shall be

100 mm dia with "Cable" and voltage grade inscribed on it.

15. INSPECTION

Before dispatch the cables offered shall be made available for inspection by the Engineer. Inspection may also be made at any stage of manufacture at the option of the purchaser and the cables found unsatisfactory due to the material used or poor workmanship shall be rejected.

The contractor shall guarantee free access to the places of manufacture to the Engineer at all times when the work is in progress. The contractor shall inform the Engineer in advance the time of starting of manufacture and the progress of manufacture of the cables offered by him so that arrangement can be made for inspection.

Inspection and acceptance of cables by the Engineer shall not relieve the contractor of his obligation of furnishing cables in accordance with the specification and shall not prevent subsequent rejection if such cables are later found to be defective.

The cables shall comply with type tests stipulated in prescribed section and the relevant standards. Test reports for all type tests shall be submitted with the tender.

All type and sizes of cables shall be subjected to routine and acceptance tests as stipulated in relevant standards without any extra cost to the purchaser. Cables should not be dispatched until the test reports are duly approved by the Purchaser or his authorized representative and specific instructions to despatch the inspected items issued.

The purchaser reserves the right of having any other special tests of reasonable nature carried out at site or at manufacturer's works or at any other place in addition to the aforesaid type and routine tests to satisfy himself that the cables comply with the specification, without any financial liability.

Six copies of test reports (or as indicated in the Schedule of Vendor Drawings) shall be supplied for approval. The reports shall indicate clearly the governing standards and the standard values specified for each test to facilitate checking of the test reports. Six bound copies of the test reports shall be submitted after approval of test reports along with the cables.

16. TESTS

All types and sizes of cables being supplied shall be subjected to type tests, routine tests and acceptance tests as specified below and according to relevant standards.

The Engineer at its discretion may ask the contractor to conduct any or all the type tests for which at least 15 days advance notice shall be given.

Charges for acceptance test and routine test shall be deemed to be included in the bid price of individual cables.

Type Tests

Type tests shall be carried out on all the types and sizes of cables if desired or alternatively test certificates shall be supplied at the sole discretion of purchaser.

The following shall constitute type tests:

Test	Remarks
For Conductor	
Annealing test	: For copper conductor only
Tensile test	: For aluminium conductor only
Wrapping test	: For aluminium conductor only
Resistance test	: For Armour Wires/Strips
Measurement of Dimensions	
Tensile test	
Elongation test	
Torsion test	: For round wires only
Winding test	: For strips only
Resistance test	
Zinc Coating test	: For G.S. strips/ wires only
For PVC/ XLPE Insulation &PVC Sheath	
Test for thickness	
Tensile strength and elongation test before aging and after aging	
Aging in air ovens	

Loss of mass test	:	For PVC insulation & sheath only. Hot deformation
test	:	-do-
Heat stock test	:	-do-
Shrinkage test	:	-do-
Cold bend/cold Impact test	:	-do-
Colour fastness to	:	-do-
Thermal stability test	:	-do-
Bleeding and blooming test	:	-do-
Hot set test		For XLPE insulation only
Water absorption test		For XLPE insulation only
For Completed Cables		
Insulation resistance test		
High voltage test		For HT cables
Partial discharge test	:	-do-
Bending test	:	-do-
Dielectric Power factor test:	:	-do-
As a function of voltage	:	-do-
As a function of temperature	:	-do-
Heating cycle test	:	-do-
Impulse with stand test	:	-do-
Measurement of eccentricity and		
ovality.	:	-do-

Short Circuit test

Short circuit test on conductors shall be carried out on cable samples.

During each short circuit test, the cable shall be subjected to thermal (rms) and dynamic (peak) short circuit current of specified duration.

The test sample shall be subject to following tests before carrying out the short circuit test and after completion of short circuit test (when cable has cooled down to ambient temperature).

- Conductor resistance measurement.
- High voltage test.
- Tan delta measurement.
- Partial discharge measurement (for HT cables).
- Volume resistivity.

Before applying the short circuit current, the test sample shall be heated up to the specified maximum conductor temperature. This may be done by eddy current heating or by giving intermittent high current impulses as per the convenience of test station. After establishing specified conductor temperature the cable shall be subjected to short circuit test.

Acceptance Criteria

After the short circuit test the test specimen shall meet the following requirements:

- HV Test
- Pd test
- Tan delta values as per standard.
- Conductor resistance not more than $\pm 5\%$.
- Volume resistivity shall not be below the standard acceptance value.
- Acceptance Test

Acceptance tests shall be carried out on each type and size of the cable on the cable drums selected at random.

The following shall constitute acceptance test:

- Annealing test
- Tensile test
- Wrapping test
- Resistance test
- Test for thickness
- Tensile strength and elongation test before aging and after aging
- Aging in air ovens
- Hot set test
- Insulation resistance test
- High voltage test
- Partial discharge test
- Measurement of eccentricity and ovality.
- Routine Test

Routine test shall be carried out for each drum of cables of all type and sizes. Following shall constitute routine tests:

- Resistance test.
- Insulation resistance test.
- High voltage test.

17. TECHNICAL PARTICULARS

HT Cables

1.	Voltage Grade UE (Part 2).	:	11/6.35 kV as per IS-7098
2.	Type	:	3 core, XLPE, armoured, screened cables.
3.	System earthing	:	Solid grounded
4.	Size	:	As per requirement
5.	Conductor	:	Aluminium stranded conductor

6. Conductor Screening by
Extrusion : Semi conducting compound
7. Insulation Properties & process
of application and application
by extrusions : Table 1 of IS-7098 (Part-II)
8. Nominal thickness of
insulation & tolerance. : As per IS:7098 Clause 11.3
Insulation screening
9. Non-metallic part : Semi- conducting compound over the
insulation¹
10. Metallic part : Armouring may constitute metallic part
of screening. where both metallic screen & armouring are used, extruded inner sheath shall be there
in between and its thickness as per Table 3 of IS 7098 (Part-II).
11. Core Identification : Coloured strips application on cores or
different colours of XLPE insulation or by numeral
(1,2,3) either by applying numbered strips or by
printing on the cores.
12. Armouring : Galvanized steel round wire/strips Outer
Sheath
thickness Not less than value specified in
Column 5 of Table 5 of IS 7098.

-L.T. Power & Control Cables

- Size of Cable : As per requirement
- Voltage rating : 650/1100 V

Cable Accessories

Description	HT Cables	LT Cables
Voltage Rating	As per cable rating	As per cable
Type of termination	Heat shrinkable	Compressed
Clamps/ terminals	Aluminium compression	Aluminium material

SECTION 8: TECHNICAL SPECIFICATION FOR LOW VOLTAGE FEEDER / SERVICE PILLARS and STREET LIGHTING PILLARS

1. SCOPE

This specification covers the design, engineering, manufacture, testing at works, packing, supply, delivery and storage at site of low voltage outdoor type feeder and lighting pillars for lighting of streets, parking areas developed area including all mounting bolts and other accessories required

to make the pillars operable for 3 phase, 4-wire, 415 volts, 50 Hz. Neutral grounded distribution system. The pillars shall be complete with links, MCCBs, MCBs, Bus bars, Ammeter with CTs, Voltmeter / indicating lights & all such other accessories as required, even though specifically not mentioned.

2. STANDARD AND SYSTEM CONDITIONS

2.1. STANDARD

The equipment covered in this specification shall conform to the following updated I.E.C. Publications / ISS

S. No	Standard Number	Description
1	IS : 375	Marking and arrangement for switchgear bus-bars, main Connectors and auxiliary wiring.
2	IS : 589	Basic climatic & Mechanical durability test for components for electronic & electrical equipment.
3	IS : 1336	Push buttons
4	IS : 1554	PVC insulated (Heavy duty) electric cables
5	IS : 2147	Degree of protection provided by enclosure
6	IS : 3202	Climatic proofing of electric equipment
7	IS : 4064	Air break switches, air break dis-connectors, air break switch disconnectors and fuse combination units for voltages not exceeding 1000V.
8	IS : 5039 - 1991	Distribution pillars for voltage not exceeding 1000 Volts.
9	IS : 8623 (Part I-3)	Specification for switchgear & control assemblies.
10	IS : 8828	Specification for MCBs
11	IS :3947 (Part-II)	Low voltage switchgear and control gear
12	IEC 664 A-1980	Insulation co-ordination with in low voltage systems including clearance and creepage distance for equipment.
13	IS : 2551	Danger plate
14	IS : 0580	Service conditions for electrical equipment
15	SP : 39-987	Guide for insulation coordination within low voltage systems.

The equipment complying with other internationally accepted standards shall also be considered if they ensure performance equivalent to or superior to Indian Standards.

2.2. SYSTEM DETAILS

The distribution system to be provided shall be underground. The electrical sub-transmission system is fed through 11kV CSS. Each distribution transformer in CSS is being fed from 11/0.433 V, delta star transformer, with neutral solidly grounded which feeds a 415 V, LV board. Each LV board feeds a number of feeder/ service pillars of 3 phase, 4 wire, 415V rating.

2.3. CLIMATIC CONDITIONS

As per Design Criteria

2.4. AMBIENT CONDITIONS FOR DESIGN

As per Design Criteria

2.5. QUALITY OF MATERIAL

All material used shall be new and of best quality and of class, most suitable for working under the conditions specified herein without distortion or deterioration.

3. DESIGN AND STANDARDIZATION

3.1. GENERAL

The equipment shall be designed to ensure satisfactory operation in which continuity of service is the first consideration and shall also be designed to withstand sudden load variations due to short circuits and fault conditions. The design shall incorporate every reasonable precaution and shall have necessary provision for the safety of all those concerned in the operation and maintenance of the pillars.

The mechanism shall be made of such materials as to prevent sluggishness due to rust or corrosion. All connections and contacts shall be of ample section and contact surface for carrying continuously the specified current without undue heating and shall be secured rigidly and locked in position. Standard sizes of stainless bolts, screws, pipes and other fittings are to be used and number of sizes is to be kept to the minimum.

Cast Iron shall not be used for any part of the equipment which may be subjected to mechanical stresses.

All apparatus shall be so designed and constructed as to obviate the risks of short circuits of the live parts by lizards etc. Metal cubical, housings and covers shall be 100% weather / vermin proof & shall be able to provide the degree of protection IP 45 in accordance with latest version of IS:2147.

All parts shall be manufactured in accordance with relevant standard specifications of IEC/IS, corresponding parts of similar equipment and apparatus shall be mutually interchangeable.

All apparatus, connection and cabling shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.

The distribution feeder / service pillars shall be suitable for working outdoor in the conditions given herein. As the feeder / service pillar will be installed normally on footpaths adjoining to the roads, these shall be made robust and capable of withstanding the vibrations normally experienced due to vehicular traffic.

3.2. CLEARANCE & CREEPAGE DISTANCES

The clearance & creepage distance shall be in accordance with IS: 13947 Part-I updated & corrected for operation under environmental conditions of site.

3.3. DRAWINGS & LITERATURE

Four sets of tentative G.A., schematic drawings and detailed literature of equipment shall be submitted within 120 days after contract award clearly giving the scope of supply and bill of material to enable the Engineer to scrutinise all aspects of design including arrangement and support of cable accessibility for maintenance work and future additions, cable connections, general appearance etc.

Further sets of drawings & literature are to be furnished by successful tenderer / bidder within 2 weeks after the award of contract by the Engineer, which shall include the following:

Complete assembly drawings of the pillars, showing plan, elevation, typical section, location of terminal blocks for external wiring connections and mounting details of various devices with dimension.

Foundation plan showing embedment channel frame in the floor with associated holes and suitable size of bolts for fixing to channel frame of feeder pillars.

Wiring diagrams including terminal wiring design and cable schedule.

Schematic control diagram for controls, relays, instruments, space heaters, cubicle illumination and receptacle etc.

Detailed bill of material of each feeder pillar. Layout plan of feeder pillar.

4. SPECIFICATION OF LT FEEDER PILLARS

4.1. CONSTRUCTIONAL DETAILS

A totally enclosed cubicle shall be fabricated out of CRCA sheets steel of thickness not less than 3.15 mm on all sides and mounted on angle iron frame.

A set of double hinged doors shall be provided on front, to enable installation, maintenance and inspection of cable connection and other equipment inside the cubicle from the front side. Three heavy duty stainless steel hinges (not visible from outside) shall be provided per door in such a way so that interior gasketing of the doors shall be continuous. Good quality neoprene gaskets, weather resistant shall be used. The design shall permit the doors being completely removed when necessary. The doors shall be so fitted as to provide the interior with maximum protection from atmospheric conditions. The doors shall get closed as in case of a steel almirah through a handle so as to have a tight fitted door.

The door handles shall be of rectangular shape made out of 12 mm round or equivalent size of flats.

A pad lock of suitable size, rust proof, operatable in outdoor humid conditions shall be welded to one of the doors. All the locks on the feeder pillars shall be opened and closed by a single master key.

The ammeter, LT CTs, voltmeter, selector switches, MCCB shall be provided on the incoming side of the MCCB on an openable and separate inside the pillar and not on the main door leaves.

The top of the pillar shall have a sloping canopy having necessary slope so that rain water does not accumulate there. The canopy shall project over the sides of the pillar shell which shall be lower than the top section.

The pillar is to be mounted on brick and cement concrete plinth by the road side and the dimensions should be such that it does not obstruct the normal traffic on the footpath.

The lower part i.e. apron should be covered with 3.15 mm sheet on all sides. The sheet covers shall be welded to the frame on three sides except on the front side where it should be bolted so that it can be removed for fixing cables. Ingress of water or any other insects etc. does not take place from this portion as well.

The stand shall be made of rust proof angle of 75x35x6mm and shall have adequate height to provide a strong supporting structure to the shell.

Suitable ventilation louvers with wire mesh inside shall be provided at the side sections of the shell in a flat frame welded inside so that no object, lizard etc. can enter the pillar through the ventilation louvers.

The gland plate shall be of thickness 3.15 mm thick Aluminium & detachable type. All the cable glands shall be chrome plated and double compression type and shall be supplied with the pillar box for the cable sizes given.

The bus bars shall be rectangular and of electrolytic aluminium.

Phase as well as neutral size shall be suitable for continuous current rating. The bus bars shall be insulated with heat shrinkable tapes with red, yellow and blue colours for the 3 phases and black for neutral. All bus bar tapping and markings shall be in accordance with relevant IEC/IS, 374-1963. The bus bar shall be mounted on insulators. The inter-connections between bus bars and MCBs units shall be solid electrolytic Aluminium / strip/Aluminium conductor permanently riveted with the busbar. The connections between outgoing side of MCBs and outgoing cable shall be through an isolating link so as to ensure a physical isolation of outgoing circuit whenever needed. These shall be suitably taped with colours as that of bus bars. Thimbles, nuts & bolts etc., (which must be non-rusting) for the incoming and outgoing cables terminals shall be included & provided with the pillar. Only external cables shall be brought from outside for making connections to the pillars at site. The bus bar joints shall be given a thin coat of conducting grease after fully cleaning both the surfaces. The terminals shall be of substantial mechanical strength & shall provide adequate electrical contact for the cable size used & shall be capable of receiving the size of cable. It will be ensured that necessary contact pressure is maintained permanently.

The above arrangement shall be got approved by contractor by designer / client / site engineer prior to fabrication.

4.2. OUTGOING FEEDERS

Outgoing circuits fed by MCB's of suitable ratings for controlling the outgoing cable circuits from feeder pillar shall be provided. A 4-pole disconnecting link of the rating corresponding to the rating of MCB shall also be provided between the cable connection terminals and MCB. This link shall provide visible disconnection in the case of any maintenance work required to be carried out on the outgoing cable circuit.

4.3. EARTHING

The distribution feeder pillar shall be provided with two separate earthing terminals on its casing for copper earthing.

The earthing terminals shall be easily accessible and so placed that the earthing connection of the distribution pillars is maintained when the cover or any other moveable part is replaced.

The earthing terminals shall be identified by means of proper indelible green sign marks adjacent to the terminals.

The feeder pillar shall also have an inside earth bus bar for connecting the cable gland earthing and the armouring to it. The size of the earth bus bar shall be suitable to carry 50 kA for one second. The bus bar shall not be visible or removable from outside the cubical. The earth bus bar shall have necessary holes, nuts & bolts including washers for making earth connection of cable glands / armouring of the incoming / outgoing cables. Mild steel galvanised or otherwise is not acceptable due to harsh environment.

4.4. FEEDER PILLAR LIGHTING & HEATING

A lamp holder with a 11 W CFL lamp and operated by an internal SP-MCB shall be fitted in the canopy of the feeder pillar for internal illumination. In addition, a 3 pin 5A socket shall also be provided with a separate SP-MCB on side of the pillar box. Space heater of suitable rating, with thermostat and SP-MCB shall also be provided inside the pillar near the bottom to avoid any moisture condensation inside the cubicle.

4.5. DANGER PLATE

An enamelled sheet steel danger plate of approved design as per IS: 2551 shall be fixed on the left upper front door of the pillar.

4.6. PAINTING

All sheet steel work shall be phosphatised in accordance with the relevant IEC/IS: 6005 Code of Practice of phosphatizing iron and steel with seven tank process.

After application of the primer, two coats of finishing synthetic enamel epoxy paint of reputed make shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The colour for the finishing paint shall be light grey as per shade no. 631 of IS:5 or other equivalent standard shade. Each coat of primer and finishing paint shall be with slightly different shade to enable inspection of the painting.

The finishing painted surface of pillars shall present aesthetically pleasing appearance free from dents and uneven surface.

A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the pillars.

4.7. TESTS

Type Tests

The Engineer may ask the manufacture to conduct the following type tests on one of the feeder pillars out of any of the consignment, considering site conditions.

Verification of temperature rise limits test

Verification of rain test to determine the degree of protection against rain.

Verification of dielectric properties.

Necessary type tests as per IS on all the bought out items such as MCB's, MCCB's etc.

The Engineer, at his option, may waive the above type tests provided type test reports of the above type tests carried out on essentially identical unit in their factory / testing laboratory of repute in India are furnished by the manufacturer.

Routine Tests

The pillars shall be subjected to high voltage tests described in the relevant ISS. The test voltage to be applied shall be for a period of one minute.

Megger tests with meggar of 500 volts before and after the high voltage test shall be carried out on the feeder pillars and the recorded readings shall be furnished to the Engineer prior to the despatch of feeder pillar. Routine tests, as per IS shall be carried out on the bought out items viz. MCCB's and MCBs etc.

Site Tests

Engineer at its sole discretion reserves to carryout the necessary tests at site to ensure that the equipment is not disturbed / damaged during transportation.

4.8. CABLE TERMINATIONS

Incoming and outgoing cables to be terminated in the feeder pillar shall be Aluminium or copper XLPE insulated PVC sheathed armoured / unarmoured.

Horizontal angle iron bars shall be provided with bolted holes so that the cables could be clamped by 'U' bolts of 12 mm diameter, so that no pull is exerted on the terminals due to the weight of the cable. U bolts of necessary size to clamp the cables shall be supplied fitted with nuts & washers, fitted on the bars.

4.9. SPECIFICATION FOR LT STREET LIGHTING PILLARS

The L.T. street lighting service pillars shall be manufactured suitable for outdoor installation and shall have all constructional details, earthing arrangement, danger plate, painting, other features and tests as specified under various paras above for L.T. feeder / service pillars. The final paint on the street lighting service pillars shall be red. The L.T., street lighting pillars shall have circuits as detailed below:

Incoming

One No. 3 phase, 4 wire incoming circuit placed on the left hand side having 4-pole MCCB of suitable rating complying with IS: 13947-2 as updated with 50-100% adjustable thermal release and & breaking capacity of 50 kA suitable for incoming XLPE aluminium conductor cable.

Outgoing circuits

3 Number Single phase 2 wire outgoing circuits with voltage rating of 240 volts & current rating of 25A having 2 pole, MCB of 16 A rating, suitable for outgoing aluminium cable of size provided.

4.10. SCADA CONTROLLED DIMMER

The above shall be provided to automatically switch OFF and switch ON the supplies in line with sunrise and sunset. Further there shall be automatic dimming arrangement with reference to time at night.

LT Moulded Case Circuit Breakers (MCCB'S)

The incoming underground cable to the feeder pillar from the LT AC Board in the substation shall be controlled by DRAW OUT, CURRENT LIMITING type moulded case circuit breaker.

The moulded case circuit breakers shall be of a robust construction and shall comprise of a switching mechanism, contact system, arc extinguishing device and a tripping unit contained in a compact moulded case and cover. The insulating case and cover shall be made of high strength, heat-resistant and flame-retardant thermo-setting insulating material.

The switching mechanism shall be quick-make / quick break type, and should be trip-free. The arc extinguishing device shall comprise of a series of grid plates mounted in parallel

between supports of insulating material. The arc shall be drawn from the moving contact into the divide chamber and extinguished.

The moulded case circuit breakers shall have a thermo-magnetic type tripping mechanism, where the heating effect and the electromagnetic effect of current are made use of to provide protection against overload and short-circuit conditions respectively. The heated-bimetal strip in each phase of the MCCB shall actuate the tripping system following on inverse-time- current characteristics depending upon the severity of the overload. During short-circuits, the system shall trip instantaneously. The tripping element provided on each pole of the MCCB shall operate on a common trip bar, thereby preventing single phasing in the event of fault on any of the phases. The tripping device shall be ambient temperature compensated type.

The MCCB shall have a minimum rupturing capacity of 25.8 MVA. Positive indication about the position of the MCCB i.e. whether 'ON', 'OFF' or 'TRIPPED' shall be provided.

The short circuit breaking capacity and operating of the MCCB shall be supported by test certificates.

The detailed specifications of the MCCBs shall be as under:

3-phase, 4 wire, neutral earthed

system no. of pole	:	4 Pole
Service voltage	:	415 volts
Normal current	:	Rating shown in SLD

Frequency : 50 Hz.

Short circuit current rating [Ics] : 36 KA

Crimp type cable lugs shall be used on the outgoing side of the MCCBs and the 4-pole links for each of the outgoing feeder.

All the MCCBs, used in LT feeder / service / street lighting pillars for controlling the LT feeders shall have a current setting of 50 to 100% of its rated current.

Miniature Circuit Breaker (MCB)

The outgoing underground feeders / service lines from the LT feeder pillars shall be controlled by MCBs. It shall provide protection against over loads and short circuit.

The MCBs shall be of robust construction with insulating case made of self-extinguishing, thermoplastic material. The switching mechanism shall be quick make / quick break.

The details specification of the MCBs shall be as under:

No. of poles : 4 and 2 poles as required

Service voltage : 415 / 240 volts

Normal current : Rating shown in SLD

Frequency : 50 Hz

Breaking capacity : 20 kA (as per clause no. 5.3.4.2 of IS: 8828-1996)

Bus-bar Details L.T. feeder pillar: Electrolytic Aluminium used for bus bar and construction shall be preferably equivalent to E91 E of BS-2398 with mechanical strength properties approximating closely to that of copper.

Protection against accidental Contact: Heat shrinkable sleeving with requisite dielectric properties leaving no voids or pin holes. Sleeving to be permanent & non removable by hand. Busbars joints and tee off, where possible to be provided with removable shrouds for complete isolation.

Temperature rise over design ambient - As per relevant BIS / IEC Temperature of 50°C for continuous current rating deg.

Indicating lamps - 240 V Space

Heater rated voltage - 240 V

Components

MCCB

No. of Pole - 4 Pole

Rating (A) - As per design

Rupturing capacity (kA)-Ics 36

Thermal Tripping range - 50 to 100%

Short circuit release - To be fixed for 36 kA

MCB

No. of Pole - 4 Pole

Rating (A) - As per design

Rupturing capacity (kA) - 20 kA

Tripping

- Thermal overload

SECTION 9: TECHNICAL SPECIFICATION FOR DIESEL GENERATOR SET

1. SCOPE

The specification covers the design, manufacture, inspection, testing at manufacturer's works/production site, supply & delivery, transportation, installation and testing and commissioning of Diesel Generator set enclosed in an outdoor non rusting type [acoustic enclosure. It shall be equipped with an "Auto Mains Failure" panel along with AC distribution panel for the Project as detailed in the schedule of requirement. The complete supply shall also include the necessary civil works, plumbing, cabling and other electrical works as required at site for each set. The set shall have provision for remote SCADA.

The contractor is required to quote for the complete Diesel Generator Sets in line with the specified requirement.

The DG Set and its control panel, switch board etc. shall be all unattended i.e, it shall be an unattended station. However, periodically the operator may access the equipment. Therefore the equipment must be HIGHLY RELIABLE and contractor must give sufficient proof of reliability in this regard.

The scope of supply shall include all parts, accessories, etc. which are necessary for construction, operation and maintenance of complete equipment even though these are not individually and specifically started or enumerated. Corresponding parts of all the equipment and spares shall be of the same material, dimensions, workmanship and finish and shall be interchangeable. All the materials and workmanship shall be of suitable quality having been used in similar services and under similar conditions.

2. QUALIFYING REQUIREMENTS

Once a DG set is planned and proposed in the bid, the contractor shall provide to Engineer a list of customers in Uttarakhand where the DG set supplier has installed or provided similar DG sets & service support availability nearest (within 50KM) to site.

3. SYSTEM DETAILS

DG Set is required as a standby source of Power Supply to meet the essential load requirements of the project in case of the power failure. The load consists of light & power for Substation, utility areas, street lighting etc.

4. SITE CONDITIONS:

As per CSS or transformer rating the DG set rating shall correspond to operation at 50°C.

5. STANDARDS

All materials and equipment shall comply with all the applicable provisions of the latest revision of Indian Standards, Indian Electricity Rules and other applicable statutory provisions, rules and regulations. Where no Indian Standards are available, the material and equipment shall comply with all applicable provisions of the latest revisions of the relevant International Standards and regulations. Some of the Standards (latest shall be applicable) to the specification are given below;

S. No	Standard Number	Description
1	IS : 1248	Direct acting indicating analogue electrical measuring instruments and their accessories.

2	IS : 1554	PVC insulated (heavy duty) electrical cables for working voltages up to and including 1100 V
3	IS : 1651	Stationary cells and batteries, lead acid type
4	IS : 2147	Degree of protection provided by enclosures for low voltage switchgear and control gear.
5	IS : 2705	Current Transformers
6	IS : 3043	Code of practice for earthing
7	IS : 3231	Electric relays for power system protection
8	IS : 4722	Rotating electrical machines
9	IS : 8623	Low voltage switchgear and control gear assemblies
10	IS : 10002	Performance requirements for constraint speed compression ignitions (diesel) engine for general purposes (above 20 KW)
11	IS : 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
12	IS : 13703	Low voltage fuses for voltage not exceeding 1100 V AC or 1500 V DC Pt-2/Sec-1
13	IS : 13947	Low voltage switchgear and control gear
14	BS : 159	Bus bars and Bus bar connections
15	BS : 5514	Diesel Engines for general purposes.

The appropriate standards applicable shall be clearly stated and the salient points of difference between the standards adopted and the Standards listed above shall be clearly brought out in the bid.

6. TECHNICAL DETAILS OF DIESEL ENGINE

Type & rating:

The diesel engine shall be stationary type, four stroke with vertical in line or "V" type cylinder arrangement, turbo charged, water cooled. The continuous engine BHP rating at the specified site conditions (refer design Basis) shall be 5% greater than the drive horse power required for rated output from alternator after allowing for derating due to power consumption for the auxiliaries of the engine. The deration due to site conditions shall be considered by the contractor as per relevant standard. The contractor shall furnish the calculations for selection of capacity of engine after deration and shall also furnish the details of power consumed by each auxiliary of engine.

Overload capacity & reliability:

The diesel engine is required to run an alternator directly coupled to the engine. The alternator shall provide the A.C supply in case of failure of Normal Supply. Hence it should be capable of quick starting and taking the full load all of a sudden, notwithstanding the fact that engine was at rest for a very long time under complete cold conditions. The engine shall also be capable of satisfactorily driving the alternator at 10% overload at rated speed for one hour in any period of 12 hours of continuous running. The material of component parts of the engine shall ensure a long service life and highest reliability of operation.

Short time capability:

The diesel generator shall be capable of supplying the starting current of induction motor (water pump motors, fridges, air conditioners etc.) connected to the control board. The diesel generator shall also be capable of short time overload of at least 1.5 times the rated capacity for 15 seconds.

Rated Speed:

The engine shall be of low speed and the rated speed shall not exceed 1500 rpm.

Engine Starting:

The engine starting shall be electrical by self-starting device. The source of starting supply shall be 24 volts maintenance free Ni-Cd batteries along with built in float & boost charger which are to be supplied, installed and commissioned by the contractor. The cranking device shall be so designed that engine starts automatically, reaches the rated speed within 30 seconds from the instant of receiving a starting impulse in case of failure of normal supply. Engine starting shall be through "Auto Mains Failure" (AMF) panel.

The fuel oil system and lubricating oil system shall also start simultaneously and automatically as soon as the starting impulse is received, to obviate any chance of seizure of piston and bearing as well as air locking in the fuel supply system.

Engine shall be supplied with DC starter of suitable rating, 24 V, Ni-Cd, high discharge performance; sealed type maintenance free batteries of suitable ampere hour capacity & reputed make complete with supporting racks & connecting leads with connectors will be included in the offer. The float charger to keep the battery floating and boost charger for charging the battery will also be included in the scope of supply. For ascertaining the battery voltage, digital voltmeter shall also be provided along with digital Ampere meter for current monitoring.

Engine Governor:

The engine shall be equipped with electronic governor in order to take care of heavy duty motor starting and it shall be capable of adjusting the delivery of fuel in response to variation in the load in order to maintain the speed substantially constant. Frequency shall not vary more than 1% under conditions of generator load from 0% to 100%.

Speed Regulation:

The speed regulation shall not be more than the following:

On suddenly taking off the rated load

Temporary speed regulation	-	Not more than 15%
Steady speed regulation	-	Not more than 5%
Maximum recovery time	-	Not more than 8 sec.

On suddenly taking in the 70% of the rated load

Temporary speed regulation	-	Not more than 10%
Maximum recovery time	-	Not more than 8 sec.

Fly wheel:

The speed drop shall be adjustable during operation from 0 to 5%. The engine shall have suitable balanced fly wheel of cast iron to smoothen the transient load variation.

Air Intake system:

The diesel engine shall be provided with oil bath type air filters having low resistance to air passage, high dust retaining efficiency and provision for easy cleaning. Filters shall be suitable for achieving

satisfactory engine operation under tropical humid conditions with sulphur dioxide and trioxide fumes, abrasive dust of 5 to 100 microns present in the atmosphere.

-Fuel oil system:

The engine shall be provided with fuel oil system suitable for high speed diesel oil marketed by Indian Oil Corporation or any other reputed oil company in India and should have workable and replaceable type primary and secondary fuel filters, injection equipment delivering correct quantity of fuel oil to the cylinders as needed by load. The fuel injection system shall be designated to permit manual adjustment of individual cylinder loading so that the vibration of exhaust, temperature and firing pressure shall be within the acceptable limits as recommended by the engine manufacturer.

Fuel oil tank:

The engine shall be provided with fuel oil service tank with a capacity of not less than that required for 10 hours continuous full load operation of engine and it shall be provided on a suitable fabricated non rusting steel platform. The tank shall be complete with level indicator marked in liters, filling inlet with removable screen, a drainage plug, an air vent and necessary piping and valves. The tank and all piping shall be painted both from inside as well as outside.

Lubricating System

The engine shall be provided with an integrated lubricating system with electric/engine driven lub, oil pump for feeding oil circulation during normal operation. It should also be equipped, if required with D.C. electric priming pump for lub, oil circulation during automatic starting and coasting down period after receiving the starting/stopping impulse. The engine lub, oil system shall be suitable to lubricate the required working parts of the engine effectively with recommended grade of oil marketed by the Indian oil Corporation or any other Indian Oil company under the climatic conditions as referred to above.

The necessary lub. Oil filters and coolers shall also be supplied. The lub. Oil system shall have adequate capacity of oil pumps fitted with arrangement for adding and draining oil to and from the system with necessary lub. Oil pressure sensing device, which shall cut off fuel supply to the engine as soon as the lub, oil pressure falls below the recommended level. The sensing device shall also act as soon as oil inlet and outlet temperatures go beyond the normal ratings.

The engine shall be fitted with primary and secondary lub, oil filtering arrangements with replaceable type lub, oil filtering elements. The lub, oil filters shall be suitable for a period of more than 500 hours of use without the necessity of its replacement or cleaning.

Differential pressure gauge across the filters or pressure gauge on either side of the filters may be provided to monitor the cleanliness of filters for lub. Oil as well as fuel oil filters.

Cooling system:

The engine shall be air/water cooled type with two section radiators. One of them shall be used for jacket water and turbo charger. The other shall be used for air cooler and lubricating oil cooler. Forced water circulation by means of a pump, driven by engine shaft shall be provided. The filtered water shall be circulated through engine block, cylinder head, water manifold, lub. oil coolers and radiator to restrict rise of temperature. Radiator fans operated by diesel engine shall be provided for cooling of radiators.

Turbo Charger:

It shall be robust construction suitable of being driven by engine exhaust having a common shaft for turbine and blower. It shall draw air from oil-bath type with adequate capacity to suit engine requirements.

Exhaust system:

The exhaust gases of turbo-charger shall be taken out above the engine through piping adopter etc. the engine shall be provided with an exhaust manifold in sections, suitable flanges, expansion joints with least bends and drain plug. The route of exhaust is discharged into atmosphere on top of the DG room avoiding the surrounding equipment being directly in front of it.

Environmental pollution control measures:

It shall be the responsibility of the contractor to supply the DG set which shall comply with the statutory government regulations relating to environmental pollution control relating to exhaust emissions, cooling water etc.

Quietness of operation:

The engine shall be designed to achieve maximum quietness of operation. The efficient silencer shall be provided for the exhaust as well as air intake. The noise level of DG set shall not exceed the permissible limits as per state authorities. The contractor shall furnish the maximum noise level at 110% load of the engine. Necessary means shall be adopted to minimise the vibration level during operation.

Engine warming:

Arrangement has to be provided to supply the hot water up to a temperature of 60 deg. C to 70 deg. C into the engine jacket and oil coolers of the engine for keeping it sufficiently warm for the purpose of quick starting of the engine under cold condition.

Piping, valves and fittings:

The engine shall be supplied with all piping, valves and fittings for fuel oil, lubricating oil, air inlet and engine exhaust system along with expansion joints, drain plugs, flanges and all other accessories. All pipes shall be painted.

Foundation bolts:

The foundation bolts of stainless steel for engine and alternator shall be supplied along with the machine. Base frames, where necessary for equipment is also to be supplied along with the machine.

Instruments:

The instruments to be supplied by the contractor shall include but shall not limit to the following:

Digital thermometers for measuring:

- Lubricating oil temperature at bearing outlet
- Lubricating oil temperature at oil cooler outlet
- Jacket water temperature at bearing outlet
- Jacket water temperature at cylinder outlet
- Jacket water temperature at radiator outlet
- Jacket water temperature at oil cooler outlet Pressure gauge
- At lubricating oil cooler outlet
- At jacket water inlet to cylinder
- On discharge of all auxiliary pumps provided with the engine

Differential pressure gauge across the lubricating oil and fuel oil filters or separate pressure gauges on either side of the filters.

Pressure switches for automatic starting of the DG motor driven stand—by lub. oil pump on low lubricating oil pressure On the lubricating oil system to give an alarm, if pressure falls below a pre-set value and subsequently trip the engine when the safe limit has been exceeded.

Thermostats

At the lubricating oil outlet from engine bearing for alarm as the temperature rises above pre-set and subsequently trip the engine when the safe limit has been exceeded. For this contractor shall furnish the details of the interlocks.

- Tachometer
- Primary sensing devices-control valves etc. for
- Lubricating oil temperature and pressure
- Fuel oil pressure
- Engine jacket water temperature Fuel oil service tank low level Lubricating oil low level

Items of Guarantee Performance:

The following items shall be guaranteed by the tenderer in respect of diesel engine set and auxiliaries when operating under specified site conditions.

Net electrical output at site conditions specified.

Fuel oil consumption at $\frac{1}{2}$, $\frac{3}{4}$, full load and 10% overload, as specified

Lubricating oil consumption at full load Jacket water temperature to and from engine Lubricating oil temperature to and from engine

10% over load for one hour without over-heating and showing signs of undue stresses within specified frequency variation during any time within 12 hour of continuous running.

Freedom from vibration and noise as specified

Governor response, over speed trip and over speed capacity.

The extra fuel oil consumption at 10% over load.

Contractor shall also state the codes and standards according to which tolerances on the performance will be applicable.

7. TECHNICAL DETAILS OF GENERATOR

- Type & rating:

Generator continuous output rating	:	As per design
Power factor	:	0.8 lagging
Overload capability for	:	a) 50% for 15
of Continuous operations	:	b) 10% for one hour
Rated voltage		
Rated frequency	:	50 HZ
Number of phases	:	3
Type of insulation		
Armature winding	:	Class F
Field winding	:	Class F (Temp. rise limited to

Class H Insulation)

Connections : Class F

Core connections : Class F

Type of enclosures screen protected preferably totally enclosed. Grounding method: neutral solidly grounded

The transient reactance shall be as low as possible consistent with the need to limit voltage drop on sudden application of load.

The generator set shall be so designed that it is capable of taking full load instantaneously. All parts of the generator shall be designed to withstand all electrical, mechanical and other stresses which may be experienced during operation, including short-circuit and over speed conditions.

The generator shall withstand an over speed of 20% and a critical speed which is not less than over speed in an emergency condition without incurring any mechanical damage. The rotor shall remain in electrical balance for all speeds up to 120% of rated speed.

The alternator shall be self-excited and automatic regulated type.

The alternator shall be having ball and roller bearings on the end shields.

Excitation system:

The excitation system shall be electronic type exciter having excellent response characteristics. The excitation transformer of suitable rating shall be included for static excitation equipment. The brushes type excitation system may also be offered as an alternative, which shall be preferred.

Voltage Regulation:

An automatic electronic type Voltage regulator [AVR] shall be supplied complete with cross current compensation. The regulator shall be supplied complete with voltage adjusting

rheostat, CTs for compensation and all accessories for successful operation including mounting and wiring, AVR shall be capable of maintaining 95% to 105% of the rated voltage under condition of rated capacity and power factor. AVR shall be fully encapsulated to give protection against moisture, sand, salt and vibration.

Terminal Arrangement:

The line and neutral side of each phase winding of the generator shall be brought out on six terminals located on terminal box mounted on the generator. Formation of star point and earthing of neutral lead for the alternator shall be carried out after mounting the CTs for protection. Two nos. diametrically opposite grounding terminals with suitable clamps shall be provided on the generator.

Terminal Box and Connection:

The alternator output terminals shall be enclosed in a terminal box mounted in an accessible position on the alternator frame. Cable glands and lugs shall be provided for all power and control cables which have to be terminated on the equipment supplied under this package. The connection for the AC and DC circuits shall be segregated from each other.

Suitably rated 240 volts single phase, thermostatically controlled space heaters shall be provided on the lower part of the stator frame. The connections of the space heaters shall be brought out to a separate terminal box. When the generator is running, the space heaters shall be automatically cut off and put on when the generator is in idle position. An isolating switch shall be provided in the heater circuit.

Control Equipment: Auto Mains Failure (AMF) Control Panel

The control equipment for the DG set shall be designed to automatically start and switch ON the DG set to the connected load in case of mains supply failure and to switch it 'OFF' as soon as the mains supply is restored back.

Even if mains AC supply is available, it shall be possible to automatically start/stop the diesel set by push button control from the panel to test the set.

In interconnecting mode of power supply, where AC supply from the outside source is available the diesel generator set will normally be at rest. On failure of normal AC supply as sensed by the under voltage relay, the starting circuit of the Diesel Generator set will be automatically energised and all the sequences involved in the complete start-up of the diesel generator set, bringing it to the rated speed and voltage shall take place automatically without the help of any operator. The contractor shall provide all the necessary control & switchgear equipment required for the purpose of automatic starting of diesel generator set involving various stages of generation in the engine auxiliary systems.

The diesel generator set shall be designed to reach its rated speed and voltage within a period not exceeding 30 sec. The voltage and frequency relays for the purpose shall be included in the scope of supply of contractor. The diesel switchboard/control panel complete with electrically operated air circuit breaker rated for 650 V, 800 A continuous current and 35 KA rupturing current of suitable rating along with adjustable thermal and short circuit protective devices, for the incoming feeder and MCB/MCCBs for the outgoing feeders, current transformers, protective relays for protection of diesel generator, ammeters, voltmeter, frequency meter, indicating lamps, annunciator relays, selector switch for selection of auto/manual control etc. shall be included in the scope of supply. MFM may be provided for various measurements.

In the existing switchgear mains 3 – phase, 415 V supply bus bars, are fed from a dedicated

11 kV/415 V transformer. It has outgoing 3 phase, 4 wire feeders and single phase, 2 wire

feeders. In case of mains failure it is proposed to feed the loads of these three phase and single phase feeders from the DG set. Besides it the provision of four three phase and four single phase spare feeders shall also be provided. Four 3-phase feeders shall have MCCB and the rest shall have MCB's of rating up to 63A TPN/SPN. The DG set along with its supply board panel shall be located near to the existing mains switchboard. The successful contractor shall provide the necessary interconnection by ACB / MCCB's during detailed engineering.

On restoration of Mains A.C. supply from the source of normal supply stopping impulse will be given to trip the diesel generator automatically.

It shall also be possible to start/stop the DG set manually through local push button [from remote on SCADA] provided on control panel. Auto-manual selector switch and local/remote selector switch for the purpose shall be mounted on the control panel.

A three attempt starting facility for the engine shall be provided in the automatic mode and in case the diesel engine fails to start and reach its rated speed within 30 seconds, it shall be disconnected and locked out automatically. Provision of remote alarm and other signals shall be provided at remote.

The diesel generator set shall be tripped under the following abnormal conditions:

DC control supply failure.

Over speed of diesel engine sensed by tachometer and/or mechanical over speed device. Low lubricating oil pressure after engine has attained 90% speed.

High jacket water temperature

Generator fault

For the abnormal conditions mentioned above, an alarm shall also be given at remote.

The contractor shall provide all the sensing devices on the diesel set and necessary relays on the control panel to achieve the above tripping conditions. These devices shall be suitable for operation on 24 volts DC supply. The DC supply will be made available at the control panel by the contractor from the battery provided.

Window type annunciator shall be provided on control panel to give visual indication of any one or more of the following abnormal conditions. One more potential free contact of each of the alarm conditions listed in this clause shall be provided and if required wired out for getting alarm on for SCADA.

Trip Alarms

High jacket water temperature

Lubricating oil pressure

Loss of 24 Volts DC control supply

Engine over-speed

Generator fault

Failure to start the engine

Over voltage

Non-trip Alarms

Lubricating oil tank level low

Sub-Fuel oil tank low Fuel oil tank level low Excitation failure

Spare windows (4 nos.)

The annunciator panel shall be modular in construction complete with visual indication. The panel shall be suitable for working on 24 volt DC supply. The initiating contacts shall be potential free. The annunciator circuit shall be provided with common accept and reset push buttons and test facility if required.

On occurrence of fault the appropriate window shall light up. The visual indication shall, however, persist until the relevant fault contact has been reset after which the visual indication can be reset by the "RESET" push button.

After acknowledgment of one fault by the "acknowledge" push button, the alarm circuit shall be ready to operate for another fault.

The control panel shall be of fabricated construction made of best quality stainless sheet steel of minimum thickness of 2.5 mm and shall be free standing floor mounting type. The panel shall be totally enclosed, completely dust-tight and vermin proof. Gaskets shall be provided between all openings and joints. The control panels shall be of folded construction compact neat and provided with double door with locking arrangement at the back. The control panel shall be epoxy painted and with the finished colour of the panel shall be light grey paint as per shade 631 of IS: 5.

All cable entries shall be from bottom. Separate cable chamber suitable for XLPE cables per phase and XLPE cable for neutral shall be provided in the control panel with cable termination facilities complete with cable glands, lugs, etc. for all incoming and outgoing cables. Enough space shall be provided in the control panel for easy access during maintenance and repairs. The contractor shall also furnish a clear cut drawing of cable connections. The size of cable shall be approved during detailed engineering.

The control panel shall be provided with 2 nos. earth terminals with accessories for connection to the earthing mat. The copper earth strip connecting the earth terminals to earth mat shall be supplied by the contractor and size of this earth strip shall be subject to Engineer's approval.

Degree of protection of control panel shall be minimum IP 54. The contractor shall furnish test certificates for similar panel conforming to IP 54 with the offer.

Flush mounted digital instruments conforming to industrial grade "A" as specified in IS:

1248 shall be provided. The indicating instruments shall be of 96x96 mm size. They shall have accuracy class of 1.5 or better. Case of the instruments shall be dust and moisture proof.

Indicating lamps shall be panel mounted, LED type and of low watt consumption. The cap of lamp indicating shall preferably be of screw type and made of unbreakable & heat resistant moulded material.

All the wiring of control panel shall be carried out with 1100 volts grade PVC insulated stranded (48) copper wire of cross section not less than 2.5 sq.mm. The wiring shall be identified at both ends by means of V plastic ferrules. Suitable internal lights shall be provided along with control switch. Control switches and push buttons shall also be flush mounted on the front of the control panels.

The panel shall contain or shall have mounted on it the automatic voltage regulator, field breaker and field discharge resistor with associated control switches and indicating lamps, or this may be provided in a separate matching cubicle to be mounted alongside of the control panel.

The control panel shall also be provided with but not limited to the following accessories.

- 1 No. 650 V, (rating as per calculation) draw out type, spring charged, electrically operated air circuit breaker/contractor for incoming circuit from Diesel set with adjustable thermal and instantaneous trip units, electrically operated complete with necessary relays, switches indicating lamps etc. The bidder shall quote considering both the options.
- 1 nos. digital AC ammeter of suitable range with three line arrangement without selector switch.
- 1 no. digital AC voltmeter of suitable range without selector switch
- 1 no. multifunction meter to read 3 phase power, maximum demand, energy, PF and other parameters.
- 1 no. Tachometer
- 1 no. digital frequency meter
- 1 no. counter to indicate number of times the DG set has been operated. Red lamp for diesel generator breaker in closed position
- Green lamp for diesel generator breaker in open position
- White lamp for diesel generator breaker in spring charged position
- DC ammeter and DC voltmeter for diesel generator field circuit / battery charger
- Battery charger of adequate rating
- 1 no. local / remote / test selector switch with status indication
- 1 no. auto OFF-MANUAL Selector switch with status indication
- Voltage and frequency sensing relay Over speed, speed & under speed relay Protection relays for the alternator Battery ON/ OFF switch
- Alarm annunciator with provision for remote annunciation

- Lamps for 24 V DC ON/ OFF Start, stop, push buttons Emergency stop switch
- Alarm accept, reset, test push buttons
- Lamp test push button
- Automatic voltage regulator
- Other components such as contactors, timers, auxiliary relays, fuses etc. required as per approved schemes.

Provision for remote indication of Diesel Generator Circuit Breaker ON/ OFF/ Auto trip

MCBs/ MCCBs with ON/ OFF indications for outgoing feeders. (The details shall be given during detailed engineering). The incomer MCCB, shall be of rating with provision for setting the range.

Protection of Alternator

The control panel shall also contain all protective and auxiliary relays for electrical protections / metering recommend by the supplier for the alternator including (but not limited to) the following digital relays:-

- Over current & E/F protection
- Restricted Earth Fault protection
- Reverse power protection
- Over-voltage protection

These shall be SCADA compatible.

The protective devices shall be selectively coordinated so that sufficient time is given to the immediate protective device to clear the fault before the operation of back-up protection. All relays shall be suitable for the type of protection required and the contractor shall replace the relay at a later date without any extra charges if found unsuitable for this type of application.

The contractor shall furnish complete protection scheme indicating CT parameters, setting range, type of relays for each protection specified above as called for in schedule of guaranteed and other technical particulars, non-compliance of which may be sufficient reason to reject the bid. The protection provided including CT parameters and relay, shall be subject to the Engineer's approval.

Co-ordination of Protection:

Complete protection schemes and curves demonstrating the selective coordination of the protective elements and recommended relay settings for each type of protection with operating characteristics shall be furnished by the contractor for approval. It shall be the responsibility of the contractor to provide adequate protection to the alternator / equipment connected to it. This aspect shall be clearly confirmed by the contractor in his offer.

Relays General Requirement:

The relays shall be of reputed make and type which shall be subject to Engineer's approval. The relay shall be enclosed in a flush or semi-flush, dust-tight, draw out case finish with dull black enamel paint. Relays shall have self-contained test facilities and provision for removing relay mechanism for inspection and maintenance. The relays shall be self-reset type, tropicalized and have silver contacts with a wiping action. The relay contacts shall be capable of making, carrying and breaking currents of associated circuit. All necessary provisions for easy testing of relays shall be incorporated and specifically brought out in the bid. Suitable devices shall be provided along with an easily accessible resetting device.

8. CIRCUIT BREAKERS

8.1. AIR CIRCUIT BREAKERS

The Air Circuit Breakers if provided shall be preferably draw out type, suitable for automatic, remote electrical, local electrical as well as manual operation.

The circuit breakers shall have the following ratings

No. of Poles	:	4
Nominal voltage	:	650 volts
Service voltage	:	415 volts
Continuous current	:	As required
Frequency	:	50 C/S
Breaking current capacity [Ics]	:	35 KA
Short time current rating	:	35 KA for 1 sec.
Making capacity	:	875 KA
Operating duty	:	0-0.3 sec.- CO-3 Sec-CO

Nominal control circuit voltage for closing

Oil, Auxiliary devices, relays etc.	:	24 V DC

Nominal control circuit voltage for trip coil 70-110% rated control circuit voltage

The closing of the circuit breakers if provided shall be effected by a compression spring automatically charged after each closing operation by an electric motor. The electric motors shall be suitable for 240 V, AC. The motor shall be able to charge the spring from fully charged condition in not more than 5 seconds. The spring once fully charged shall be capable for trip, close and trip operation successfully. It shall be possible to charge the spring manually with manual handle. A position indicator shall be provided on the respective based serving the condition of spring.

The circuit breaker shall be provided with adjustable temperature compensated thermal overload and instantaneous over current tripping device with setting to suit full load to 40% of the current of the individual circuit. The circuit breaker shall be trip free type and shall be provided with anti-pumping device. The closing coil and other auxiliary devices shall operate satisfactorily at all voltage between 70 – 110% of the rated control voltage. The circuit breaker shall be provided with “ON” “OFF” “AUTO TRIP”, Trip circuit healthy and spring charged indicating lamps. Sufficient number of auxiliary contacts for interlocking, alarms and annunciation on the DG control panel and remote panel shall be provided. Lockable Auto / Manual and local/ remote selector switches for selection of circuit breaker control point shall be provided on the panel.

The provision for following controls, indicator, instrumentation and annunciation on the remote panel for each circuit breaker shall be made.

Close / Open push button

ON / OFF Auto trip indicating lamps

Trip circuit supervision lamps

Breaker trip alarm & Indication.

8.2. MOULDED CASE CIRCUIT BREAKERS (MCCB)

MCCBs shall be draw out type provided with on/off indication and thermal overload & short-circuit releases. It should be possible to set the overload, setting between 70 to 100% rating.

MCCBs shall be plug in type and shall be suitable for manual operation. The circuit breaker shall have the following rating.

No. of pole	:	4
Nominal voltage	:	650 volt
Service voltage	:	415 volts
Continuous current	:	To be indicated during detailed engineering
Breaking current capacity	:	35 KA
Short time current rating	:	35 KA for 1 sec.

8.3. CURRENT TRANSFORMERS

All CTs shall be of reputed make and type which shall be subject to Engineer's approval. The CTs shall be dry cast resin type suitable for indoor mounting. The CTs shall have suitable short time current rating, rated transformation ratio and adequate VA burden output to suit the connected relays/instruments. The CTs for restricted earth fault protection shall be of PS accuracy class and shall have knee point voltage, secondary resistance and excitation current value to suit the protection. Typically the CTs for other protection shall have 15 VA, 5P10 rating. The CTs for metering shall be of accuracy class 1.0 rated VA output not less than 5 VA. All, the current transformers shall conform to the requirements of latest issue of IS: 2705 (Part I to IV).

8.4. VOLTAGE TRANSFORMERS

The voltage transformers shall conform to the requirements of IS: 3156/IEC 186. Voltage transformer shall be dry cast resin type suitable for indoor mounting. The potential transformer shall be single phase type and shall be suitably connected for the specified winding connection.

The technical particulars of voltage transformer are as below:

Rated primary voltage	:	415 volts
Rated secondary voltage	:	110/V 3 volts
Winding connection	:	STAR/STAR
Frequency	:	50 HZ
Accuracy class	:	1 for metering 3P for protection
One minute power frequency withstand test voltage		
Primary winding	:	3 KV
Secondary winding	:	3 KV

8.5. D.C. CONTROL SUPPLY

For control, protection and indication, 24 V maintenance free type battery of suitable capacity, along with float charger and boost charger shall be included in the scope of offer. The step down transformer to step down single phase/three phase 415V/240 V A.C. supply for float charger and boost charger circuits shall be included in the scope of offer.

8.6. CABLING

All the power and control cables for connection between Diesel Generator and its control panel/switch board shall be included in the scope of the tenderer. Necessary accessories such as crimping lugs, compression glands etc. is included in the scope of supply of tenderer.

All the power cables shall be single core/3 core (with neutral conductor wherever applicable), XLPE, insulated AL conductor and shall be of suitable size to carry continuous, overload and short

circuit currents. The cable size shall be subject to approval of the Engineer. The cables shall conform to IS 1554. All control cabling shall be done with 1100 volts grade PVC insulated XLPE cable with copper conductor of cross section not less than 2.5 sq.mm.

The cables shall be subjected to routine tests, type tests and acceptance tests as per IS: 1554 Part – I and test reports for the same shall be furnished for approval.

Test reports for tests conducted on similar type of cables shall be furnished with the bid. To ward off the incidence of fire the cables shall be FRLS type

8.7. SOUND PROOF ACOUSTIC ENCLOSURE

To reduce noise pollution, the DG set should be enclosed in a sound proof acoustic enclosure. This enclosure should be made out of cold rolled stainless steel or other non- rusting type material and epoxy painted.

It should consist of a suitable designed ventilation system, high quality acoustic insulation material as per IS-8183 which should withstand the internal temperature. The noise level should not exceed 70 dB (A) [or lower to meet statutory requirements] at a distance of 3 m.

8.8. EARTHING

The alternator neutral shall be brought out as per of the specification and shall be earthed solidly. Proper earthing for alternator frame, diesel engine frame, diesel generator control panel, shall also be done by the contractor by suitable size of copper flat as per I.E. rules and relevant Indian Standards. The size and material of earthing strip shall be subject to Engineer's approval.

8.9. TESTING AND INSPECTION

Diesel engine, alternator, control and switchgear panels, DG board, AVR battery, circuit breaker, battery and battery chargers, cables, instruments, busbars, relays, CTs, contactors and all accessories etc. shall be subject to routine, type and acceptance tests in accordance with the requirements of the latest issue of relevant Indian Standards in the presence of Engineer. The contractor shall clearly state the testing facilities available at his works for testing the complete equipment with all fittings and accessories offered.

Each complete wired control panel and board shall be tested to ensure that all its protective, control interlock systems are satisfactorily functioning as per requirements. Test certificates for functional tests shall be furnished to the Engineer.

The tests to be carried out on diesel generator set shall include (but not limited to) the following:

- Diesel engine
- Power output at full throttle on auto governor.
- RPM, torque, fuel rate, fuel pressure, lubricating oil pressure, intake manifold pressure blow by exhaust temperature and smoke checks.
- Performance parameters measurements at full load, half load, $\frac{3}{4}$ load and $\frac{1}{4}$ load shall be noted.
- RPM and lubricating oil pressure at high idle and low idle shall be noted.
- Engine washing for leakage check
- Performance parameters at 10% overload
- Calculations for horsepower and efficiency at full load, $\frac{1}{2}$ load, $\frac{3}{4}$ load, $\frac{1}{4}$ load and
- 10% overload shall be furnished.

- Time from initiation of start command to rated speed shall be noted.
- Alternator
- Phase sequence and polarity marking tests
- Check of direction of rotation
- Insulation resistance measurement both before and after high voltage tests
- Vibration test

Measurement of resistance of field winding, main armature winding, space heaters etc. and leakage reactance measurement.

- Open circuit test
- Short circuit test

Temperature rise test and 50% overload test for 15 seconds after temperature rise tests

- High voltage tests
- Wave form test
- 120% over speed
- Momentary overload test
- Regulation test
- Efficiency test
- Exciter
- Nominal exciter response test
- Load characteristic measurements
- Momentary overload
- Temperature rise test
- High voltage test
- Measurement resistance
- Measurement of insulation resistance
- Regulation and efficiency tests
- Voltage regulator
- Response time tests
- Sensitivity tests
- Control panel/board
- Physical dimension check
- Verification of apparatus
- Control wiring verification
- A.C. and D.C. wiring check
- Functional tests
- High voltage tests

- Insulation resistance (Megger) test
- Tests on completely assembled DG set:
- Functional checks for local, manual, auto start, stop, speed and voltage control
- Tests to check the starting time from completely cold conditions
- Vibration and noise tests
- One hour at full load, one hour at $\frac{3}{4}$ load running
- Four hours at full load followed by one hour continuous load of 110%
- Fuel consumption tests at efficient load
- Automatic starting and interlocks checks
- Governor response
- Over-speed test and over-speed trip test
- Site tests:

Tests to prove the guaranteed performance of the diesel generating set shall be carried out at site after proper installation.

The Contractor shall give fifteen (15) days' notice for readiness for inspection and testing so that the Site Engineer/ Client representative may be deputed to witness the tests. Before the notice of testing, the contractor shall furnish the schedule of tests with procedure which shall be followed during the testing.

Six copies of the test reports, duly signed by the Engineer who have witnessed the tests, shall be furnished for approval. No material shall be dispatched to site without taking Engineer's approval. Should the inspection be waived off by the Engineer, such waiver shall be not relieve the contractor, in any manner, from his entire obligation under the contract.

All requisite testing meters, instruments and equipment for carrying out the site tests shall be arranged by the Contractor.

Should be results of any test indicate any defect, the contractor shall rectify these at his own cost and retest shall be done till satisfactory results are obtained. Should the equipment ultimately fail to pass the specified tests, the Engineer shall have the right to reject the material.

8.10. OPERATION AND MAINTENANCE MANUALS

- Operation and maintenance manuals in respect of Diesel Generator set shall contain the following information.
- Technical details of the diesel engine such as ratings, construction, governor, fuel oil system, lubricating oil system, cooling water system, starting system, air system (after cooler turbo-charger etc.) exhaust system etc.
- Technical details of the generator such as ratings, construction, stator, rotor, ventilation, insulation of windings, stator terminals, space heaters, temperature detectors, excitation system, neutral earthing details, automatic voltage regulator, protection etc.
- Technical details of the control panels/boards such as type, construction, functions that are performed in sequence of operation, details of accessories and equipment mounted on it, annunciator panel, earthing details etc.
- Technical details of other equipment such as CTs location, type, technical particulars and functions, starting lead acid battery and charger rating, type, location, technical particulars. Fuel oil tanks capacity, material, location etc.

- Instructions for maintenance of each component of DG set and associated accessories.
- General arrangement drawings of all equipment.
- Approved control and protection schematic diagram of control panel
- Approved bill of material with make, type and rating of each component
- Descriptive literature, catalogues of all accessories
- Assembly drawings identifying the component parts
- Technical details of acoustic enclosure
- Twelve sets of bound volumes of above manuals shall be supplied to the Engineer before commissioning and handing over. Two sets of the same manual shall be supplied to the consultants.

8.11. PERFORMANCE REQUIREMENTS

The diesel generator and its accessories shall be designed to meet the following performance requirements which shall be guaranteed by the contractor:-

The unit shall be capable of starting from cold conditions reaching synchronous speed and taking up full load within 30 seconds from the instant of giving start impulse without wear or stress on engine. In case of main supply failure, within 3 seconds it should be possible by AMF panel to switch on automatically the DG set to the connected load. Similarly as soon as the main supply is restored the DG set shall automatically trip to permit the connected load to be fed by the main supply.

The unit shall be capable of delivering continuously at generator terminals rated output (net power) at rated p.f. This output shall be obtained after necessary derating of engine due to site conditions and with auxiliary power requirements have been considered.

The unit shall be capable of delivering peak output of 10% in excess of rated output for a period of one hour, without exceeding the permissible temperature rise limits.

- With the unit running at No. load with rated voltage and speed, the transient voltage drop at its terminals shall not exceed 10% of rated voltage on simultaneous starting of direct on line motors and other loads which were already connected to the station service board.

8.12. ERECTION / CONSTRUCTION / MAINTENANCE TOOLS & EQUIPMENT

One set of all special tools & equipment required for installation, testing, operation and maintenance of Diesel Generator set & associated accessories shall be supplied by the contractor.

8.13. SPARE PARTS

The contractor shall furnish a list of recommended spare parts required for five years satisfactory operation of all equipment to be supplied by him.

The contractor shall guarantee that they shall supply spare parts whenever required on the mutually agreed terms & conditions for the life time of the equipment. Mandatory spare parts:

The contractor shall provide the following: -

Generator & engine

Shaft bearing set	:	1 no. set
Gland packing & gaskets	:	1 set of each type
Crank pin bolt assembly	:	1 set
Liner ring	:	1 set

Oil seals	:	1 set of each type
Mechanical seals	:	1 set of each type
Filter elements (air, water, fuel, oil)	:	4 sets of each type
Ignition sets	:	2 Nos.
Piston ring & oil ring	:	1 set of each type of rings
Valves (air inlet, exhaust)	:	1 set of each valve
Piston pins	:	1 set
Heaters (air, water)	:	1 set of each type
Current transformers	:	1 no. of each type
Control panel Relays and base	:	1 no. of each type
Indicating lamps	:	10% of total
Emergency stop push button	:	1 no.
Ammeter	:	1 no. of each type & range
Voltmeter	:	1 no. of each type & range

Any of the above items may be increased or decreased or deleted at the absolute discretion of the client.

8.14. FIRE PROTECTION

All equipment connections, cable etc. shall be designed and arranged in such a manner as to minimize the risk of fire and any damage which may be caused in the event of fire. The contractor may suggest the fire protection, measures necessary for the equipment.

8.15. DEVIATION FROM SPECIFICATIONS

All fittings, apparatus, accessories & components which may not be specifically mentioned in the specifications but are required for completeness of equipment shall be deemed to be included in the scope of these specifications.

All deviations from the specifications shall be brought presented to the Engineer for evaluation and approval, if any. The deviation shall be given in full along with the clause numbers and reasons for the same.

In the absence of any deviation schedule, it shall be presumed that requirements of the specifications are fully complied with by the contractor and any deviation shall not be considered later on.

8.16. CIVIL WORKS FOR DG SETS

DG set shall be placed in a plinth (along with enclosure) and covered by a shed. Plinth height shall be 500mm or more if required due to flooding study at the location. It shall be covered all around with a mesh fence and provided with a shutter. These design / layout shall be provided by contractor for approval of Engineer.

SECTION 9: Not Used

SECTION 10: TECHNICAL SPECIFICATION FOR EXTERNAL ILLUMINATION

1. SCOPE

The specification covers the design, engineering, material, fabrication testing, inspection, packing, forwarding supply, delivery and installation of Poles composite street light, LED lights fittings complete in all respects for the street lighting system by underground cables under the project.

Exterior lighting shall be provided for streets, parking areas, open areas developed areas, as per following items of work.

2. POWER SUPPLY

The voltage available for the street lighting and security lighting will be 415 volts three phase and neutral 50Hz AC from the main external lighting board located in outdoor area.

3. WIRING OF FIXTURES

The street light fixtures shall be wired from terminal block by means of flexible (3 * 2.5 sq mm) copper conductor, PVC insulated cable through a rewire-able MCB and neutral or suitable sized MCB.

4. CABLE

All cables shall be aluminum conductor (unless copper wire is specifically asked for), PVC insulated, PVC sheathed, armored of 1100 V grade. The wire of different colors should be used for quick identification of phase wire and neutral. The cable shall be of approved make as specified in the list of makes

5. GENERAL

All light luminaires shall conform to the relevant Indian Standard Specification. The assembly of light luminaires shall be such that it is easy to handle, install, operate and maintain them. The equipment shall be reliable in operation.

All the hardware used in the assembly of the luminaires, shall be either galvansied or painted with corrosive paint.

The internal wiring of the luminaires, from the junction box shall be done with wires of adequate size. All the accessories of the fittings shall be clamped/supported suitably at the entry to the luminaires.

All light luminaires and the associated control gear shall be rated for operation at 230 V, 50

Hz. A.C. supply unless otherwise specified in this specification.

The supplier shall supply all the technical features, light distribution diagrams; zonal luminous flux diagram and isocandala diagram of the luminaries. A dimensional drawing giving the overall dimension of the luminaires shall also be supplied.

The lighting circuits are generally of three phase and neutral 500 V distribution with

Aluminum conductor PVC insulated armoured cables.

Installation price of cables buried underground shall include excavation and back filling, supplying of sand, brick, protective cover, identification tags. Termination of lighting cables at both ends and all accessories are grouped together. The installation price of lighting poles shall include all necessary foundation work including concreting, mounting of loop-in and loop-out box. Lighting luminaires fixing along with a PVC insulated copper conductor cable from the loop in and loop-out box to fittings is taken together in one item. *(50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).*

The installation price of earthing electrode shall include burying of the electrode and the termination of the earthing conductor.

For all the installation work necessary materials, accessories, hardware etc. as required to make the installation complete in all respects shall be included in the offer.

While loading, transporting, unloading and erecting the poles, care shall be taken so that the poles do not get bent out of shape and where necessary, such defects shall be rectified before the poles are erected in position. The poles shall be erected in plumb line and correct level as indicated in drawing and to the satisfaction of the Engineer-in-charge. They shall be kept in this position

with the help of manila ropes until the foundations are constructed, (for a minimum period of 7 days) and the backfilling is complete.

At road crossing, the cables shall be taken through RCC Hume pipe to be buried at a depth of 1 meter below the finished ground level and shall cover and run below the drainages on both sides of the road. The trenches excavated for embedding the RCC Hume pipe shall be back filled with the excavated earth and compacted to same degree as that of the surrounding area.

The protection of cement mortar for brick work to be used shall be CM:1:4 for covering the hume pipe at the road crossing.

6. ROUTE MARKER

Cable route marker marked "CABLE" shall be provided along route of the cable and location of loops. The route markers shall be of tapered concrete slab of 60 * 60cm at bottom and 50 * 50cm at top having a thickness of 10cm having 1:2:4 mix. Cable marker shall be mounted parallel to and 50 cm away from the edge of the trench. The concrete marker shall be laid over the trench projecting over the surrounding surface.

7. STEEL TUBULAR POLES

The steel tubular poles shall be Galvanised octagonal types.

7.1. GALVANIZED OCTAGONAL POLES

7.1.1. Design

The Octagonal poles shall be designed to withstand the maximum wind speed of 169 KM / Hr. 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 BS : 5649 Part VI 1982.

7.1.2. Pole Shaft

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. The welding of pole shaft shall be done by submerged Arc Welding (SAW) process.

All octagonal pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

7.1.3. Door opening

The octagonal poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal resistance and shall be weather proof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing. The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

7.1.4. Material

Octagonal Poles	-	HT Steel Conforming to grade S355JO
Base Plate	-	Fe 410 conforming to IS 226 / IS 2062
Foundation Bolts	-	EN.8 grade

7.1.5. Welding

The welding shall be carried out confirming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

7.1.6. Pole sections

The Octagonal Poles shall be in single section (upto 11 mtr). There shall not be any circumferential weld joint.

7.1.7. Galvanization

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 70 micron. The galvanizing shall be done in single dipping.

7.1.8. Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

7.1.9. Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for Installation of the luminaries.

7.1.10. Manufacturing

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

7.1.11. Service window

A service window of the size 150 mm x 100 mm shall be provided in the base of the pole to allow access to electrical connections and terminations. It shall be covered with MS plate and proper rubber gaskets shall be provided to prevent any ingress of water etc..

7.1.12. Electrical connections

Four way connectors shall be provided along with Slide lock and 1 no. 6 amps Sp MCB including 2.5 sqmm PVC insulated copper conductor wires from the terminal block to the fixture and 2 nos. 32 mm dia GI sleeves of suitable length shall be provided upto the service window. An earth boss is provided on the control plate along with connectors and interrupters.

8. TESTS

The supplier, before handing over the installation to the Engineer-in-charge, shall carry out tests on all fittings and cables as per IS Specifications.

The test shall include:

- Megger test
- Continuity test.
- Phase sequence and polarity test.

9. LED STREET LIGHT LUMINAIRE

Supply of LED streetlight luminaries complete with pressure die cast/extruded aluminium housing and adhering to the following specifications and lighting design requirements will be as per actual applications-

Efficiency of driver electronics shall be more than 90%.

The LED should be driven at the suitable current and within the permissible limits specified by the LED manufacturer.

Power factor of the electronic driver should be at least >0.95 with THD $<10\%$.

The LED luminaries shall produce constant lux level in the voltage range of 100V to 280V. Voltage variations/ fluctuations in the specified voltage range shall not impinge upon the lux level it produces.

The life span of the LED source including its Driver shall be greater than 50000 hours.

The luminaries shall conform to IEC 60598 or equivalent standard. The driver should comply with IEC 61347-2-13, IEC 61547, CISPR-15; and 61000-3-2.

The luminaire shall be suitable for 80W, LED and for mounting height up to 9mtrs from ground level.

10. ELECTRONIC COMPONENTS

The electronic components used shall be as follows-

IC (integrated circuit) used shall be of industrial grade.

The resistors shall be preferably made of metal film of adequate rating.

The conformal coating used on PCBs should be cleared and transparent and should not affect color code of electronic components.

The heavy components shall be properly fixed. The solder connection should be with good finish.

11. CONSTRUCTION

The casing of the lighting luminaries shall be made of pressure die cast aluminium coated with epoxy polyester powder coat single, self-contained device not requiring any on-site assembly for installation onto an existing lighting luminaries integral with power supply unit. The driver unit must be accessible and if need be replaceable easily and with minimum use of tools.

The casing made of non-corrosive aluminium having high conductivity shall have external surface designed in a manner so as to act as an efficient heat sink to extract heat generated at pn-junction of a LED. Efforts shall be made to keep the overall outer dimensions as minimum as possible without compromising on the performance of the LEDs or luminary.

The assembly and manufacturing process for the LED source assembly in modules/ arrays shall be designed to assure all internal components are adequately supported to withstand sudden impacts and mechanical shock and vibration from high winds and other sources.

No part shall be constructed of polycarbonate unless it is UV stabilized

Material used for the lens of LED source shall be of toughened glass, heat resistant and shall not undergo discoloration during lifetime of the LED source. It shall conform to ASTM specifications for the materials. Any discoloration observed in the lens shall be considered a failure under warranty clause.

All luminaires shall be provided with acrylic / polycarbonate / glass diffusers and/or aluminized reflectors and/or lenses to provide proper road lighting distribution.

Toughened and/or tempered glass of sufficient strength may be provided under the LED chamber to protect the LEDs and luminaires.

The LED lens shall be UV stabilized and shall be capable of withstanding ultraviolet (direct sunlight) exposure for a minimum period of 60 months without exhibiting evidence of deterioration.

The luminaries shall be capable of operating normally in ambient temperatures from -20°C

to 50°C maintaining junction temperature below 100°C and heat sink temperature below 60°C, ensuring efficient thermal management of the luminaire.

The fixture shall be designed in such a manner that it is easy to handle and install, is not too large and unwieldy, is of robust construction, light weight and conforms to minimum IP65 class of protection for outdoor use against dust and moisture intrusion.

The luminaire shall be provided with a built-in external heat sink as well as an aluminum MCPCB printed circuit board, designed in such a way that the heat generated within the LED source is efficiently dissipated to the surrounding atmosphere without abnormal rise in temperature. Any debris build up shall not degrade heat dissipation performance of the luminaires.

SECTION 11: TECHNICAL SPECIFICATION FOR EARTHING

1. SCOPE

This specification covers the technical and associated requirements for the entire earthing system substations, required to protect persons and equipment and to allow safe service and maintenance of the installations. The earthing system includes the underground grid, ground rods and connections. The earthing system shall be designed to minimize the dangers from step, touch and transferred potentials which can occur under maximum fault conditions. The Contractor shall design, furnish and install the substation earthing system in accordance with the provision on latest IEEE Std. 80, Guide for Safety in Substation Earthing, IS: 3043, Code of Practice For Earthing and the provision of this specification. The contractor shall submit calculations in support of his design.

In addition to the above codes and standards, the Contractor shall comply with applicable national and local laws, codes, regulations, statutes and ordinances.

The Contractor shall bear full responsibility that the earthing system materials have been designed and fabricated in accordance with all codes and standards and that they perform under the conditions and to the standards specified herein.

The Contractor shall carry out earth resistivity measurement for the substation site. Based on the result of this measurement and the system parameter, the appropriate design and the calculation will be determined whether impermissible touch and step voltages occur at any place of the station (including outside area) which may be endangered. These calculations will decide on the provisions for earthing to be made with the relevant part of the civil works related to foundations. It shall be agreed between Engineer and Contractor, about special arrangements, if calculations prove that touch and step voltages are higher than permitted and the Contractor proves that he modified the earthing grid to its optimum. Only calculations built up on computer generated design programmed shall be accepted. A special software for providing detailed analysis of the actual step and touch voltages likely to be generated has to be used.

The HV and LV systems are solidly earthed at the neutral point of the power transformer. The size of earthing conductors to be connected with the earthing system shall be designed for an earth fault level of 25 kA (3 sec). The material for earthing in particular for jointing shall be selected to prevent corrosion at the connection points as well as at the earthing material itself, both underground and exposed to air. If necessary, cathodic protection of an approved design shall be applied. In order to minimise the effect of seasonal variations of earth resistance, the earthing system shall be designed for the worst conditions.

2. DESCRIPTION OF SERVICES

The Contractor shall provide a complete earthing system consisting of:

- The main outdoor subsoil earthing system, with individual loops around each building, foundation, structure, etc., of the site.

- Sub-earthing systems for buildings, foundations, structures, tanks, etc., being connected to the subsoil earthing system as required
- All electrical equipment such as motors, transformers, substations, foundations, switchboards, control boards, relay and auxiliary relay boards, all other subsidiary electrical equipment as well as all metal parts of civil construction or the mechanical equipment such as transformer rails, pumps, pipes, steel structure, tanks, cable trays, etc. shall be connected to the earthing system.
- All materials and parts which are not specifically mentioned herein but are necessary for the safety of operating personnel and safe operation of the substation shall be furnished and determined by the Contractor at no increase in cost to the Owner.

3. DESIGN REQUIREMENTS

3.1. GENERAL

- The ground grid shall be composed of a system of galvanized conductors buried approximately 600 mm below finished ground level, excluding crushed rock surfacing. The grid system shall cover the entire fenced substation area and shall be extended to the outer of the substation fence. A perimeter conductor shall run around the substation in a distance of 0.6m to the fence and shall be connected to the inner earthing grid and to the fence in regular intervals. Where necessary to reduce the overall earth resistance, earth electrodes shall be provided and connected to the perimeter of the main earth grid. A minimum of four (4) of the specified ground rods must be installed (one at each corner of the ground grid). The Contractor shall determine the spacing of ground grid conductors and the total number and location of ground rods and their lengths.
- Earthing conductors buried in the soil shall be of galvanized steel rounds, coated if and as necessary. Earthing conductors embedded in concrete shall be of galvanized steel. Adequate corrosion protection shall be provided when conductors leave the concrete, respectively the soil.
- Earthing conductors laid on cable trays or similar shall be galvanized steel.
- All interconnections of the earthing grid to equipment and the connections between the earthing grid and the earthing rods shall be made by the termite welding process. Only those connections located in earthing pits and occasionally intended to be opened for testing purposes shall be of the bolted type.
- When a substation is located adjacent to the existing earthing system, the ground systems of the existing or new facilities shall be connected together by at least three galvanized steel strips appropriately sized for mechanical strength and the specified fault current with minimum conductor size to be 125 mm².
- Drawings and calculations shall be submitted for approval giving sufficient information on the earthing, lightning protection, the earthing of structure mounted equipment, as well as on methods of measuring the earth resistance, respectively the earth voltage, the touch and the step voltage.
- If the actually measured resistance of the Contractor-designed and installed ground grid is higher than one ohm or as specified, the Contractor shall install, at no extra cost to the Owner, additional earthing rods, mats, earthing electrodes, etc., until the field-measured resistance is equal to or less than the specified value.

3.2. EQUIPMENT AND MATERIALS REQUIREMENTS

- The equipment and materials shall be suitable for outdoor installation and use at specified service condition without corrosion, deterioration or degradation of performance characteristics.

3.3. EARTHING CONDUCTORS

- Earthing conductor shall be copper conductor of soft drawn concentric stranding bare copper conductor.
- Ground leads running down from the lightning rod or air terminal rods shall be hard drawn galvanised steel and shall be provided with the required clamp supports mounted on the steel structure at approximately 1.5 m intervals.

3.4. GROUND RODS

- The ground rod shall be copper-covered steel of circular cross section, with a nominal diameter of 19 mm and not less than 3 meters long in section of 1.5 meters. If more than one earthing rod are necessary they shall not be less than 3 m apart.
- Each ground rod shall have a conical swaged point at one end and shall have a continuous smooth copper covering of at least 0.254 mm thickness molten-welded or copper bonded (electro-deposit) to a steel core. The copper clad or pressed type will not be accepted.
- Where earth plates are indicated, they shall be 600mm x 600mm minimum, of solid or lattice copper not less than 3mm thick.
- Electrodes shall be installed in undisturbed ground. The distance between any two electrodes shall be not less than the sum of the lengths of the two electrodes.
- Backfill immediately surrounding plate electrodes shall have a low specific resistivity and good water retention properties, and shall be well compacted.

3.5. INSPECTION PITS

- Unless otherwise indicated or required, connection between an earth conductor and its associated earth electrode system shall be in an enclosure.
- The enclosure shall have a removable top cover, which shall be flush with finished ground level. The enclosure shall be a purpose made inspection pit made of concrete. The earth electrode connection shall be just below the lid of the inspection pit with adequate access for testing purposes. The enclosure shall be clearly labelled to indicate the electrodes function and, where appropriate, its identification number.

3.6. EARTHING HARDWARE

3.6.1. STEEL STRUCTURE EARTHING

- Every steel structure that carries insulators or apparatuses shall be connected to the earthing grid. To ensure contact even if a connection fails or a conductor is cut off, every structure must be connected via two different risers to two different parts of the earthing grid.
- Steel structures with more than one leg should have two legs connected to the grid, with one connection to each leg. The legs with the greatest spacing between shall be chosen for the earth connection.
- Circuit breaker framework is not considered as proper connections between steel structures. If there are no connections between the legs which are able to carry the current, all legs must be connected to the grid with their own risers.
- Operating mechanisms and motor drives placed on separate stands shall be connected as above.

3.6.2. TRANSFORMER EARTHING

- The transformer tank shall be connected to earth following the same principles as for steel structures.

- The neutral point of transformers shall be connected to the earthing grid via an isolated link or conductor. The connection to the two earthing rods, which are also connected to earthing grid, shall be made by two independent copper strips from the neutral.

3.6.3. EARTHING OF SWITCHGEAR

- Earthing switches are to be connected via a direct earthing connection and not via the steel structure. Connections between any type of earthing device, e.g. earthing switch, and risers from the earthing grid shall be made through a copper wire connected between the earth contact of the earthing device and a riser. The neutral of the primary winding of Voltage Transformer, shall be grounded via a separate earthing connection to earthing rod and not via the steel structure.
- Each lightning arrester shall be grounded separately with a full rated earthing connection and not via the steel structure. In addition, an earthing rod shall be driven into the ground at each earthing point of a lightning arrester as close as possible to the lightning arrester and connected to it.

3.6.4. EARTHING INSIDE BUILDINGS

- For potential equalising of the building an earthing grid of 8 mm reinforcement bars shall be cast into the surface concrete of all floors of all switchgear room or basements with power cables installed. The connection points shall be welded. The mesh size shall not be greater than 3 x 3 m. Suitable connection points shall be brought out of the concrete to allow connection to the main earthing and to all parts of equipment and building to be earthed. The part of these connecting points which protrudes from the concrete shall be tinned. The earthing grids of the different levels shall be connected at 8 to 10 m. on the periphery distributed locations.
- The size of the main earthing shall be defined by earthing calculations. The design value for the main earthing grid shall be 25 kA (3s) rating and with consideration of CADWELDED joints.
- To ensure that reinforcement grid is made electrical continuous, a sufficient number of connection points shall be brought out of the concrete. Together with the detailed civil engineering drawings, the earthing design is to be checked before releasing for construction.
- The connections to these parts should be of tinned copper of adequate cross section of at least 70 mm². Further similar connection points shall be installed at a number of places for the connection of portable earthing equipment when working in the station. All iron parts of the building and the reinforcement shall be connected to this common earthing installation.
- Generally, each electrical device must be equipped with an earthing screw of sufficient diameter for connection to the earthing system. The same applies to all metallic parts such as panels, doors, rails, fences, transformers, etc. are effectively connected by earth conductors.
- High voltage equipment and each GIS or metal enclosed switchgear bay shall be equipped with at least two terminal bolt M 16 in diameter or suitable earthing pads of adequate size to accommodate at least two bolts for proper connection to the earthing system.
- For connection to all kind of control, protection, LV, panels etc. an earthing grid shall be laid in all cable trenches of at least 50 x 5 mm tinned copper bar.
- Control panels and desks, switchboards, etc. consisting of several individual sections or compartments shall each be connected to this tinned copper earth bar unless all panels are solidly welded together, or other approved means are applied ensuring solid earthing connections. In such a case, provisions for earthing must be made at one end at least.

3.6.5. EARTHING OUTSIDE BUILDINGS

- As a minimum, one grading ring of galvanized steel strip shall be laid around each building at a distance of 1 m (each) and at a depth of 0.6 m.

- The connections to the building earthing installation shall be made within the building. An earthing grid of sufficient size, defined by earthing calculations and consisting of galvanised steel conductor with a maximum mesh size of 3 x 3 m shall also be installed in the transformer bays.
- All individual earthing grids shall be interconnected at spacing by not more than 5 meters. Buried in ground or supported on building structures, cable trenches, walls, etc. by means of brass clamps with spacing of not more than 1.25 m.
- Steel fences within and around the substation area shall be connected to the earthing system at least at two different points and at maximum 10 meters intervals. All metal parts have to be connected through by welding or suitable earthing conductors.
- Other Earthing Arrangements
- Connection boxes for low voltage or control cables shall be connected via one 50 mm² wire (35 mm² copper if the terminal of the box does not allow more), irrespective of whether the box is mounted on an otherwise earthed steel structure or not.
- Poles for lighting and other types of metal structures within the substation area, not mentioned hitherto, shall be connected to the earthing grid one connection for each item.

3.6.6. EARTHING EQUIPMENT

- To meet the safety regulations before any maintenance or repair works are started on the HV/ LV power equipment, the disconnected "live" parts of the equipment shall be grounded by means of mobile earthing sets. The portable or mobile earthing sets (Substation Earthing Sets) shall be supplied by the Contractor. One earthing set shall be supplied per substation and voltage level.

3.7. TESTS

3.7.1. DESIGN TESTS

Conductors, hardware's and materials shall be subjected to the design (or type) tests in accordance with applicable Indian or equivalent IEC standards. Even though the Engineer witnesses the required tests and the earthing, hardware's and materials meet the acceptance criteria, the Contractor shall not be relieved of the responsibility of providing conductors, hardware's and materials conforming to all the requirements of the specification.

3.7.2. QUALITY CONFORMANCE AND ROUTINE TEST

- Earthing Conductors

The tests shall be performed in accordance with IEC 60621-2 and shall include, but not limited to the following:

- Tensile strength tests
- Elongation tests
- Conductor resistivity tests
- Dimension measurement
- Surface finish inspection
- Weight of conductor
- Miscellaneous Hardware

The test shall be performed in accordance with IEC 60621-2 and the manufacturer standard. The routine tests shall be performed by selecting the samples from each lot of equipment. The number of samples required for the tests shall be: all for 1-3 sets; 3 for 4-30 sets; and 10% for over 30 sets.

- General inspection
- Measurement of dimensions
- Tensile tests
- No. of samples required: 1 for 20-50 sets;
- 2 for 51-100 sets; and
- 4 for over 100 sets
- Galvanising tests
- Earthing Materials

Quality conformance tests are required to verify the quality of materials and workmanship. They are to be made on fittings taken on random from the various lots offered for acceptance.

3.7.3. ROUTINE TESTS

These tests are intended to eliminate defective materials and fittings. They are to be made on all materials and fittings of the type to which they are applicable, per applicable standards and / or per Contractor's quality assurance methods if accepted by the Employers Engineer.

3.7.4. FIELD TESTS

Field tests and acceptance tests, if any shall be performed by the contractor as per IS: 3043 / IEC/IEEE-80 standard. The Contractor shall provide instructions and acceptance criteria including the calculated value of the resistance of the installed earthing grid for field testing and measurement prior to energising the substation / equipment. Measurement of the earth voltage by the voltmeter/ammeter method, test current 100 - 300 A or an equivalent approved method. Measurement of the step and touch voltage.

3.7.5. TEST REPORT

Five (5) copies of test reports of all standard tests as per IS: 3043 / IEEE-80, performed subsequent to the date of award. All routine tests shall be certified by the inspector and submitted to the Employers Engineer within fifteen (15) days after test. The Contractor shall bear the costs of furnishing these records and reports.

SECTION 12: TECHNICAL SPECIFICATION FOR LIGHTNING PROTECTION

This specification covers the technical and associated requirements for the lightning protection system for the 33kV switching station. The lightning protection system shall be designed and installed as per latest IEC 62305 standards

1. CODES AND STANDARDS

All standards, specifications and codes of practice referred to the latest editions including all applicable official amendments and revisions as on up to date. All work shall be carried out as per the following standards and codes.

CODE No.	TITLE
IS 513	Cold rolled low carbon steel sheets and strips
IS 3043	Code of Practice for Earthing
IS 2309	Code of Practice for the Protection of Building and allied structure against lightning.
IS 2629	Recommended practice for hot dip galvanizing of iron & steel.
IS 2633	Method for testing uniformity of coating on zinc coated articles
IS 2062	Steel for general structural purposes.
IS 6745	Methods for determination of weight of zinc coating on zinc coated iron & steel articles.
IS 808	Dimensioning of hot rolled steel Beam Column Channel and angle sections.
IS 1367 (Part 1)	Technical supply conditions for threaded steel fasteners. Introduction and general Information.
IS 1367 (Part 13)	Hot dip galvanized coatings on threaded fasteners.
IS 1079	Hot rolled carbon steel sheet & Strips
IS 1239 (Part 1)	2004 Steel Tubes, Tubulars and Other Wrought Steel Fittings

2 GENERAL TECHNICAL REQUIREMENT

- The materials, of which protection systems are made, shall be resistant to corrosion or shall be acceptably protected against corrosion. No materials shall be used that form an electrolytic couple of such nature that will with the presence of moisture cause corrosion.
- Roof conductor and Ring down conductor: Bare, high conductivity, annealed copper strip, 25 x 3 mm.
- OPERATION OF THE PROTECTIVE ROD The Protective Rod tip plays a triple role:
 1. Collect the energy necessary to power the electrical device contained in the cylinder.
 2. Emit the brush discharges created by the high-voltage pulses.
 3. Capture the lightning current to convey it to the ground. The metal disc is the upper part of the external air gap designed to convey the lightning current from the tip to the ground. The metal cylinder contains the electric device of the Protective Rod system that generates the brush discharges. The pole serves to fix the Protective Rod for installation. The connecting clamp must be fixed to it, together with the down conductor.
 4. TEST LINKS: two- bolt split- coupling, copper alloy, made to join two ends of down conductor specified. Plate indicating position and number of electrodes is to be fitted above each test link.

3 TESTS

- I. All tests shall be followed as per IEC 62305 standards.

4 DOCUMENTS AND DRAWINGS

- li. The following drawings, data and manuals shall be provided:

4.1 After award of work

- Datasheet for the supplied earthing and lightning protection materials.

- GA drawing for pipe/rod electrodes & Earth pits, Lightning spike, Test links, Earth Bus and Insulated cleats.
- Material test certificates for all supplied earthing and lightning protection materials.
- Quality Assurance Plan.

D.4. CETP AND STP

SPECIFICATIONS

Common Effluent Treatment Plant (CETP):

The list of equipments in each unit of 6.8 MLD CETP (Phase 1) is detailed in Table below.

Table D-11: Effluent Treatment Units in CETP

S. No.	Unit	Equipment Specifications
1	Collection chamber	Quantity: 1 No Size: 14.5 mtrs x 14.5 mtrs x 2 mtrs SWD (to match the Invert level the excavation and structure to be build) MOC: RCC Pit
2	Pump house	Quantity: 1 Nos Size: 4 mtr x 6 mtr x 4 mtr (height) MOC: Brick wall construction with PCC/RCC floor
3	Feed Pumps	Quantity: 3 Nos Philosophy: 1W+2S (during peak time 2 pumps shall be in running) Capacity: 200 m3/hr Head: 25 mtrs Type: Vertical Centrifugal MOC: CI casing and SS Impeller
4	Screen chamber	Quantity: 2 No Size: 3 mtrs x 3 mtrs x 1.2 mtrs MOC: RCC Channel type
5	Coarse Screen Chamber	Quantity: 1 No Size: 3 mtrs x 2.5 mtrs x 1.2 mtrs Specification: 20 mm opening screen MOC: Chamber RCC and Screen SS 304
6	Fine Screen Chamber	Quantity: 1 No Size: 3 mtrs x 2.5 mtrs x 1.2 mtrs Specification: 6 mm opening screen MOC: Chamber RCC and Screen SS 304
7	Oil and grease trap	Quantity: 1 No Size: 3 mtrs x 2.5 mtrs x 1.2 mtrs Specification: Skimmer MOC: Chamber RCC and Screen SS 304/Non-metallic
8	Equalization tank	Quantity: 2 No Size: 13 mtrs x 13 mtrs x 5 mtrs SWD + 0.5 mtrs FB MOC: RCC tank
9	Air Grids in Equalization tank	Quantity: 1 Lot MOC: uPVC/HDPE pipe with 4 mm holes
10	Air Blower for Equalization tank and Filter backwash	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 600 m3/hr Head: 0.6 bar Type: Tri Lobe MOC: CI
11	pH Correction dosing system	Dosing tanks: 2 Nos (one for Acid and one for Caustic) MOC of Tank: HDPE Capacity of tanks: 2000 lit Dosing pumps: 4 Nos (2W+2S, 2 for each) MOC of pumps: PP Capacity of pumps: 0-150 lph Type of pumps: Diaphragm metering pump Agitators in tank: 2 Nos (One in each tank)

S. No.	Unit	Equipment Specifications
		MOC of Agitators: MSFRP Auto pH Sensor: 1 No, auto pH sensing and correction by dosing
12	Advanced Pipe flocculator for Primary Float settler	Quantity: 1 No MOC: uPVC Schedule 80
13	Dosing system for Float settler	Dosing tanks: 3 Nos (one for Coagulant, one for Flocculant and one De-foamer) MOC of Tank: HDPE Capacity of tanks: 2000 lit Dosing pumps: 6 Nos (3W+3S, 2 for each) MOC of pumps: PP Capacity of pumps: 0-150 lph Type of pumps: Diaphragm metering pump Agitators in tank: 2 Nos (One in each tank) MOC of Agitators: MSFRP
14	Float Settler System	Quantity 1 No Shell MOC: PP/SS304 Internals Non Metallic/SS304/SS316 White water generation Dissolved air generation system with SS304 turbine type pump
15	Float Settler Platform	Quantity: 1 No MOC: MSFRP Size: 4 mtrs x 5 mtrs
16	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 35 m ³ /hr Head: 25 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller
17	Advanced Oxidation Feed tank	Quantity: 1 No Size: 13 mtrs x 13 mtrs x 5 mtrs SWD + 0.5 mtrs FB MOC: RCC tank
18	Advanced Oxidation system	Quantity 1 No Type Skid consists of the Cavity, controls, pump and panel Reaction tank 2 mtrs x 2 mtrs x 1.5 mtrs SWD + 0.5 mtrs FB Reaction tank MOC RCC
19	Bio feed tank (Advanced attached growth biological system)	Quantity: 1 No Size: 11 mtrs x 11 mtrs x 2.5 mtrs SWD + 0.5 mtrs FB MOC: RCC tank
20	Bio Feed pumps	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 160 m ³ /hr Head: 10 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller
21	Bio tank	Quantity: 1 No (with 4 chambers) Total Size: 1080 m ³ MOC: RCC tank
22	Bio film	Media Quantity: 393 m ³ Media MOC: Virgin HDPE Aeration grid 1 Lot Aeration grid MOC SS 304 Type: Medium bubble diffusion with 3 mm opening Media retaining sieves SS304 Type of sieves Wedgewire screen in aeration tanks & flat screens in Anoxic tank Mixer in Anoxic tank

S. No.	Unit	Equipment Specifications
23	Air Blower for Bio tank	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 3600 m ³ /hr Head: 0.6 bar Type: Tri Lobe MOC: CI
24	Nutrient dosing system	Dosing tanks 2 Nos (one for DAP and one for Phosphoric acid) MOC of Tank HDPE Capacity of tanks 1000 lit Dosing pumps 4 Nos (2W+2S, 2 for each) MOC of pumps PP Capacity of pumps 0-90 lph Type of pumps Diaphragm metering pump Agitators in tank 2 Nos (One in each tank) MOC of Agitators MSFRP
25	Advanced Pipe flocculator for Secondary float settler	Quantity: 1 No MOC: uPVC Schedule 80
26	Dosing system for Secondary Float settler	Dosing tanks 2 Nos (one for Coagulant, one for Flocculant) MOC of Tank HDPE Capacity of tanks 2000 lit Dosing pumps 6 Nos (3W+3S, 2 for each) MOC of pumps PP Capacity of pumps 0-150 lph Type of pumps Diaphragm metering pump Agitators in tank 2 Nos (One in each tank) MOC of Agitators MSFRP
27	Secondary Float Settler System	Quantity 1 No Shell MOC: PP/SS304 Internals Non Metallic/SS304/SS316 White water generation Dissolved air generation system with SS304 turbine type pump
28	Secondary Float Settler Platform	Quantity: 1 No MOC: MSFRP Size: 4 mtrs x 5 mtrs
29	Sludge Transfer Pump	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 10 m ³ /hr Head: 25 mtrs Type: AODD (air operated double diaphragm pumps) MOC: CI casing and SS Impeller
30	High-rate media filter feed tank	Quantity: 1 No Size: 11 mtrs x 11 mtrs x 2.5 mtrs SWD + 0.5 mtrs FB MOC: RCC tank
31	Filter Feed pumps	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 160 m ³ /hr Head: 30 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller
32	Filter	Quantity: 1 No Size of filter 3 mtr dia x 2.2 mtrs Height MOC: Filter – MSRL, Piping- MSRL, Media: 6 layers of media (Fine sand, gravel, magnetite, alumina, flint and Anthracite)
33	Filter Backwash pumps	Quantity: 2 Nos

S. No.	Unit	Equipment Specifications
		Philosophy: 1W+1S Capacity: 240 m ³ /hr Head: 35 mtrs Type: Horizontal Centrifugal MOC: CI casing and SS Impeller
34	RO 1 feed tank	Quantity: 1 No Size: 11 mtrs x 11 mtrs x 2.5 mtrs + 0.5 mtr SWD MOC: RCC tank
35	RO 1 Skid	No of stages 2 Nos Feed pump: 2 nos 160 m ³ /hr @ 30 mtr head, SS304 Micron Cartridge filter MSRL with PP cartridge (wound type) High Pressure pump 2 nos 160 m ³ /hr @ 15 bar, SS316 Membranes BWRO, 144 Nos Pressure Tubes 300 PSI, 18 Nos Dosing Skids 3 Nos with 200 lits HDPE tank, MSFRP Agitator & 6 nos of PP dosing Pumps (3W+3S)
36	RO 2 feed tank	Quantity: 1 No Size: 7 mtrs x 7 mtrs x 2.5 mtrs + 0.5 mtr SWD MOC: RCC tank
37	RO 2 Skid	No of stages 2 Nos Feed pump: 2 nos 64 m ³ /hr @ 30 mtr head, SS316 Micron Cartridge filter MSRL with PP cartridge (wound type) High Pressure pump 2 nos 64 m ³ /hr @ 37 bar, SS316 Membranes SWRO, 56 Nos Pressure Tubes 600 PSI, 7 Nos Dosing Skids 3 Nos with 200 lits HDPE tank, MSFRP Agitator & 6 nos of PP dosing Pumps (3W+3S)
38	RO 3 feed tank	Quantity: 1 No Size: 5 mtrs x 5 mtrs x 2.5 mtrs + 0.5 mtr SWD MOC: RCC tank
39	RO 3 Skid	No of stages 2 Nos Feed pump: 2 nos 32 m ³ /hr @ 30 mtr head, SS316 Micron Cartridge filter MSRL with PP cartridge (wound type) High Pressure pump 2 nos 32 m ³ /hr @ 39 bar, SS316L Membranes SWRO, 30 Nos Pressure Tubes 600 PSI, 5 Nos Dosing Skids 3 Nos with 200 lits HDPE tank, MSFRP Agitator & 6 nos of PP dosing Pumps (3W+3S)
40	RO 4 feed tank	Quantity: 1 No Size: 3.5 mtrs x 3.5 mtrs x 2.5 mtrs + 0.5 mtr SWD MOC: RCC tank
41	RO 4 Skid	No of stages 2 Nos Feed pump: 2 nos 16 m ³ /hr @ 30 mtr head, SS316L Micron Cartridge filter MSRL with PP cartridge (wound type) High Pressure pump 2 nos 32 m ³ /hr @ 49 bar, Duplex Membranes Low Fouling SWRO, 18 Nos Pressure Tubes 1200 PSI, 3 Nos Dosing Skids 3 Nos with 100 lits HDPE tank, MSFRP Agitator & 6 nos of PP dosing Pumps (3W+3S)
42	RO 5 feed tank	Quantity: 1 No Size: 3.5 mtrs x 3.5 mtrs x 2.5 mtrs + 0.5 mtr SWD MOC: RCC tank
43	RO 5 Skid	No of stages 2 Nos Feed pump: 2 nos 17 m ³ /hr @ 50 mtr head, SS316L Micron Cartridge filter MSRL with PP cartridge (wound type)

S. No.	Unit	Equipment Specifications
		High Pressure pump 2 nos 17 m ³ /hr @ 80 bar, Duplex Membranes ET membranes, 14 nos in stage 1 & 40 nos in stage 2 Pressure Tubes 1200 PSI, 2 Nos of 8" & 5 Nos of 4" Dosing Skids 3 Nos with 100 lits HDPE tank, MSFRP Agitator & 6 nos of PP dosing Pumps (3W+3S)
44	Treated water tank	Quantity: 1 No Size: 26 mtrs x 26 mtrs x 5 mtrs + 0.5 mtr SWD MOC: RCC tank
45	Advanced Evaporation system	Quantity: 1 No Housing MOC Powder coated MS (Complete system to be enclosed) Noise Level 60 db Evaporation chamber SS316 Compressor/V-Pump SG-Iron with Corrosion Resistant Coating for Longer Life. Protected with water cooling, seals and oil lubrication. Heat Exchanger SS316 Control panel Delta and fully automatic system CIP System Inbuilt Tubes MOC SS316 Ti Dryer Suitable to produce solids with 90% solid consistency
46	Sludge Pit	Quantity: 1 No Size: 12 mtrs x 12 mtrs x 2.5 mtrs SWD MOC: RCC tank
47	Belt Press Feed pumps	Quantity: 2 Nos Philosophy: 1W+1S Capacity: 30 m ³ /hr Head: 15 mtrs Type: Screw (Progressive captive pump) MOC: CI casing and SS Impeller
48	Belt Press	Quantity 1 No Type Belt press Accessories Drive, Flocculation tank
49	De-water poly dosing system	Dosing tanks 1 Nos MOC of Tank HDPE Capacity of tanks 2500 lit Dosing pumps 2 Nos (1W+1S) MOC of pumps PP Capacity of pumps 0-150 lph Type of pumps Diaphragm metering pump Agitators in tank 2 Nos (One in each tank) MOC of Agitators MSFRP
50	Additional Civil works	Primary Float settler platform: 10 mtr x 12 mtr Secondary Float settler platform: 10 mtr x 12 mtr Filter platform 5 mtr x 5 mtr RO & Panel Building 15 mtr x 10 mtr Drains As required Roads As required
51	Interconnecting Piping	Piping uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines Valves uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines Fitting uPVC/HDPE & GI (for air lines), SS304, SS316, SS316L and Duplex for high pressure lines
52	MCC & Control panel	MCC Type Draw-out type Control panel Relay based Cables Suitable

S. No.	Unit	Equipment Specifications
		Junction box Suitable
53	Instruments	Pressure gauges at pumps, blowers, filter etc DO meter at Bio tank Flow meter inlet, outlet, across all ROs and Evaporation Level Switches at all the tanks Differential pressure switch at Filter & ROs pH Control at Equalization tank ORP control across all ROs SDI analyzers across all ROs Conductivity meter across all ROs
54	Miscellaneous	Platforms For Blowers, pumps, screw press, panels etc. Room/Building for MCC & Control panel and Blowers Structural steel for cables, piping etc. Cable trays for electrical & control cables

50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures

Sewage Treatment Plant (STP):

The selection of treatment technology and process is based on influent, effluent characteristics, land availability and techno-economic viability. The list of equipments proposed in each unit of the treatment facility is detailed in the table below.

Table D-12: Treatment Units in 1 MLD STP

S.No	Equipment Details	Specifications
1	Collection chamber	
	Quantity:	1 No
	Size:	5 mtrs x 5 mtrs x 2.5 mtrs SWD (to match the
	Invert level the excavation and structure to be build)	
	MOC:	RCC Pit
2	Pump house	
	Quantity:	1 Nos
	Size:	2.5 mtr x 4 mtr x 3.5 mtr (height)
	MOC:	Brick wall construction with PCC/RCC floor
3	Feed pumps	
	Quantity:	3 Nos
	Philosophy:	1W+2S (during peak time 2 pumps shall be in running)
	Capacity:	21 m ³ /hr
	Head:	25 mtrs
	Type:	Vertical Centrifugal
	MOC:	CI casing and SS Impeller
4	Screen Chamber	
	Quantity:	2 No
	Size:	1 mtrs x 1.5 mtrs x 1.2 mtrs
	MOC:	RCC Channel type
5	Coarse Screen Chamber	
	Quantity:	1 No
	Size:	1 mtrs x 1.5 mtrs x 1.2 mtrs
	Specification	20 mm opening screen
	MOC:	Chamber RCC and Screen SS 304
6	Fine Screen Chamber	
	Quantity:	1 No
	Size:	1 mtrs x 1.5 mtrs x 1.2 mtrs

S.No	Equipment Details	Specifications
	Specification	6 mm opening screen
	MOC:	Chamber RCC and Screen SS 304
7	Grit removal system	
	Quantity:	1 No
	Size:	2.5 mtrs x 2.5 mtrs x 1.5 mtrs
	Specification	Skimmer
	MOC:	Chamber RCC and Screen SS 304/Non-metallic
8	ASBR tank	
	Quantity	1 No
	Dimensions	7.2 mtr x 12.6 mtr x 4 mtr SWD + 0.5 mtr FB
	MOC	RCC with Partitions
9	ASBR internals	
	Blower	400 m ³ /hr
	VFD for blowers	As required
	DO meters	1
	Fine bubble diffusers	1 Lot
	Aeration grid	1 Lot
	Valves for auto operation	1 Lot
10	Chlorine contact tank	
	Quantity	1 No
	Size:	3.5 mtr x 3.5 mtr x 2 mtr SWD + 0.5 mtr FB
	MOC:	RCC
11	Chlorine dosing system	
	Dosing tank	HDPE
	Volume of tank	500 Lit
	Dosing pump	2 nos PP
	Dosing pump capacity	0-90 lph
	Pump type	diaphragm type
12	Sludge collection pit	
	Quantity	1 No
	Size:	3.5 mtr x 3.5 mtr x 2 mtr SWD + 0.5 mtr FB
	MOC:	RCC
13	Screw press feed pump	
	Quantity:	2 Nos
	Philosophy:	1W+1S
	Capacity:	1 m ³ /hr
	Head:	15 mtrs
	Type:	Screw (Progressive captive pump)
	MOC:	CI casing and SS Impeller
14	Screw Press	
	Quantity	1 No
	Type	Screw type
	Accessories	Drive, Flocculation tank
15	De-water poly dosing system	
	Dosing tanks	1 Nos
	MOC of Tank	HDPE
	Capacity of tanks	500 lit
	Dosing pumps	2 Nos (1W+1S)
	MOC of pumps	PP
	Capacity of pumps	0-90 lph
	Type of pumps	Diaphragm metering pump
	Agitators in tank	2 Nos (One in each tank)

S.No	Equipment Details	Specifications
	MOC of Agitators	MSFRP
16	Additional Civil works	
	Screw press platform	5 mtr x 4 mtr
	Panel & Blower Building	10 mtr x 8 mtr
	Drains	As required
	Roads	As required
17	Interconnecting Piping	
	Piping	uPVC/HDPE & GI (for air lines)
	Valves	uPVC/HDPE & GI (for air lines)
	Fitting	uPVC/HDPE & GI (for air lines)
18	MCC & Control panel	
	MCC Type	Draw-out type
	Control panel	Relay based
	Cables	Suitable
	Junction box	Suitable
19	Instruments	
	Pressure gauges	at pumps, blowers
	DO meter	at SBR
	Level Switches	at all the tanks
20	Miscellaneous	
	Platforms	For Blowers, pumps, screw press, panels etc
	Building	for MCC & Control panel and Blowers
	Structural steel	for cables, piping etc
	Cable trays	for electrical & control cables

50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures

CODES AND STANDARDS

The design, manufacture, inspection, and testing of the treatment plant shall comply with all currently applicable statues, regulations and safety codes in the locality, where the facility is to be installed.

Nothing in this specification shall be construed to relieve the contractor of this responsibility. The equipments shall conform to the latest edition of the standards mentioned in all the specifications. In case of conflict between the Standards and any specific requirement, or conflict between the requirements of any two or more of the Standards, the more stringent requirements shall govern. Some of the minimum codes and standards to be followed by selected agency are given in Table below.

Table D-13: Minimum Codes and Standards to be Followed

Code/Standard	Year of Edition*	Description
IS 5120 / ISO 2858 & ISO 5199	1977 for IS 5120 /1975 for ISO 2858/ 2002 for ISO 5199	Centrifugal Pumps
ASME B16.5	2015	Flanges
ASME Section VIII Div. 1	2015	Pressure vessel / Tanks
ASME SEC.IX	2015	Welding, brazing & fusion qualification
API620/API 650	2007 add. 2009	Atmospheric Conical roof & Flat Bottom Welded Steel Storage Tank
IS:875 (Part-3)	1987	Equipment/ Structure Design for wind load
IS:1893	2005	Equipment/ Structure Design for Seismic Load
BS EN 1321-3	2008/2016	GRP tanks and vessels for use above ground
BS 4994	-	Specification for design & construction of vessels & Tanks

Code/Standard	Year of Edition*	Description
* - Latest Edition with Addendum to be followed		

D.5. TRUCK TERMINAL, BOUNDARY WALL, ENTRANCE GATE AND CIVIL WORKS FOR POWER INFRASTRUCTURE

(A) CIVIL WORKS

Detailed Specification:

General -All the specification for item of works for Building works, Road works and Electrical works has been followed with reference to the UTTAKHAND PWD, CPWD, MORTH, CPHEEO and relevant IS Specifications.

Material of construction - The materials of construction to be used in the work shall be governed by the MORTH/ IRC specifications for Rural roads/ other IRC Publications and their manual/ latest CPWD specifications/ PWD specifications/ IS codes, for buildings and the relevant Indian standard specification with amendments and revisions Issued up to the date of tender notice Where ever any material has ISI mark such material alone has to be used.

Workmanship – The work shall be carried out according to the specification referred to hereinafter and according to sound engineering practice. The decision of the Executive Engineer, in respect of workmanship will be final.

Specification for Building Work: - (Including water Supply and sanitary fittings.) - The contractor shall execute the work In conformity with the standards and procedure laid down latest CPWD specifications/PWD specifications/IS codes for buildings or special specification when ever enclosed separately and in accordance with the approved drawings.

The rates quoted for items of work shall include working in all conditions at all heights/ depths including in/ under water, liquid mud, foul conditions etc.

The EIC/PROJECT MANAGER reserves the right to withdraw from the scope of work and/or to order to any other agency for any item or group of work, or to split the work between two or more sub-CONTRACTOR if necessary. Such a step shall not constitute a breach of the contract.

All the items of work shall be carried out as per description given in the Bill of Quantities and as shown in the drawings. All materials to be got approved from the EIC/PROJECT MANAGERS.

Clearing

The contractor shall clear the site of all rubbish and old buildings remove all grass and low vegetation and remove all bush wood, trees, stumps of trees, and other vegetation only after consultation with the EIC/Project Manager as to which bushes and trees shall be saved. All disused foundations, drains or other obstructions met with during excavation shall be dug out and cleared.

Site Levels

The contractor shall carry out the survey of the site and shall establish sufficient number of grids and level marks to the satisfaction of the EIC/Project Manager, who shall decide on the basis of this information, the general level of the plot and the plinth.

Bench-marks

Prior to commencement of construction, the contractor shall in consultation with the EIC/Project Manager, establish several site datum bench-marks, their number depending on the extent of the site. The bench-marks shall be sited and constructed so as to be undisturbed throughout the period of construction.

Site investigation

The soil investigation report is attached with tender for their scrutiny. The contractor shall however inspect the site and study the findings from the trial pits or bores in order to assess the problems involved in and methods to be adopted for excavation and earthwork. The contractor shall ascertain for himself all information concerning the sub-soil conditions, Ground water table periods and intensity of rainfall, flooding of the site and all data concerning excavation and earthwork.

Setting out the work

The contractor shall set out the works and during the progress of the building shall amend at his own cost any errors arising from inaccurate setting out.

During the execution of the work contractor must cross check his work with the drawings. The contractor shall be responsible for all the errors in this connection and shall have to rectify all defects and/or errors at his own cost, failing which the EIC/Project Manager reserves the right to get the same rectified at the risk and cost of the contractor.

Cleaning up and handing over

Upon completion of the work all the areas should be cleaned. All floors, doors, windows, surface, etc. shall be cleaned down in a manner which will render the work acceptable to the EIC/Project Manager. All rubbish due to any reason, shall be removed daily from the site and an area of up to ten metres on the outer boundaries of the premises will be cleaned by the contractor as a part of the contract. Upon completion of the project, the contractor shall turn over to the EIC/Project Manager the following:

- a) Written guarantee and certificates.
- b) Maintenance manuals, if any, and
- c) Keys.

Tests

A Quality Assurance Plan(QAP) shall be finalise by PMC, Client & Contractor before start of the work .QAP shall be based upon IS codes/CPWD specification/BS and good engineering practice to decide various material for testing/ method of testing and their frequency and various format for quality control to be adopted. Once QAP is finalise, all the materials needs to be tested accordingly and if results are not as per the desired result than such materials shall be rejected. All the test shall be done at govt approved testing facilities and cost shall be borne by contractor. The testing facilities shall be approved by Client before any sample is being sent for testing.

Mode of Measurements

All measurements will be taken in accordance with IS 1200 latest issue unless otherwise specified in the BOQ and specifications.

MAKING GOOD

The contractor shall cut, leave or form holes, recesses, chases etc, in concrete, MASONRY work, walls, ceilings, floors and in any other situations as required or as directed by the EIC/Project Manager and make good in cement and sand mortar (1:3)/PCC (1:2:4) as decided by EIC/Project Manager and finish to match the adjoining surfaces. No extra payment shall be admissible in this regard (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

GUIDELINES TO BE FOLLOWED BY CONTRACTORS DURING CONSTRUCTION

The Contractor should follow the Erosion and Sedimentation Control (ESC) plan as per Annexure – A of these technical specifications.

The Contractor should follow the Air Quality Management Plan (AQMP) as per Annexure B of these technical specifications.

The Contractor should have the First Aid kit as per the provisions listed in Annexure C of these technical specifications.

All the above are in addition to the conditions prescribed anywhere else in the tender. The Contractor is supposed to quote rates considering the above provisions in contract and nothing extra on any account shall be admissible to the contractor.

1) EARTHWORK

EXCAVATION:

All excavation operations manually or by mechanical means shall include excavation and 'getting out' the excavated materials. In case of excavation for trenches, basements, water tanks etc. 'getting out' shall include throwing the excavated materials at a distance of at least one meter or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation stating lead. During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 meters from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2 metres from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horizontal: 4 vertical). Where the soil is soft, loose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in-Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge regarding the stepping, sloping or shoring to be done for excavation deeper than 2 meter.

The excavation shall be done true to levels, slope, shape and pattern indicated by the Engineer-in-Charge. Only the excavation shown on the drawings with additional allowances for centering and shuttering or as required by the Independent Engineer-in-Charge shall be measured and recorded for payment.

In case of excavation for foundation in trenches or over areas, the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Independent Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for leveling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

While carrying out the excavation for drain work care shall be taken to cut the side and bottom to the required shape, slope and gradient. The surface shall then be properly dressed. If the excavation is done to a depth greater than that shown on the drawing or as required by the Independent Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched. In case the drain is required to be pitched, the back filling with clay puddle, if required, shall be done simultaneously as the pitching work proceeds. The brick pitched storm water drains should be avoided as far as possible in filled-up areas and loose soils.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.

In case the excavation is done wider than that shown on the drawings or as required by the Independent Engineer-in-Charge, additional filling wherever required on the account shall be done by the contractor at his own cost.

The excavation shall be done manually or by mechanical means as directed by Independent Engineer-in-charge considering feasibility, urgency of work, availability of labour /mechanical equipments and other factors involved. Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor will any extra payment be made on this account.

Excavation in Ordinary/Hard Rock:

All excavation operations shall include excavation and 'getting out' the excavated matter. In case of excavation for trenches, basements, water tanks etc. 'getting out' shall include throwing the excavated materials at a distance of at least one metre or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the item of excavation stating lead.

During the excavation, the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or under cutting shall not be done.

Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Independent Engineer-in-Charge in writing for resorting to the blasting operations. Blasting operations shall be done and chiseling shall be done to obtain correct levels, slopes, shape and pattern of excavation as per the drawings or as required by the Engineer-in-Charge and nothing extra shall be payable for chiseling.

Where blasting operations are prohibited or are not practicable, excavation in hard rock shall be done by chiseling.

In ordinary rock excavation shall be carried out by crowbars, pick axes or pneumatic drills and blasting operation shall not be generally adopted. Where blasting operations are not prohibited and it is practicable to resort to blasting for excavation in ordinary rock, contractor may do so with the permission of the Engineer-in-Charge in writing but nothing extra shall be paid for this blasting.

If the excavation for foundations or drains is done to a depth greater than that shown in the drawings or as required by the Independent Engineer-in-Charge. The excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for leveling/ bed concrete for foundations. Soft/ defective spots at the bed of foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling with earth duly watered, consolidated and rammed.

In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, filling wherever required on this account shall be done by the contractor at his own cost.

Only the excavation equal to PCC in foundation shown on the drawings or as required by the Engineer-in-Charge shall be measured and recorded for payment except in case of hard rock, where blasting operations have been resorted to, excavation shall be measured to the actual levels, provided the Engineer-in-Charge is satisfied that the contractor has not gone deeper than what was unavoidable. Bottom width of PCC shall be measured as given in foundation drawings and details showing the width of the bedding concrete only and any side clearance or offsets considered for excavation will not measure separately for payment for excavation. The contractor should cover this in his rate. Contractor may make such allowances in his rates to provide for excavation in side slopes keeping in mind the nature of the soil and safety of excavation. Margin for stepping, slopes, space for providing & removing of shuttering, shoring etc, are deemed to have been considered in the rates.

The excavation shall be done manually or by mechanical means as desired by Engineer-in- Charge considering feasibility, urgency of work, availability of labour /mechanical equipments and other factors involved Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor will any extra payment be made on this account.

Planking and Strutting: When the depth of trench in soft/loose soil exceeds 2 meters, stepping, sloping and/ or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer-in-Charge according to the nature of soil.

Planking and strutting shall be 'close' or 'open' depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the Engineer-in-Charge. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapse. Engineer-in-Charge should take guidance from IS: 3764 for designing the shoring and strutting arrangements and specifying the profile of excavation Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called 'poling boards'. These shall be 250x38 mm in section or as directed by the Engineer-in-Charge.

The boards shall generally be placed in position vertically in pairs. One boards on either side of cutting. These shall be kept apart by horizontal walling of strong wood at a maximum spacing of 1.2 metres cross strutted with ballies, or as directed by Engineer-in-Charge. The length and diameter of the ballies strut shall depend upon the width of the trench. Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'wallings' which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken in the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed. The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and preceded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-Charge to be left permanently in position.

Open Planking and Strutting: In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards 250 mm wide & 38 mm thick shall be spaced sufficiency apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distance apart shall be subject to the approval of the Engineer-in-Charge. In all other respect, specifications for close planking and strutting shall apply to open planking and strutting.

During excavation and trenching work etc. the contractors shall ensure compliance to the guidelines in such matter laid down by the authority to ensure that there is minimum hazard to the operating personnel and user, minimum inconvenience to users, minimized damage to the underground plant / services of other utilities in a coordinated way in the interest of public inconvenience and overall safety of the adjoining structures etc.

Any trenching and digging for laying sewer lines/waterlines/cables etc. shall be commenced by the contractor only when all men, machinery's and materials have been fully arranged and closing of the trench (s) thereafter shall be ensured within the least possible time.

Surplus excavated earth which is beyond the requirement of PWD shall have to be disposed of by the contractor at his own cost beyond the PWD boundary or at places identified by engineer in Charge and no payment shall be made by the department for such disposal of surplus excavated earth.

The contractor shall, at his own expenses and without extra charges, make provisions for all shoring, pumping, dredging or bailing out water, if necessary, irrespective of the source of water. The

foundation trenches shall always be kept free from water by continuous pumping out of water by contractor at his own cost while all the works below ground level are in progress, without any extra payment.

Measurements: The dimensions shall be measured correct to the nearest cm and the area of the face supported shall be worked out in square meters correct to two places of decimal.

Works shall be grouped according to the following:

- (a) Depth not exceeding 1.5 m.
- (b) Depth exceeding 1.5m in stages of 1.5 m.

Planking and strutting to the following shall be measured separately:

- (a) Trenches.
- (b) Areas- The description shall include use and waste of raking shores.
- (c) Shafts, walls, cesspits, manholes and the like.
- (d) Where tightly driven close but jointed sheeting is necessary as in case of running sheeting is necessary as in case of running sand the item shall be measured separately and packing of cavities behind sheeting with suitable materials included with the item.
- (e) Planking and strutting required to be left permanently in position shall be measured separately.

Rates: Rates shall include use and waste of all necessary timber work as mentioned above including fixing and subsequent removal.

➤ **FILLING IN TRENCHES, PLINTH, UNDER FLOOR ETC.**

Earth: Normally excavated earth from same area shall be used for filling. Earth used for filling shall be free from shrubs, rank, vegetation, grass, brushwood, stone shingle and boulders (larger than 75mm in any direction), organic or any other foreign matter. Earth containing deleterious materials, salt peter earth etc. shall not be used for filling. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the earth is used for filling.

Earth Filling: The space around the foundations and drains in trenches shall be cleared of all debris, brick bats etc. The filling shall be done in layers not exceeding 20 cm in depth. Each layer shall be watered, rammed and consolidated. Ramming shall be done with iron rammers where possible and with blunt end of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches. In case of filling under floor, the finished level of filling shall be kept to the slope intended to be given to the floor.

Filling Side of Foundations: The cubical contents of bed concrete leveling course and masonry/ concrete in foundations up to the ground level shall be worked out and the same deducted from the cubical contents of earthwork in excavation for foundations already measured under the respective item of earth work to arrive at the quantity for filling sides of foundation. The quantity shall be calculated correct to two places of decimal.

Filling in Plinth and under Floors: Depth of filling shall be the consolidated depth. The dimensions of filling shall be on the basis of pre-measurement correct to the nearest cm and cubical content worked out in cubic meters correct to two places of decimal.

Compaction Quality: Compaction of earth and sand filling in areas where foundation & floors are located, the degree of compaction achieved shall be minimum 95% of maximum dry density. As obtained by proctor compaction as per IS: 2720 (Part-IIIV). In road and other areas the degree of compaction shall be 90%. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Testing of Filling Layer: After the compaction of each layer, samples shall be taken from compacted layer and tested for dry density as per IS practice. The next layer of filling shall not be permitted until the engineer in charge is satisfied that pervious layer has achieved required compaction. If any particular layer fails to meet the required compaction, it shall be re-compacted as directed by the engineer in charge and fresh samples shall be taken to ascertain the compaction density. Such re-compaction shall be continued till the desired compaction is achieved. The thickness of each compacted layer shall not exceed 200mm.

Rates: The rates include cost of all the operations described above.

➤ **SAND FILLING IN PLINTH**

Sand: Sand shall be clean and free from dust organic and foreign matter and its grading shall be within the limits of grading zone IV or V.

Filling: Sand filling shall be done in a manner similar to earth filling in plinth except that consolidation shall be done by flooding with water. The surface of the consolidated sand filling shall be dressed to the required level or slope and shall not be covered till the Engineer-in-Charge has inspected and approved the sand filling (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Measurements: The length, breadth and depth of consolidated sand shall be measured with steel tape correct to the nearest cm and cubical contents worked out in cubic metres correct to two places of decimal.

Rates: The rates include the cost of material and labour involved in all the operations described above.

➤ **SURFACE DRESSING:**

Surface dressing shall include cutting and filling up to a depth of 15 cm and clearing of shrubs, rank vegetation, grass, brushwood, trees and saplings of girth up to 30 cm measured at a height of one meter above the ground level and removal of rubbish and other excavated material up to a distance of 50 meters outside the periphery of the area under surface dressing. High portions of the ground shall be cut down and hollows depression filled up to the required level with the excavated earth so as to give an even, neat and tidy look.

Measurements: Length and breadth of the dressed ground shall be measured correct to the nearest cm and the area worked out in square meters correct to two places of decimal.

Rates: The rates shall include cost of labour involved in all the operations described above.

➤ **JUNGLE CLEARANCE:**

Jungle clearance shall comprise uprooting of rank vegetation, grass, brushwood, shrubs, stumps, trees and saplings of girth up to 30 cm measured at a height of one meter above the ground level. Where only clearance of grass is involved it shall be measured and paid for separately.

Clearance of Grass: Clearing and grubbing operation involving only the clearance of grass shall be measured and paid for separately and shall include removal of rubbish up to a distance of 50 m outside the periphery of the area under clearance.

Measurements: The length and breadth shall be measured correct to the nearest cm and area worked out in square meters correct to two places of decimal.

Rates: The rate includes cost of all the operation described above.

➤ **ANTI-TERMITE TREATMENT:**

Termite control in existing as well as new building structures is very important as the damage likely to be caused by the termites to wooden members of building and other household article like furniture, clothing, stationery etc. is considerable. Anti-termite treatment can be either during the time of

construction i.e. pre-constructional chemical treatment or after the building has been constructed i.e. treatment for existing building. Prevention of the termite from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

Materials: Chemicals: Any one of the following chemicals in water emulsion to achieve the percentage concentration specified against each chemical shall be used:

- (i) Chlorphriphos emulsifiable concentrate of 20%
- (ii) Lindane emulsifiable concentrate of 20%

Anti-termite treatment chemical is available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, Chemical should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemical with water in the required proportion to achieve the desired percentage of concentration. For example to dilute chemical of 20% concentration, 19 parts of water shall be added to one part of chemical for achieving 1% concentration.

Engineer-in-Charge shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorized dealers; chemical shall be kept in the custody of the Engineer in- Charge or his authorized representatives and issued for use to meet the day's requirements. Empty containers after washing and concentrated chemical left unused at the end of the day's work shall be returned to the Engineer-in-Charge or his authorized representative.

Pre Constructional Chemical Treatment: This is process in which chemical treatment is applied to a building in the early stages of its construction. Hand operated pressure pump shall be used. Proper check for uniform spraying of chemical, graduated container shall be used. Proper check should be kept that the specified quantity of chemical is used for the required area during the operation.

Time of Application: Soil treatment should start when foundation trenches and pits are ready to take mass concrete in foundations. Laying of mass concrete should start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment should not be carried out when it is raining or soil is wet with rain or sub soil water

Disturbance: The treated soil barrier shall not be disturbed after they are formed. If by chance, treated soil barrier is disturbed, and immediate steps shall be taken to restore the continuity and completeness of the barrier system.

Treatment of column-pits, wall-trenches and Basement-excavations: The bottom surface and the sides (up to height of about 300mm) of the excavations made for column pits, wall trenches and basements shall be treated with the chemical at the rate of 7.5 litres per sqm of the surface area.

Treatment of Top Surface of plinth filling: The top surface of the filled earth with in plinth walls shall be treated with chemical emulsion at the rate of 5 litres per sqm. of the surface before the sand/ subgrade is laid. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Measurements: Concentrated chemical in sealed containers shall be measured in liters. Chemicals of different types and concentration shall be measured separately.

Rate: The Rate for the concentrated chemical shall include the cost of material, containers and all the operations involved in transportation and delivery at the place specified

2) FORM WORK

➤ FORM WORK (CENTERING & SHUTTERING)

Form Work: Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

General Requirement: It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete. Form shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections, care shall be taken to see that no piece is keyed into the concrete.

Material for Form Work:

Centering/Staging:

(a) Propping and Centering: All propping and centering should be either of steel tubes with extension pieces or built up sections of rolled steel.

Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/ beams etc. and as per levels as shown in drawing. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

Shuttering: Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-Charge shall be provided in the joints. Steel shuttering used or concreting should be sufficiently stiffened.

Two qualities of form work shall be used i.e Rough form work and wrought form work, as noted on the Project Manager's drawings or described hereafter.

Rough form work may be constructed of sawn timber or other material as agreed by the Project Manager. The edges of the boards shall be planned or otherwise rendered grout tight. Provided it remain grout tight, rough formwork may be used any number of time. This form work shall be adopted for surfaces not exposed/buried needing no surface finish viz. Foundations/Pile caps.

Wrought form work, to all surfaces for which a smooth fair faced finish is required, shall be constructed of plastic coated plywood so that tight joints can be formed which will prevent loss of liquid from the concrete. The use of a particular material for wrought form work shall be consistently maintained throughout the structure. The surfaces of the form work in contact with the concrete shall be smooth and free from all blemishes. The number of times wrought form work may be used shall be subject to the surfaces, joints and edges being clean and undamaged.

Camber: Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per meter (1 to 250) or as directed by the Engineer-in-Charge, so as to offset the subsequent deflection, for cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer-in-Charge.

Removal of Form work (Stripping Time): In normal circumstance and where various types of cements are used, forms may generally be removed after the expiry of the following periods:

Type of Form work	Minimum period Before Striking Form work for OPC 43 grade
(a) Vertical form work to columns, or as directed by EIC Walls, beams	16-24 hr
(b) Soffit form work to slabs (Props to be fixed immediately after removal of formwork)	3 days
(c) Soffit form work to beams (Props to be re-fixed immediately after Removal of formwork)	7 days
d) Props to slabs: (1) Spanning up to 4.5m (2) Spanning over 4.5m	7 days 14 days
(e) Props to beams and arches: (1) Spanning up to 6m (2) Spanning over 6m	14 days 21 days

Note 1: For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally If Portland pozzolana or low heat cement or OPC with direct addition of fly ash has been used for concrete, the stripping time will be 10/7 of the period stated for OPC with 43 grade cement above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Surface Treatment

Oiling the Surface: Shuttering surfaces of form work are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

Inspection of Form Work: The completed form work shall be inspected and approved by the Engineer-in-Charge before the reinforcement bars are placed in position.

Measurements:

General: The form work shall include the following:

- (a) Splayed edges, notching, allowance for overlaps and passing at angles, sheathing battens, strutting, bolting, nailing, wedging, easing, striking and removal.
- (b) All supports, struts, braces, wedges as well as mud sills, piles or other suitable arrangements to support the form work.
- (c) Bolts, wire, ties, clamps, spreaders, nails or any other items to hold the sheathing together.
- (d) Working scaffolds ladders, gangways, and similar items.
- (e) Filleting to form stop chamfered edges of splayed external angles not exceeding 20mm wide to beams, columns and the like.
- (f) Where required, the temporary openings provided in the forms for pouring concrete, inserting vibrators, and cleaning holes for removing rubbish from the interior of the sheathing before pouring concrete.
- (g) Dressing with oil to prevent adhesion and
- (h) Raking or circular cutting.

Rate: The rate of the form work includes the cost of labour and materials required for all the operations described above.

3) PLAIN & REINFORCED CONCRETE WORK

➤ CONCRETE MIX PROPORTIONING:

The determination of the proportion of cement, aggregate and water to attain the required strength shall be made as follows:

(a) By designing the concrete mix: such concrete shall be called 'Design mix concrete', for details reference may be made to RCC Chapter.

(b) By adopting nominal concrete mix: Such concrete shall be called 'Nominal mix concrete'. Design mix concrete is preferred to nominal mix. If design mix concrete cannot be used for any reason on the work for grades of M-20 or lower, nominal mixes may be used with the permission of Engineer-in-Charge, which, however, is likely to involve higher cement content.

Nominal Mix Concrete: Nominal Mix Concrete may be used for concrete of M-20 or lower.

Batching: To avoid confusion and error in batching, consideration should be given to using the smallest practical number of different concrete mixed on any site or in any one plant. In batching concrete, the quantity of both cement and aggregate shall be determined by mass; admixture, if solid, by mass; liquid admixture may however be measured in volume or mass; water shall be weighed or measured by volume in a calibrated tank (see also IS: 4925).

Ready-mixed concrete supplied by ready-mixed concrete plant shall be preferred. For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (see IS: 4926).

Except where it can be shown to the satisfaction of the Engineer-in-Charge that supply of properly graded aggregate of uniform quality can be maintained over a period of work, the grading aggregate should be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, the different sizes being stocked in separate stock-piles. The material should be stock-piled for several hours preferably a day before use. The grading of coarse and fine aggregate should be checked as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge to ensure that the specified grading is maintained. The accuracy of the measuring equipment shall be within + 2 percent of the quantity of cement being measured and within + 3 percent of the quantity of aggregate, admixtures and water being measured.

Proportion/Type and grading of aggregates shall be made by trial in such a way so as to obtain densest possible concrete. All ingredients of the concrete should be used by mass only.

Volume batching may be allowed only where weigh-batching is not practicable and provided accurate used in concrete have earlier been established. Allowance for bulking shall be made in accordance with IS: 2386 (Part 3). The mass volume relationship should be checked as frequently as necessary, the frequency for the given job being determined by Engineer-in-Charge to ensure that the specified grading is maintained. It is important to maintain the water cement ratio constant at its correct value. To this end, determination of moisture contents in both fine and coarse aggregates shall be made as frequently as possible, the frequency for a given job being determined by the Engineer-in-Charge according to Weather conditions.

Mixing: Concrete shall be mixed in mechanical batch type concrete mixers conforming to IS: 1791 having two blades and fitted with power loader (lifting hopper type). Half bag mixers and mixers without lifting hoppers shall not be used for mixing concrete. In exceptional circumstances, such as mechanical breakdown of mixer, work in remote areas or power breakdown and when the quantity of concrete work is very small, hand mixing may be done with the specific prior permission of the Engineer-in-Charge in writing subject to adding 10% extra cement, when hand mixing is permitted.

Compaction: Concrete shall be thoroughly compacted and fully worked around embedded fixtures and into corners of the form work. Compaction shall be done by mechanical vibrator of appropriate type till a dense concrete is obtained. The mechanical vibrators shall conform to IS: 2505, IS: 2506, IS: 2514 and IS: 4656. To prevent segregation, over vibration shall be avoided. Compaction shall be completed before the initial setting starts. For the items where mechanical vibrators are not to be used, the contractor shall take permission of the Engineer-in-Charge in writing before the start of the work. After compaction the top surface shall be finished even and smooth with wooden trowel before the concrete begins to set.

Curing: Curing is the process of preventing loss of moisture from the concrete. The following methods shall be employed for effecting curing.

Moist Curing: Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, Hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland cement and at least 10 days where mineral admixtures or blended cements are used. The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions. In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum periods may be extended to 14 days.

Membrane Curing: Approved curing compounds may be used in lieu of moist curing with the permission of the Engineer-in-Charge. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set. Impermeable membrane such as polythene sheet covering the concrete surface may also be used to provide effective barrier against the evaporation. Freshly laid concrete shall be protected from rain by suitable covering.

Measurements: Dimensions of length, breadth and thickness shall be measured correct to nearest cm. except for the thickness of slab and partition which shall be measured to nearest 5 mm.

Rate: The rate is inclusive of the cost of labour and materials involved in all the operations described above.

➤ **REINFORCED CEMENT CONCRETE:**

General: Reinforced cement concrete work may be cast-in-situ or Precast as may be directed by Engineer-in-Charge according to the nature of work. Reinforced cement concrete work shall comprise of the following which may be paid separately or collectively as per the description of the item of work.

- (a) Form work (Centering and Shuttering)
- (b) Reinforcement
- (c) Concreting: (1– Cast-in-situ), (2 – Precast)

Materials: Water, cement, fine and coarse aggregate shall be as specified.

Fly Ash admixed cement concrete (FACC) and fly ash Blended cements in Cement Concrete (PPCC) in RCC structures. Fly ash Blended Cements conforming to IS: 1489 (Part I) may be used in RCC structures as per guidelines given below.

(i) IS: 456- 2000 Code of Practice for Plain and Reinforced Concrete (as amended up to date) shall be followed in regard to Concrete Mix Proportion and its production as under:

(a) The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause-9 of IS 456 mentioned above.

(b) Concrete shall be manufactured in accordance with above mentioned IS: 456 covering quality assurance measures both technical and organizational, which shall also necessarily require a qualified

Concrete Technologist to be available during manufacture of concrete for certification of quality of concrete.

(ii) Minimum M -25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.

50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures.

Submittals

Along with their bid the contractors shall be required to submit the following information regarding the equipment's proposed to be used by them: -

(i) Type, number, capacity, range, mounting, nature of primary power used and the operating weight of pump and mounting.

(ii) Manufacturer's specifications for pipe lines giving pressure ratings, sizes and material for straight and curved sections.

(iv) Manufacturer's certificates.

Sampling and Testing (Materials)

Aggregates

(i) Supplier of aggregates shall furnish the following information before the material is delivered to site: -

- Precise location of source from where the material is to be supplied.

- Trade group of principal rock type as per table given below:

Trade group name of	: Granite, Gabbro,
Aggregates to be used for concrete	: Dolerite, Rhyolite, Basalt, Quartzite, Gneiss

(ii) The supplier shall also furnish reports on test results giving the following information for approval to Engineer-in-Charge before delivery of material at site: -

Specific gravity

Bulk density

Moisture content

Absorption Value

Aggregate crushing strength

Aggregate impact value

Abrasion value

Flakiness index

Elongation index

Limits of deleterious substances in the aggregate

Soundness of aggregate

All tests shall be conducted in accordance with IS: 2386 (Part-I to VIII).

Cement: Supplier of cement shall furnish the following documents before the cement is delivered to site:-

(i) Certificate confirming that chemical composition and physical characteristics are within the stipulated values for types of cement supplied as per relevant codes.

(ii) Certificate confirming that the chloride content in the cement is not in excess of 0.05 percent of mass of cement.

(iii) If during subsequent testing of cement supplied in lots any of the properties are found to be outside the acceptable limits, the lot of cement shall be rejected.

(iv) Each 1000 bags or part there of the cement or each wagon load of cement shall constitute one lot of cement for the purpose of on ducting tests at site before cement is accepted.

(v) Samples for testing at site shall be taken at random from 2% of the total quantity supplied in one lot. For cement supplied in bags, samples shall be drawn from minimum of 5 bags and the 2% value shall be rounded off to the next higher integer.

For bulk cement, sampling shall be done with the help of slotted sampler to be as per IS: 3535.

(vi) Results of test conducted on samples drawn shall be submitted to the Engineer-in-Charge for his approval. If in the opinion of the Engineer-in-Charge, the test results are not within permissible limits, the lot of cement from which samples have been obtained from testing shall stand rejected and the material shall be removed from site.

(vii) Following tests shall be conducted at site on each lot of cement delivered: -

Mandatory tests	Number of test per lot
1. Consistency of standard cement paste	5
2. Initial and final setting time	5 each
3. Compressive strength test	10

Mean values of the results from the above results shall be taken as the representative value and the acceptance criteria shall be based on these test. All test procedures and computation of test results shall be as per IS: 4031.

(viii) Apart from mandatory tests specified above, the Engineer-in-Charge may at his discretion, call for any additional tests that he may consider necessary. All such tests shall be done on representative samples taken from each lot and testing and computation of test results shall be done as per IS: 4031.

Water:

(i) Water to be used in manufacturing and curing of concrete shall be tested before use. All such test results shall be submitted to the Engineer-in-Charge for his approval before water is used. Water used for mixing & curing of concrete shall be fresh, clean, free from salt, acids, alkali, other chemicals and organic matter.

(ii) Manufacturer/ Contractor responsible for curing concrete shall identify and inform the Engineer in- Charge, precisely the location of source of water intended to be used. Each such source of water shall be separately tested. In the event of a change in the source of water all tests specified herein shall have to be repeated.

(iii) In the event water is drawn from tube wells or open-wells, water samples shall be tested for Seasonal fluctuations in water table or at intervals to be directed by the Engineer-in-charge.

(iv) Water sample from each source shall be tested as under: -

Test	Number of test for each source
Acidity	3
Alkalinity	3
Presence of solids	3

Mean values of the above test shall be taken as the representative value and the acceptance. Criteria shall be based on these test results. All testing procedure and computation of test results shall conform to IS: 3025.

Admixtures:

(i) Suppliers of Admixtures for concrete shall supply the following before any admixtures is approved by the Engineer-in-Charge for their used: -

Certificate confirming that the use of a particular brand of admixture shall not be harmful to concrete in any way. Certificate confirming the exact dosage of admixture of a particular brand. Certificate stating the specific purpose for which the admixture is to be used. Special precautionary measures to be taken in the manufacturer of concrete when using the particular brand of admixture.

Certificate confirming that the admixture conforms to specifications of IS: 9103 or to ASTM-C260, ASTM – C10, ASTM – C 595 or to ASTM- C 618.

(ii) Engineer-in-Charge at his discretion may require tests to be performed to reconfirm the Characteristic properties of any admixture. All such tests shall be done in accordance with IS: 9103.

(iii) All tests shall be done at the site laboratory or at a Laboratory to be identified by the Engineer-in-Charge depending on the test to be conducted.

(iv) All tests shall be done in the presence of a representative nominated by the Engineer-in-Charge and a representative of the concrete Manufacturer/ Contractor when tests are performed at the site laboratory. All observation and reports of test shall be jointly signed by the two representatives before the test results are submitted to the Engineer-in-Charge.

(v) Expenses for all materials used for testing, sampling procedures and testing including preparing reports shall be borne by the concrete Manufacturer/ Contractor.

(vi) Rate of concrete is inclusive of cost of admixtures. The contractor shall not be paid anything extra for admixtures required for achieving direct workability without any change in specified water cement ration for RCC/CC work.

Sampling and Testing for Quality Control of Fresh Concrete: Fresh concrete shall be tested for:

- (a) Slump
- (b) Compacting Factor/ Workability
- (c) Consistency.
- (d) Weight per cubic meter, cement factor and air content

4) WATER PROOFING

➤ CEMENT WATER PROOFING COMPOUND:

It shall be used for cement mortar for plastering or concrete work.

Water Proofing Compound: Integral cement water proofing compound conforming to IS: 2645 and of approved brand and manufacture, enlisted by the Engineer-in-Charge from time to time shall be used.

The contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

Measurement: It shall be measured by weight.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

➤ ROOF WATER PROOFING:

Unless otherwise indicated waterproofing shall be brick koba chemical treatment to be carried out by an approved specialist agency.

Preparation of surface: The surface to be water proofed shall be cleaned of all dust and other foreign matter. It shall then be wetted before applying the treatment.

Horizontal surface: Cement slurry admixed with acrylic based concrete chemical of approved make and conforming to IS: 2645:1975 @ 0.5 kg per 50 kg of cement or as recommended, shall be applied on the cleaned and prepared roof surface. A layer of 20mm thick (average) cement sand mortar of ratio 1:4 (1cement: 4 coarse sand) admixed with acrylic chemical @ 0.5 kg per 50 kg of cement or as recommended by manufacturer shall be laid over the bed prepared with cement slurry. A layer of broken brick/brick bats of 40mm thickness shall be laid over the aforementioned mortar bed. after proper curing for about two days, the joints including all voids varying from 15mm to 30mm thick shall be grouted with 1:4 cement mortar admixed with acrylic water proofing chemicals and then with cement slurry admixed with acrylic water proofing chemicals. The top surface shall then be finished smoothly with cement mortar (1:4) admixed with acrylic water proofing chemicals and such topping shall not be less than 20mm thick marked with 300mm X 300mm squares. If so required, the top surface shall be finished rough to receive top finishing, as specified & directed.

Vertical surfaces: This shall be of 20 mm thickness in two coats:

The under coat shall be of 10mm thick 1:4 (1cement: 4 coarse sand) admixed with acrylic water proofing chemical @ 0.5 kg per 50kg of cement or as recommended and shall be applied on the prepared vertical surface. The top surface shall be brought to a true surface with wooden straight edge. The surface shall be left rough and furrowed 2mm deep with a scratching tool diagonally both ways, to form key for the finishing coat. The surface shall be kept wet till the finishing coat is applied.

The finishing coat of same mix admixed with acrylic water proofing chemical and same thickness as under coat shall be applied when the under coat has sufficiently set but not dried and in any case not later than 48 hours. It shall be finished hereinafter including making/rounding gola with brick bat filled with cement sand mortar 1:4 admixed with acrylic chemical (50:50 ratio of River sand and crusher/Robo Sand is proposed). **Curing:** The finished surface shall be cured by flooding of water for period of two weeks.

➤ **WATER PROOFING ON FLOORS AND WALLS OF SUNKEN AREAS:**

Preparation of surface: The surface to be water proofed shall be cleaned of all dust and other foreign matter. It shall then be wetted before applying the treatment.

Horizontal surface: Cement slurry @ 2kg of cement per sq m of area admixed with acrylic based chemical @0.5 kg /50 kg of cement in the form of slurry shall be spread smoothly over the RCC shrunk floor which has been cleaned and prepared prior to laying the slurry. A layer of 20mm thick (average) cement sand mortar of ratio 1:4 (1cement: 4 coarse sand) admixed with acrylic chemical @ 0.5 kg per 50 kg of cement or as recommended by manufacturer shall be laid over the bed prepared with cement slurry. A layer of broken brick/brick bats of 40mm thickness shall be laid over the aforementioned mortar bed. after proper curing for about two days, the joints including all voids varying from 15mm to 30mm thick shall be grouted with 1:4 cement mortar admixed with acrylic water proofing chemicals and then with cement slurry admixed with acrylic water proofing chemicals. The top surface shall then be finished smoothly with cement mortar (1:4) admixed with acrylic water proofing chemicals and such topping shall not be less than 20mm thick. The top surface shall be finished smooth and corners rounded off.

Vertical surfaces: This shall be of 20 mm thickness in two coats: The under coat shall be of 10mm thick 1:4 (1cement: 4 coarse sand) admixed with acrylic water proofing chemical @ 0.5 kg per 50kg of cement or as recommended and shall be applied on the prepared vertical surface. The top surface shall be brought to a true surface with wooden straight edge. The surface shall be left rough and furrowed 2mm deep with a scratching tool diagonally both ways, to form key for the finishing coat. The surface shall be kept wet till the finishing coat is applied. The surface shall be finished smooth. The junction of vertical plastered surface and floor surface shall be rounded off. The finishing coat of same mix admixed with acrylic water proofing chemical and same thickness as under coat shall be applied when the under coat has sufficiently set but not dried and in any case not later than 48 hours.

It shall be finished hereinafter including making/rounding gola with brick bat filled with cement sand mortar 1:4 admixed with acrylic chemical. (50:50 ratio of River sand and crusher/Robo Sand is proposed).

Curing: The finished surface shall be cured by flooding of water for period of two weeks before filling sunken areas with concrete.

Precautions: While filling the areas with concrete it is to be ensured that the floor and the wall surface treated with water proofing treatment does not get damaged.

Guarantee: It shall be guaranteed that the building is completely water & leak proof for a period of 5 years. Such a guarantee shall be directly given by the specialist agency to the employer in a form approved by the Engineer in Charge.

WATER PROOFING IN BASEMENT & PODIUM AREAS: The waterproofing in Basement & Podium areas shall be Crystalline waterproofing system as specified in the Schedule.

EXPANSION JOINT TREATMENT: The Expansion Joint treatment in walls and floor and roof shall be as specified in the Schedule. The expansion joints must be protected with suitable water proofing treatment, taking precaution to enable the joints move freely and meeting the architectural requirements.

After the initial curing, if the cured sealant is found to have pinholes / blowholes, the same has to be repaired at the locations. In case, large surface is found to have air entrapped and pin holes are observed, the affected section needs to be cut, removed and re-done

Immediately after filling the joints, the sealant should be tooled either with a stainless steel or wooden spatula. While tooling, the spatula should be wetted with a wetting agent

During tooling ensure complete removal of air bubbles and to fill up all voids by the compacting action ensuring proper adhesion to the joint sides, Remove the masking tape immediately by pulling it outwardly after tooling is done

5) BRICK WORK

AAC MASONRY WORK

Materials

MASONRY to be used in the Building works shall be Autoclaved Aerated Concrete Blocks of approved make of size 600mm x 200mm x 200 mm with 55-60% Fly ash, 2-3% Gypsum, 10-12% cement, Lime 12-14%, Aluminum powder and balance slurry solids generated during process. Length and height can vary as per availability; however, the thickness of blocks shall be 200mm.

Fly ash to be used in the manufacturer of fly ash cement masonry shall conform to Grade 1 or 2 of IS-3812-1981.

Minimum percentage of fly ash to be used in the AAC masonry shall not be less than 40%. Manufacturers and test certificate and independent testing conforming chemical and physical requirement / characteristics and proportion of fly ash shall be produced by the contractor to the EIC/Project Manager for approval. Fly ash shall be procured from coal / lignite based thermal power plants.

Water absorption for the AAC masonry shall not be more than 20% of weight.

Efflorescence when tested according to IS-3495 (Part III) 1976 shall have the rating of efflorescence not more than 12.5%.

The Compressive strength of AAC blocks shall not be less than 4.0 N/sqm and shall conform to IS 2185.

The normal dry density shall be 550-650 kg/cum, sound absorption upto 60 dB, fire resistance of minimum 4 hours, thermal conductivity "K'0.16 W/sqmK, thermal resistance 0.46 K-sqm/W, heat transmission coefficient 2.17 w/sqmK and drying shrinkage not less than 0.02% (length of the block).

The AAC Blocks shall conform to IS 2185 (Part III) and the masonry shall be carried out as per IS 6041 (1995) and IS 1905 (1987).

WORKMANSHIP

All masonry work shall be built in CM (1:6).

Masonry work in panels shall be jointed with RCC columns by means of wall ties of MS flat 30mm x 3mm at every fourth course. The bonding length of reinforcement and MS flat shall be as under unless otherwise shown on drawings: -

Junction of 200 mm thick wall and RCC column etc- 20cm

Faces of masonry walls indicated to be pointed on external faces of masonry work or where shown to be provided with pointing (BFP) shall be faced with specially selected facing masonry. Masonry shall be uniform in colour, texture and shall have arises so that true horizontal and vertical joints are formed in the facing. Extra cost required for this shall be included by the contractor in his quoted rates.

Width of concrete lintels, beams, cills, columns and the like coming in conjunction with masonry walls/pillars shall be kept to the actual width of masonry work unless off sets have been specifically shown, in that case width as shown on drawings shall be maintained.

Centerline dimensions of rooms, verandahs etc as shown in drawings shall be maintained. Internal and overall dimensions if at variance from whatever is shown in drawings shall be deemed to have been amended accordingly. The dimensions of various heights shall be maintained as shown on the drawings

Mortar bed joints shall be such that four courses of masonry work and three joints taken consecutively shall measure 3 to 4cm in addition to the combined height of the masonry, themselves.

➤ **BRICKS:**

Bricks shall be of 1st class quality and confirm to the latest Indian standard specification no 1077-1992. Bricks shall be sound well burnt, free from cracks, to ring when struck and not to crack or break when shocked in water and uniform in size. They shall be best of class designation obtainable in the market and of the best quality and in every respect to be approved by the engineer in charge unless otherwise specified they shall be FPS bricks of size 230 x 110 x 70 cm. Bricks to be thoroughly cleaned well wetted or soaked in fresh water before being used on the work. Specified brick quality shall be tested as per IS: 3495-1992. The course shall be laid flush in mortar and every course shall be thoroughly grouted, the joint shall be broken vertically and they shall not exceed 10mm in thickness

The horizontal joints shall not be more than 10mm in thickness. The work shall not be laid more than 12 courses per day.

Bricks used in the masonry may be of the following type:

(a) The Common Burnt Clay Bricks shall conform to IS: 1077 and shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws warpage and organic matter, have a frog 100 mm in length 40 mm in width and 10 mm to 20 mm deep on one of its flat sides. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials

(b) Fly Ash Lime Bricks (FALG Bricks): The Fly Ash Lime Bricks (FALG Bricks) shall conform to IS: 12894. Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with or without frog on one of its flat side.

Fly Ash: Fly ash shall conform to IS: 3812.

Note: This item will be operated only for load bearing structure upto 2 storeys and for non-load bearing walls 23 cms thick for multi-storeyed buildings. Bottom ash used as replacement of sand shall not have more than 12% loss on ignition when tested.

Sand: Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime: Lime shall conform to class 'C' hydrated lime of IS: 712.

Additives: Any suitable additive considered not detrimental to the durability of bricks may be used

(c) Clay Fly Ash Bricks: The clay fly ash bricks shall conform to IS: 13757. The bricks shall be sound, compact and uniform in shape and colour. Bricks shall have smooth rectangular faces with sharp and square corners. The bricks shall be free from visible cracks, flaws, warpage, nodules of free lime and organic matter, the bricks shall be hand or machine moulded. The bricks shall have frog of 100 mm in length 40 mm width and 10 to 20 mm deep on one of its flat sides. If made by extrusion process may not be provided with frogs. Fly Ash shall conform to grade I or grade II of IS: 3812.

Compressive Strength: The bricks, when tested minimum average compressive strength for various classes as given in Table. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any individual brick tested exceeds the upper limit specified in Table for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified in Table for the purpose of calculating the average compressive strength.

Class Designation	Compressive strength			
	Not less than		Less than	
	N/mm ²	(Kgf/cm ²)	N/mm ²	(Kgf/cm ²)
100	10	(100)	12.5	125
75	7.5	(75)	10	100
50	5	(50)	7.5	75
40	4	(40)	5.0	50
35	3.5	(35)	4.0	40
25	2.5	(25)	3.0	30
20	2.0	(20)	2.5	25

Water Absorption: The average water absorption of bricks when tested shall be not more than 20% by weight.

Efflorescence: The rating of efflorescence of bricks when tested shall be not more than moderate.

Laying: Bricks shall be laid in English Bond unless otherwise specified. For brick work in half brick wall, bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

Note: Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers.

The brick work shall be built in uniform layers: No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal. Toothing shall not be permitted as an alternative to raking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

Bricks shall be laid with frog (where provided) up. However, when top course is exposed, bricks shall be laid with frog down. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the brick in position. In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

Finishing of Joints: The face of brick work may be finished flush or by pointing. In flush finishing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently plastering.

Curing: The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

Measurements: Work shall be measured in cubic meters unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall Brick be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq meters and the cubic contents shall be worked out to the nearest 0.01 cubic meters. Brick work shall be measured separately in the following stages:

- (a) From foundation to floor one level (Plinth level).
- (b) Plinth (floor one) level to floor two level.
- (c) Between two specified floor levels above floor two level.

➤ **HALF BRICK WORK:**

Brick work in half brick walls shall be done in the same manner as described above that the bricks shall be laid in stretcher bond. When the half brick work is to be reinforced, 2 Nos. M.S. bars of 6 mm dia. shall be embedded in every third course as given in the item (the dia of bars shall not exceed 8 mm). These shall be securely anchored at their end where the partitions end. The free ends of the reinforcement shall be keyed into the mortar of the main brick work to which the half brick work is joined. The mortar used for reinforced brick work shall be rich dense cement mortar of mix 1:4 (1cement: 4 coarse sand). Lime mortar shall not be used. Over laps in reinforcement if any shall not be less than 30 cm.

Measurements: The length and height of the wall shall be measured correct to a cm. The area shall be calculated in sqm. Where half brick wall is joined to the main walls of one brick or greater thickness and measurements for half brick wall shall be taken for its clear length from the face of the thicker wall.

Rate: The rate includes the cost of the materials and labour involved in all the operations described above except reinforcement which is to be paid for separately.

➤ **MOULDING AND CORNICES:**

Mouldings and cornices shall be made with bricks as specified for brick work. The bricks shall be cut and dressed to the required shape as shown in the architectural drawings. Cornices shall not ordinarily project by more than 15 cm to 20 cm and this projection shall be obtained by projecting each brick course by more than one fourth of the length. For cornices projecting more than 20 cm and requiring more than quarter bricks projection, metal cramps shall be used and paid for separately.

Corbelling shall be brought roughly to shape by plastering with the specified mortar. When the mortar is still green; the mouldings shall be finished straight and true with the help of metal templates.

Curing and Protection: The Mouldings and cornices shall be cured for at least seven days. These shall be protected from the effects of sun and rain by suitable covering and also from damage during the execution of the work.

Measurements: For the purpose of measurements, the sectional periphery of mouldings and cornices (excluding the portion in contact with wall) shall be measured in centimeters and length in metres. The girth and length shall be measured correct to a cm. No deduction shall be made from the masonry of wall for the bearing of the moulding and cornices.

Rate: The rate includes the cost of materials and labour involved in all the operations described above.

6) WOOD WORK

➤ **TIMBER:**

Timber is classified as under:

- (i) Teak wood
- (ii) Deodar wood
- (iii) Non-coniferous timbers other than teak.
- (iv) Coniferous timber other than deodar.

The timber shall be free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, splits and cracks. The timber shall be graded as first grade and second grade on the basis of the permissible defects in the timber as given in Appendix 'A' of. For both the grades, knots should be avoided over a specified limit.

Teak Wood (*Tectona Grandis*): It is of outstanding merit in retention of shape and durability. The heart wood is one of the most naturally durable woods of the world. It usually remains immune to white ant attack and insect attack for very long periods. It is, however, not always immune from fungus attack (rot). Taken as a whole, good quality teak is very durable, it is relatively easy to saw and work. It can be furnished to a fair surface and takes polish well. It is generally used for making furniture and all important timber construction.

Superior Class Teak Wood such as Balarsha, Malabar and Dandeli: Individual hard and sound knot shall not be more than 12 mm in diameter and the aggregate area of all the knots shall not exceed one half per cent of the area of the piece. It shall be close grained.

Deodar Wood (*Cedrus Deodars*): It is the strongest of the Indian conifers. Its weight and strength is 20% per cent less than teak. It is easy to saw and works to a smooth finish. It is not, however, a suitable wood for polish or paint work as the oil in the wood and especially near knots, always seeps through such finishes and discolours them. It is used for house building, furniture and other construction work. It is also suitable for beams, floors, boards, posts, window frames and light furniture etc.

Sal Wood (*Shoera Robusta*): Sal is about 30 per cent heavier than teak, 50 per cent harder, and about 20 to 30 per cent stronger. In shock resistance it is about 45 per cent above teak. Its heart wood is a naturally durable wood, and usually remains immune to attack by white ants and fungi for a long period, While its sapwood is very perishable and should not be used. Well dried sal is not a really easy wood to saw and work. It is a rough constructional wood than a carpentry timber. No individual hard and sound knot shall exceed 25 mm in diameter and the aggregate area of all the knots shall not exceed 1% of the area of the piece.

Seasoning of Timber: The process of drying timber under controlled conditions is called seasoning of timber. Timber shall be either air seasoned or kiln seasoned. Kiln seasoning of timber, where specified, shall be done as per IS: 1141 in a plant approved by Engineer in- Charge.

Preservation of Timber: Preservative treatment does not improve basic properties of timber but gives varying degree of protection against deterioration due to attacks by fungi, termites, borers and marine organisms. Preservative treatment, where specified, shall be done using Oil type, Organic solvent type or Water-soluble type preservative. Oil type preservatives shall be used if the timber is not required to be polished or painted. Before preservative treatment, the timber shall be sawn and seasoned. All surfaces exposed after treatment, except due to planning, shall be thoroughly brushed with the preservative before jointing. Preservative treatment of timber shall be done as per IS: 401 in a plant approved by the Engineer-in-Charge

➤ **PANELLING MATERIAL:**

Timber: Timber panels shall be preferably made of timber of larger width. The minimum width and thickness of a panel shall be 150 mm and 15 mm respectively. When made from more than one piece, the pieces shall be joined with a continuous tongue and groove joint, glued together and reinforced with metal dowels. The grains of timber panels shall run along the longer dimensions of the panels. The panels shall be designed such that no single panel exceeds 0.5 square metre in area.

Plywood/ Plywood Boards: Plywood boards are formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of glue. Face veneers may be either decorative on both sides or one side commercial and the other decorative. Plywood shall be of BWP grade or BWR grade as per IS: 303.

Marking: Each plywood board shall be legibly and indelibly marked or stamped with following particulars along with such other marks as the purchaser may stipulate at the time of placing order.

- (a) Manufacturer's name, initials or recognized trade mark, if any.
- (b) Year of manufacturing.
- (c) Abbreviation indicating the species of timber used in each ply.
- (d) Batch number.

➤ **DOOR, WINDOW AND VENTILATOR FRAMES:**

Timber for door, window and ventilators frames shall be as specified. Timber shall be sawn in the direction of the grains. All members of a frame shall be of the same species of timber and shall be straight without any warp or bow. Frames shall have smooth, well-planned (wrought) surfaces except the surfaces touching the walls, lintels, sill etc., which may be left clean sawn. Rebates, rounding or moulding shall be done before the members are jointed into frames. The depth of the rebate for housing the shutters shall be 15 mm, and the width of the rebates shall be equal to the thickness of the shutters. A tolerance of ± 2 mm shall be permitted in the specified finished dimensions of timber sections in frames.

Joints: The Jamb posts shall be through tenoned in to the mortise of the transoms to the full thickness of the transoms and the thickness of the tenon shall be not less than 2.5 cm. The tenons shall closely fit into the mortise without any wedging or filling. The contact surface of tenon and mortise before putting together shall be glued with polyvinyl acetate dispersion based adhesive conforming to IS: 4835 or adhesive conforming IS: 851 and pinned with 10 mm dia hard wood dowels, or bamboo pins or star shaped metal pins. The joints shall be at right angles when checked from the inside surfaces of the respective members. The joints shall be pressed in position. Each assembled door frame shall be fitted with a temporary stretcher and a temporary diagonal brace on the rebated faces.

Fixing of Frames: The frames shall be got approved by the Engineer-in-Charge before being painted, oiled or otherwise treated and before fixing in position. The surface of the frames abutting masonry or concrete and the portions of the frames embedded in floors shall be given a coating of coal tar. Frames shall be fixed to the abutting masonry or concrete with holdfasts or metallic fasteners as

specified. After fixing, the jamb posts of the frames shall be plugged suitably and finished neat. Vertical members of the door frames shall be embedded in the floor for the full thickness of the floor finish and shall be suitably strutted and wedged in order to prevent warping during construction. A minimum of three hold fasts shall be fixed on each side of door and window frames one at centre point and other two at 30 cm from the top and bottom of the frames. In case of window and ventilator frames of less than 1 m in height two hold fasts shall be fixed on each side at quarter point of the frames. Hold fasts and metallic fasteners shall be measured and paid for separately.

Measurements: Wood work wrought, framed and fixed shall be measured for finished dimension without any allowance for the wastage or for dimensions beyond specified dimension. However, in case of members having mouldings, roundings or rebates and members of circular or varying sections, finished dimensions shall be taken as the sides of the smallest square or rectangle from which such a section can be cut. Length of each member shall be measured over all to the nearest cm so as to include projection for tenons. Width and thickness shall be measured to the nearest mm and the quantity shall be worked out in unit of up to three places of decimal.

Rate: The rate shall include the cost of material and labour involved in all the operations described above except the hold fasts or metallic fasteners which will be paid for separately.

➤ **FLUSH DOOR SHUTTERS:**

Flush door shutters shall have a solid core and may be of the decorative or non-decorative (Paintable type as per IS: 2202 (Part I). Nominal thickness of shutters may be 25, 30, 35 or 40 mm. Thickness and type of shutters shall be as specified. Width and height of the shutters shall be as shown in the drawings or as indicated by the Engineering- Charge. All four edges of the shutters shall be square. The shutter shall be free from twist or warp in its plane. The moisture content in timbers used in the manufacture of flush door shutters shall be not more than 12 per cent when tested according to IS: 1708.

Core: The core of the flush door shutters shall be a block board having wooden strips held in a frame constructed of stiles and rails. Each stile and rail shall be a single piece without any joint. The width of the stiles and rails including lipping, where provided shall not be less than 45 mm and not more than 75 mm. The width of each wooden strip shall not exceed 30 mm. Stiles, rails and wooden strips forming the core of a shutter shall be of equal and uniform thickness. Wooden strips shall be parallel to the stiles. End joints of the pieces of wooden strips of small lengths shall be staggered. In a shutter, stiles and rails shall be of one species of timber. Wooden strips shall also be of one species only but it may or may not be of the same species as that of the stiles and rails. Any species of timber may be used for core of flush door. However, any non-coniferous (Hard wood) timber shall be used for stiles, rails and lipping.

Lipping: Lipping, where specified, shall be provided internally on all edges of the shutters. Lipping shall be done with battens of first class hardwood or as specified of depth not less than 25 mm. For double leaved shutters, depth of the lipping at meeting of stiles shall be not less than 35 mm. Joints shall not be permitted in the lipping.

Laminated Veneer Lumber (LVL) Door Shutters: This specification lays down requirements regarding types, sizes, material, construction, workmanship and finish, performance evaluation, sampling, measurements, rates and testing of Laminated Veneer Lumber (LVL) door shutter for use in domestic buildings, offices, schools, hospitals etc. This specification does not cover large size door shutters for industrial and special buildings such as workshops, garages, godowns etc. The material of each lot shall be supported by a certificate to that effect: Each lot of LVL materials shall be accompanied by the test reports.

Paneling Materials: Plain Particle Board: Plain particle boards used for panels shall be FPT-1 conforming to IS: 3087 and shall have been bonded with BWP type of synthetic resin adhesive as per

IS 848. Pre-laminated Particle Board: Pre-laminated particle boards used for panels shall conform to IS: 12823. .

Medium Density Fibre Board: Medium density fibre board used for panels shall conform to exterior grade as per IS 12406 made from agro-forest products or agricultural wastes or natural fibers. Pre-laminated Medium Density Fibre Board: Pre-lamination in pre-laminated medium density fiber board shall conform to the requirements such as Abrasion Resistance, Resistance to Steam, Crack Resistance, Resistance to Cigarette Burn and Resistance to Stain as specified in IS: 12823.

Glass: Glass for glazing shall conform to IS: 2835 or IS: 2553. The use of other types of glass, such as frosted glass, wired glass and coloured glass may also be specified by the Engineer-in- Charge.

Wire Gauze: Wire gauze shall generally conform to IS 1568 and shall be regularly woven with equally spaced galvanized mild steel wires of 0.63 mm nominal diameter in both warp and weft directions to form aperture of average width 1.40 mm.

Construction and Workmanship: Laminated Veneer Lumber (LVL) panelled, glazed and panelled and glazed shutter shall be constructed in the form of LVL framework of stiles and rails with panel inserts conforming to para above of plain or perlaminated particle board, plain or prelaminated medium density fibre board, wire gauze or glass. The panels shall be fixed by either providing grooves in stiles and rails and beading as specified. The stiles, top rails, lock rails and bottom rails shall be jointed to each other by mortice and tenon joints (Rails having width of 150 mm or more shall have plain double tenon joints. Other rails shall have single tenon joints. The bottom lock and top rails shall be inserted 25+3 mm short of the width of stiles to form a stub mortice & tenon joint. After assembling shutter complete with panels, Bamboo pins of 6 mm dia shall be fitted on each tenon & mortise joint by drilling suitable size of holes (2 pins per joint for rail width up to 150 mm and 3 pins for rails of greater width). All the four edges of shutter shall be beaded with 12 mm thick rubber wood /plantation wood lipping. Lipping on top and bottom rails shall be of one piece and lipping on stiles may be in two pieces. All lippings shall be glued to shutter with water resisting glue (Synthetic rubber passed adhesive) at the rate of 0.15 kg/m². All members of the shutters shall be straight, smooth and with well planed faces at right angles to each other. Any warp or bow shall not exceed 1.5 mm. The right angle for the shutters shall be checked by measuring the two diagonals from one extreme corner to the opposite one and the difference between the two diagonals shall not be more than 3 mm.

Beading: All the panels except glass and wire gauze shall be fixed with grooves but additional beading may be provided either on one side or on both the sides, if so specified. In so far as glass and wire gauze panels are concerned, beading shall be provided without grooves. In such a case where beading is provided without the grooves, the beading shall be only on one side, the other side being supported by rebate from stiles. The beading shall have a size not less than 15 mm x 10 mm. It can be fixed by suitable headless nailing or screwing. The beading shall be of plantation timber section, preservative chemically treated of fixed type as per IS: 401-1982. Stiles, top rails, bottom rails and lock rails of shutters shall each be made in one piece of LVL, only. Mullions and glazing bars shall be tubtenoned to the maximum depth which the size of the member would permit or to a depth of 25 mm, whichever is less.

Two common methods for jointing of panels with stiles/rails are shown in minimum depth of grooves of stiles and rails shall be 12 mm for all types of panelling. The panels shall be framed into grooves to the full depth of groove leaving an air space of 1.5 mm and the faces shall be closely fitted to the sides of the groove. LVL Shutters shall be manufactured in factories under controlled conditions.

Acoustic Paneling: Plain and Pre-Laminated Particle Board Paneling: The paneling shall be of 12mm thick celotax glass wool/rock wool boards stuck to 12mm thick commercial ply backing.

Opening for Glazing: When required by the purchaser opening for glazing shall be provided and unless otherwise specified the opening for glazing shall be 250 mm in height and 150 mm or 200 mm in width unless directed otherwise. The bottom of the opening shall be at a height of 1.4 m from the bottom

of the shutter. Opening for glazing shall be lipped internally with wooden batten of width not less than 25 mm. Opening for glazing shall be provided where specified or shown in the drawing.

Fitting shall be of mild steel brass, aluminium or as specified. Some mild steel fittings may have components of cast iron. These shall be well made, reasonably smooth, and free from sharp edges and corners, flaws and other defects. Screw holes shall be counter sunk to suit the head of specified wood screws. These shall be of the following types according to the material used.

(a) Mild Steel Fittings: These shall be bright finish black stone enameled or copper oxidised (black finish), nickel chromium plated or as specified.

(b) Brass Fittings: These shall be finished bright satin finish or nickel chromium plated or copper oxidised or as specified.

(c) Stainless Steel Fitting: These fittings shall be of stainless steel with stainless screw etc complete.

(d) Aluminium Fittings: These shall be anodised to natural matt finish or dyed anodic coating not less than grade AC 10 of IS: 1868. The fittings to be actually provided in a particular work shall, however, be decided by the Engineer-in-Charge.

Screws used for fittings shall be of the same metal, and finish as the fittings. However, chromium plated brass screws or stainless steel screws shall be used for fixing aluminium fittings. These shall be of the size as indicated in respective figures. Fittings shall be fixed in proper position as shown in the drawings or as directed by the Engineer-in-Charge. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with screw driver and not hammered in. Recesses shall be cut to the exact size and depth for the counter sinking of hinges.

Butt Hinges: These shall be of the following types according to the material used.

(a) Mild steel butt hinges (Medium).

(b) Cast brass butt hinges light/ordinary or heavy.

(c) Extruded aluminum alloy butt hinges.

(d) Stainless steel butt hinges.

Fixing of Frames: The frames are to be fixed in prepared openings in the walls. All civil work and tiling should be completed before the fixing of the frames. The frames are to be fixed directly on the plastered wall. In case tiling is to be done in the place the frames are to be fitted, a 50 mm strip should be left untiled at the location where the frames are to be fitted. The frames are erected in the prepared opening such that the vertical members of the door frame are embedded 50 mm in the floor. The frame shall be fitted truly in plumb. A minimum of three anchor bolts or screws of size 65/100 shall be used to fix each vertical member. One bolt shall be fixed at 200 mm from the top member and one bolt shall be fixed at 200 mm from the floor. The third anchor bolt shall be fixed in the center. The top horizontal member shall be fixed using two 65/100 size anchor bolts or screws at a distance of 200 mm from both the corners.

Measurements: The outer length of the vertical and horizontal members of UPVC door frame shall be measured in running metres including embedded length in floor corrected up to a cm.

Rate: The rate includes the cost of the materials and labour involved in all the operations described above. The cost of anchor bolts or screws for joining the frame is included in the rate. Any other hardware, which may be required, shall be paid for separately.

➤ **UPVC DOOR FRAMES:**

UPVC door frame shall be made of PVC material conforming to IS: 10151. The door frame shall be made from extruded UPVC section having overall dimensions of 48 x 40 mm or 42 x 50 mm having wall thickness of 2.0 mm + 0.2 mm. Corners of the door frame to be jointed by M.S. galvanized

brackets. Joints mitred and plastic welded. The hinge side vertical outer frames shall be reinforced by galvanized M.S. Tube of size 19 x 19 mm of wall thickness 1 mm + 0.1 mm and a tie rod shall be provided at the bottom of the frame. The frame shall be fabricated in factory as per nomenclature of the item and directions of Engineer-in-Charge.

Fixing of Frames: The frames are to be fixed in prepared openings in the walls. All civil work and tiling should be completed before the fixing of the frames. The frames are to be fixed directly on the plastered wall. In case tiling is to be done in the place the frames are to be fitted, a 50 mm strip should be left untilled at the location where the frames are to be fitted. The frames are erected in the prepared opening such that the vertical members of the door frame are embedded 50 mm in the floor. The frame shall be fitted truly in plumb. A minimum of three anchor bolts or screws of size 65/100 shall be used to fix each vertical member. One bolt shall be fixed at 200 mm from the top member and one bolt shall be fixed at 200 mm from the floor. The third anchor bolt shall be fixed in the center. The top horizontal member shall be fixed using two 65/100 size anchor bolts or screws at a distance of 200 mm from both the corners.

Measurements: The outer length of the vertical and horizontal members of UPVC door frame shall be measured in running metres including embedded length in floor corrected upto a cm.

Rate: The rate includes the cost of the materials and labour involved in all the operations described above. The cost of anchor bolts or screws for joining the frame is included in the rate. Any other hardware, which may be required, shall be paid for separately.

➤ **PVC DOOR SHUTTERS:**

The shutters shall be fabricated at factory as per nomenclature of the item and directions of Engineer-in-Charge. Shutter shall be made of PVC material conforming to IS: 10151.

24 mm thick PVC Door Shutter

30 mm Thick PVC Door Shutters

Sampling and Criteria for Conformity:

General Precautions: The test specimens shall not have been exposed to a temperature below 40°C for 24 hours immediately preceding the test and shall be free from all visible moisture. The specimen shall be inspected and any specimen with visible flaws shall be discarded. If any test specimen fails because of mechanical reason, such as failure of testing equipment or improper specimen preparation, it shall be discarded and another specimen taken.

Fixing of Shutters: PVC door shutter shall be side hung on three bolt hinges of size 100 mm, one at the centre and the other two at 200 mm from the top and bottom of the shutter. The flat of the hinges shall be neatly counter sunk in to the recesses cut out to the exact dimensions of the hinge flap. The door shall be drilled on the thickness to fit hinges. Screws for fixing the hinges shall be screwed in with screwdrivers and not hammered. The length of the screws should be 8 mm/30 mm. The hinges used should be of stainless steel.

Tolerance: The tolerance on the width and the height of the door shall be + 5 mm and the tolerance on the nominal thickness of the door shall be + 2 mm.

Fittings: Fittings shall be provided as per schedule of fittings decided by Engineer-in-Charge. In moisture prone areas M.S. fittings and screws should not be used. Hardware such as handles, tower bolt, stopper, buffer etc. should be directly screwed (not pre-drilled) and fitted on the door.

Measurements: Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Area is calculated to the nearest 0.01 sqm.

Rate: The specified rate includes the cost of the door shutter and labour involved in fixing of the shutter. Fittings & fixtures on the door shutter except hinges & screws shall be paid extra as provided.

➤ **PANEL PVC DOOR SHUTTER:**

Panel PVC Shutters are factory made shutter and shall be brought to site fully assembled. The Solid Panel PVC Door shall be fabricated from 5 mm PVC sheet. The sheets used may be in plain colour, printed design or prelam veneer shade as approved by the Engineer-in-Charge. The shutters shall be fabricated at factory as per nomenclature of the item and directions of the Engineer-in-charge. 30 mm thick panel PVC door shutters.

7) STEEL & ALUMINUM WORK

➤ **STEEL WORK IN BUILT UP SECTION (WELDED):**

The steel work in built up sections (welded) such as in trusses, form work etc.

Fabrication: Fabrication shall generally be done as specified in IS 800. In major works or where so specified, shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details of rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer-in-charge. The drawings shall indicate the shop and field rivets, bolts and welds. The steel members shall be distinctly marked or stenciled with paint with the identification marks as given in the shop drawings.

Welding: Welding shall generally be done by electric arc process as per IS: 816 and IS: 823. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the contractor at his own cost unless otherwise specified. Gas welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-in-charge. Gas welding shall not be permitted for structural steel work. Gas welding required heating of the members to be welded along with the welding rod and is likely to create temperature stresses in the welded members. Precautions shall therefore be taken to avoid distortion of the members due to these temperature stresses. The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used.

As far as possible every effort shall be made to limit the welding that must be done after the structure is erected so as to avoid the improper welding that is likely to be done due to heights and difficult positions on scaffolding etc. apart from the aspect of economy. The maximum diameter of electrodes for welding work shall be as per IS: 814. Joint surfaces which are to be welded together shall be free from loose mill scale, rust, paint, grease or other foreign matter, which adversely affect the quality of members, and holes for riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting as per required dimensions. The base of steel columns and the positions of anchor bolts shall be carefully set out at the required location.

Assembly: Before welding is commenced, the members to be welded shall first be brought together and firmly clamped or tack welded to be held in position. This temporary connection has to be strong enough to hold the parts accurately in place without any disturbance. Tack welds located in places where final welds will be made later shall conform to the final weld in quality and shall be cleaned off slag before final weld is made.

Erection: The work of erection may be done in suitable units as may be directed by the Engineer-in-charge. Fabricated members shall be lifted at such points so as to avoid deformation or excessive

stress in members. The structure or part of it placed in position shall be secured against over-turning or collapse by suitable mean.

Painting: Before the member of the steel structures are placed in position or taken out of the workshop these shall be painted as specified.

Measurements: The work as fixed in place shall be measured in running meters correct to a millimeter and weights calculated on the basis of standard tables correct to the nearest kilogram. The standard weight of steel sections shall conform to IS 808 with tolerance in sizes as per IS: 1852.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

➤ **STAINLESS STEEL WORK IN BUILT UP SECTION (WELDED):**

The steel work in built up sections (welded) such as in trusses, railing, guard rail etc.

Fabrication: Fabrication shall generally be done as per shop drawings giving complete information for the fabrication of the component parts of the structure including the location, type, size, length and details or rivets, bolts or welds, shall be prepared in advance of the actual fabrication and approved by the Engineer-in-charge.

Welding: Welding shall generally be done by electric arc process. The electric arc method is usually adopted and is economical. Where electricity for public is not available generators shall be arranged by the contractor at his own cost unless otherwise specified. Gas welding shall only be resorted to using oxyacetylene flame with specific approval of the Engineer-in-charge. Precautions shall therefore be taken to avoid distortion of the members due to these temperature stresses. The work shall be done as shown in the shop drawings which should clearly indicate various details of the joint to be welded, type of welds, shop and site welds as well as the types of electrodes to be used.

Erection: The work of erection may be done in suitable units as may be directed by the Engineer-in-charge. Fabricated members shall be lifted at such points so as to avoid deformation or excessive stress in members. The structure or part of it placed in position shall be secured against over-turning or collapse by suitable mean.

Measurements: The work as fixed in place shall be measured in running meters correct to a millimeter and weights calculated on the basis of standard tables correct to the nearest kilogram. The standard weight of steel sections shall conform to IS 808 with tolerance in sizes as per IS: 1852.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

Rolling shutters:

General: Rolling shutters shall be of best quality and obtained from approved make. These shall include necessary locking arrangement handles etc. These shall be suitable for fixing in position as specified i.e. outside or below lintel or between jams of the opening. The door shall be push and pull type and also operated with chain crank as required.

Shutters: The shutters shall consist of MS plates of 1.25mm thick and 80mm wide as specified. The laths shall be machine rolled and straightened with effective bridge depth of 16 mm and shall be interlocked together through out their entire length and joined together at the end with locks. These shall be mounted with on specifically mounted on specifically designed pipe shaft. Each lath section shall be continuous single strip piece without any joint.

Spring: The springs shall be preferably of coiled type. The spring shall be manufactured from high tensile spring steel wire or strip of adequate strength to balance the shutters in all positions. & the spring pipe shall be supported on strong mild steel brackets. The guide channels shall be of mild steel deep channel section and of rolled, Pressed or built up construction. The thickness of the sheet used

shall not be less than 3.15mm. The minimum depth of the guide channels shall be 60mm for clear width of shutters up to 3.5 m and 75 mm for 3.5 m and above. The gap between the two channels shall be sufficient to allow the free movement of curtain and at the same time closes enough to prevent the rattling of curtain due to wind. Each guide rail shall be provided with a minimum three fixing cleats to the wall or columns by means of bolts or screws.

Fixing: Brackets shall be fixed on the little or under the lintel as shown in the drawing with rawl plugs, screws, bolts etc. The shaft along with the spring shall then be fixed to the brackets.

The shutter shall be laid on the ground and the side guide channel shall be bound with it with ropes etc. The shutters then be placed in position and top fixed with pipe shaft with bolts & nuts. The side guide channels and the cover frame shall then be fixed to the walls through the plate welded to the guides. Fixing shall be done accurately in workmanlike manner so that manner so that the operation of the shutter is easy & smooth.

Grilled Curtain: Wherever specified rolling shutter shall be provided with grilled curtain.

Finishing: The rolling shutter together with guide channel, cover and accessories shall be supplied with two coats of approved primer and shall be painted finally with two coats of approved paint at site after installation, as specified.

Metal Inserts' in RCC & Block Work: Anchor bolts, rolled steel sections sleeves, pipes, inserts, etc shall be galvanized and shall be fixed or inserted as shown or directed the contractor shall supply and place in the shuttering all such inserts as may be required for sanitary, electric or work of any other trade. Work shall be done exactly as required for the purpose, to the satisfaction of engineer in charge.

Quality of steel: All mild steel used in this work shall be tough with even surface and shall be cleanly rolled, sound and free from flaws, cracks, crop ends and other defects. Workmanships:

All work shall be carried out as per drawing in a neat and good craftsman like manner by especially skilled men known for good quality work.

Measurements to be checked: The contractor shall check all measurements at site and with surroundings works as per approval of engineer in charge.

Assembly: Work carried out in sections shall be carefully assembled. All members shall be secured together or to the anchored by welding or as shown in the details. All welds shall be ground smooth and made to match surrounding surface and finished to the satisfaction of the engineer in charge.

➤ **PRESSED STEEL DOOR FRAMES:**

Materials: Steel door frames shall be manufactured from commercial mild steel sheet of specified thickness, conforming to IS: 2062 and 4351. Steel door frames may be manufactured to suit doors of either type opening inwards or outwards as directed by the Engineer-in-Charge.

Construction: Each door frame shall consist of hinge jamb, lock jamb, head and if required angle threshold. These shall be welded or rigidly fixed together by mechanical means. Where no angle threshold is required, temporary base tie shall be screwed to the feet of frames in order to form a rigid unit. Where so specified base ties shall be of pressed mild steel 1.25 mm thick adjustable to suit floor thickness of 35 or 40 mm and removable, or alternatively, threshold of mild steel angle of section 50 x 25 mm, minimum shall be provided for external doors frames.

Fabrication: The pressed steel door frames shall be got fabricated in an approved workshop as approved by the Chief Engineer.

Fixing Lugs: There shall be three adjustable lugs with split end tail to each jamb without fan light, and four for jamb with fan light.

The head of the fixing lug shall be of one of the following lengths:

- (a) 98 mm long for use with profile A
- (b) 120 mm long for use with profile B
- (c) 160 mm long for use with profile C

The head shall be made from flat steel strip 25 mm wide and not less than 1.60 mm thick

The tail of the lugs shall be 200mm long and shall be made of steel strip not less than 40 mm wide and not less than 1 mm thick.

Hinges: 20 mm mild steel butt hinges shall be used. For door frames 80 cm wide and under, three hinges shall be rigidly fixed to one jamb and for door frames above 80 cm wide, four Hinges shall rigidly fix to one jamb, if it is single shutter, where the height of door shutter metres, one additional hinge shall be provided for every 0.5 m or part there of the additional height. In all cases the hinges shall be so fixed that the distance from the inside of the head rebate to the top of the upper hinge is 20 cm and the distance from the bottom of the door frame to the bottom of the bottom hinge is also kept about 200 mm. The middle hinges shall be at equal distances from lower and upper hinges or as agreed to between the purchaser and the supplier. Hinges shall be made of steel 2.5 mm thick with zinc coated removable pin of 6 mm diameter. The space between the two leaves of the hinge when closed shall be 3 mm and the leaf that is not welded to the frame shall have four counter sunk holes to take No. 10 cross recessed head wood screws.

Mortar Guards: Mortar guards of thickness of main frame sheet shall be provided in accordance to provisions of IS 4351 and as instructed by Engineer-in-charge shall be provided. These shall be welded to the frame at the head of the frame for double shutter doors to make provision for bolts. These shall also be provided to the frame behind the hinges, mortice locks and latches, slots, aldrop and sliding /tower bolts.

Lock – Strike Plate: There shall be an adjustable lock- strike plate of steel complete with mortar guard to make provision for locks or latches complying with the relevant Indian Standards.

(IS: 4351) Lock-strike plates shall be of galvanized mild steel and fixed at 95 cm from the head of the frame.

Shock Absorbers: For side hung door there shall not be less than three buffers or rubber or other suitable material inserted in holes in the rebate. One shall be located at the centre of the lock jamb and the other two shall be at 30 cm. from top and bottom of the frame. For double leaf shutter door, two buffers shall be provided.

Finishing: The surface of door frame shall be thoroughly cleaned, free of rust, mill-scale dirt oil etc. either by mechanical means, for example sand or shot blasting or by chemical means such as pickling. After pretreatment of the surface one coat of approved primer i.e. red oxide zinc chrome primer conforming to IS: 2074. Two coats of paints as directed by the Engineer-in-charge shall be applied to the exposed surface.

Fixing: Frames shall be fixed up right in plumb and plane. To avoid sag or bow in width during fixing or during construction phase, temporary struts across the width preventing sides bulging inwards may be provided. Wall shall be built solid on each side and grouted at each course to ensure solid contact with frame leaving no voids behind the frame.

Three lugs shall be provided on each jamb with spacing not more than 75 cm. The temporary struts should not be removed till the masonry behind the frame is set. In case screwed base tie is provided, this should be left in position till the flooring is laid when it can be removed. After pretreatment of the surface, one coat of steel primer and two coats, of paint, as directed by Engineer-in-charge shall be applied to the exposed surface.

Measurements: The length shall be measured in running metre correct to a cm along the centre line of the frames.

Rate: The rate shall include the cost of labour and material involved in all the operation described above including one coat of approved steel primer but excluding two coats of paint.

➤ **ALUMINIUM: DOOR, WINDOW, VENTILATOR AND PARTITION FRAMES:**

Frame Work: First of all, the shop drawings for each type of doors/ windows/ ventilators etc. shall be prepared by using suitable sections based on architectural drawings, adequate to meet the requirement/ specifications and by taking into consideration varying profiles of aluminium sections being extruded by approved manufacturers. The shop drawings shall show full size sections of glazed doors, windows, ventilators etc. The shop drawings shall also show the details of fittings and joints. Before start of the work, all the shop drawings shall be got approved from the Engineer-in-Charge. Actual measurement of openings left at site for different type of door/ window etc. shall be taken. The fabrication of the individual door/ windows/ ventilators etc. shall be done as per the actual sizes of the opening left at site. The frames shall be truly rectangular and flat with regular shape corners fabricated to true right angles. The frames shall be fabricated out of section which have been cut to length, mitered and jointed mechanically using appropriate machines. Mitered joints shall be corner crimped or fixed with self tapping stainless steel screws using extruded aluminium cleats of required length and profile. All aluminium work shall provide for replacing damaged/broken glass panes without having to remove or damage any member of exterior finishing material.

Fixing of Frames: The holes in concrete/masonry/wood/any other members for fixing anchor bolts/fasteners/screws shall be drilled with an appropriate electric drill. Windows/ doors/ ventilators etc. shall be placed in correct final position in the opening and fixed to Sal wood backing using stainless steel screws of star headed, counter sunk and matching size groove. of required size at spacing not more than 250 mm c/c or dash fastener. All joints shall be sealed with approved silicone sealants.

In the case of composite windows and doors, the different units are to be assembled first. The assembled composite units shall be checked for line, level and plumb before final fixing is done. Engineer-in-Charge in his sole discretion may allow the units to be assembled in their final location if the situation so warrants. Snap beadings and EPDM gasket shall be fixed as per the detail shown in the shop drawings. Where aluminium comes into contact with stone masonry, brick work, concrete, plaster or dissimilar metal, it shall be coated with an approved insulation lacquer, paint or plastic tape to ensure that electrochemical corrosion is avoided. Insulation material shall be trimmed off to a clean flush line on completion. The contractor shall be responsible for the doors, windows etc. being set straight, plumb, level and for their satisfactory operation after fixing is complete.

Measurements: All the Aluminium sections including snap beadings fixed in place shall be measured in running meter along the outer periphery of composite section correct to a millimeter. The weight calculated on the basis of actual average (average of five samples) weight of composite section in kilogram correct to the second place of decimal shall be taken for payment (weight shall be taken after anodizing). The weight of cleat shall be added for payment. Neither any deduction nor anything extra shall be paid for skew cuts.

Rate: The rate shall include the cost of all the materials, labour involved in all the operations as described in nomenclature of item and particular specification.

➤ **DOOR, WINDOWS AND VENTILATOR SHUTTERS:**

Material, fabrication and dimensions of aluminium doors, windows and ventilators manufacture extruded aluminium alloy sections of standard sizes and designs complete with fittings, ready for being fixed into the building shall be as per IS: 1948.

Material: Aluminium alloy extruded sections used in the manufacture of extruded window sections shall conform to IS: 733. Hollow aluminium alloy sections used shall conform to IS: 1285.

Glass Panes: Glass panes shall weigh at least 7.5 kg/m² and shall be free from flaws, specks or bubbles. All panes shall have properly squared corners and straight edges.

Fabrication:

Frames: Frames shall be square and flat; the corners of the frame being fabricated to a true right angle. Both the fixed and opening frames shall be constructed of sections which have been cut to length, mitered and welded at the corners. Where hollow sections are used with welded joints, argon-arc welding or flash butt welding shall be employed (gas welding or brazing not to be done).

➤ **FITTINGS:**

Fitting shall be of mild steel brass, aluminum or as specified. Some mild steel fittings may have components of cast iron. These shall be well made, reasonably smooth, and free from sharp edges and corners, flaws and other defects. Screw holes shall be counter sunk to suit the head of specified wood screws. These shall be of the following types according to the material used.

Mild Steel Fittings: These shall be bright satin finish black stone enamelled or copper oxidised (black finish), nickel chromium plated or as specified

Brass Fittings: These shall be finished bright satin finish or nickel chromium plated or copper oxidized or as specified.

Aluminium Fittings: These shall be anodised to natural matt finish or dyed anodic coating not less than grade AC 10 of IS: 1868.

Stainless Steel Friction Stay: The stainless steel friction stays of make approved by the Engineer-in-Charge shall be used. The SS friction stays shall be of grade AISI-304 and of sizes specified in nomenclature of item.

Lockable Handles: The lockable handle shall be of make approved by the Engineer-in-Charge and of required colour to match the colour of powder coated /anodized aluminium window sections.

Hydraulic Floor Spring: The hydraulic floor spring shall be heavy duty double action floor spring of make approved by the Engineer-in-Charge suitable for door leaf of weight minimum 100 kg. The top cover plate shall be of stainless steel, flushing with floor finish level. The contractor shall cut the floor properly with stone cutting machine to exact size & shape. The spindle of suitable length to accommodate the floor finish shall be used. The contractor shall give the guarantee duly supported by the company for proper functioning of floor spring at least for 10 years.

Measurements: All the aluminum sections including snap beadings fixed in place shall be measured in running meter along the outer periphery of composite section correct to a millimeter. The weight calculated on the basis of actual average (average of five samples) weight of composite section in kilogram correct to the second place of decimal shall be taken for payment (weight shall be taken after anodizing). The weight of cleat shall be added for payment. Neither any deduction nor anything extra shall be paid for skew cuts.

Rate: The rate shall include the cost of all the materials, labour involved in all the operations as described in nomenclature of item and particular specification.

Aluminium Sheet: Aluminium Sheets for use as panels shall be 1.25 mm thick aluminium alloy sheet conforming to IS: 737. Aluminium alloy sheet for use in general paneling work shall be of types and thickness as specified and conforming to the requirement of IS: 737. Aluminium sheets shall be of approved make and manufacturer. Aluminium panel may be prefabricated units manufactured on modular or non-modular dimension.

Fixing: The required size of panel, keeping sufficient margin to be inserted inside the section, shall be cut to correct size and fixed firmly in the frame with CP brass or aluminium or stainless steel screws of star headed, counter sunk and matching size groove. Joints sealed with epoxy resin or silicon sealant to make the unit water proof.

Float Glass: The glass shall be clear float glass and should be approved by the Engineer in Charge. It shall be clear, float transparent and free from cracks subject to allowable defects. The float glass shall conform to the IS: 14900.

8) ROOFING & CEILING

➤ CORRUGATED GALVANISED STEEL SHEET ROOFING C.G.S. SHEETS:

These shall be of the thickness specified in the description of the item and shall conform to IS: 277. The sheets shall be of 275 grade unless otherwise specified in the description of item. The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanizing shall be non-injured and in perfect condition. The sheets shall not show signs of rust or white powdery deposits on the surface. The corrugations shall be uniform in depth and pitch and parallel with the side.

Purlins: Purlins of the specified material or M.S. rolled sections of requisite size shall be fixed over the principal rafters. These shall not be spaced at more than the following distances given below:

Thickness of C.G.S. sheet	Maximum spacing of purlins
1.00 mm	2.00 metre
0.80 mm	1.80 metre
0.63 mm	1.60 metre

The top surfaces of the purlins shall be uniform and plane. They shall be painted before fixing on top. Embedded portions of wooden purlins shall be coal tarred with two coats.

Slope: Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontals. The normal pitch adopted shall usually be 1 vertical to 3 horizontals.

Laying and Fixing: The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

Lapping in C.G.S. sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paint suitable for G.S. sheet, before the sheets are fixed in place. Sheets shall not generally be fixed into gables and parapets. They shall be bent up along their side edges close to the wall and the junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at least 7.5 cm. The laying operation shall include all scaffolding work involved.

Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with galvanized J or L hook bolts and nuts, 8 mm diameter, with bitumen and G.I. limpet washers or with a limpet washer filled with white lead as directed by the Engineer-in-Charge. While J hooks are used for fixing sheets on angle iron purlins, and L hooks are used for fixing the sheet to R.S. joists, timber or precast concrete purlins. The length of the hook bolt shall be varied to suit the particular requirements.

The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm.

There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins. The galvanized coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections which would impair serviceability.

Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal) sheets shall be joined together at the side laps by galvanized iron bolts and nuts 25 × 6 mm size, each bolt provided with a bitumen and a G.I. limpet washer or a G.I. limpet washer filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zig -zag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheet.

Wind Tie: Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified. These shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. The ties shall be paid for separately unless described in the item of roofing.

Finish: The roof when completed shall be true to lines and slopes and shall be leak proof.

Measurements: The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal.

The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

No deduction in measurement shall be made for opening up to 0.4 sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

Rate: The rate shall include the cost of all the materials and labour involved in all the operations described above including a coat of approved steel primer and two coats of approved steel paint on overlapping of C.G.S. sheets. This includes the cost of roof sheets, galvanized iron J or L hooks, bolts and nuts, galvanized iron seam bolts and nuts, bituminous and galvanized iron limpet washers etc.

➤ **RIDGES AND HIPS OF PLAIN GALVANISED STEEL SHEETS**

Ridges and Hips: Ridges and hips of C.G.S. roof shall be covered with ridge and hip sections of plain G.S. sheet with a minimum lap of 20 cm on either side over the C.G.S. sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 20 cm. The ridges and hips shall be of 60 cm overall width plain G.S. sheet, 0.6 mm or 0.8 mm thick as given in the description of the item and shall be properly bent in shape.

Fixing: Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins. Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips, on either side. If this is not possible extra hook bolts shall be provided.

The end laps of ridges and hips shall be joined together with C.G.S sheet by galvanised iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or white lead as directed by the Engineer-in-Charge. There shall be at least two such bolts in each end lap. Surface of C.G.I. sheets of ridge and hip sections and the roofing sheets which overlap each other shall be painted with a coat of approved primer and two coats of approved paint suitable for painting G.S. Sheets before they are fixed in place.

Finish: The edges of the ridges and hips shall be straight from end to end and their surfaces should be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

Measurement: The measurements shall be taken for the finished work in length along the centre line of ridge or hip, as the case may be, correct to a cm. The laps in ridges and hips and between ridges and hips shall not be measured.

Rate: The rate shall include the cost of all labour and materials specified above, including painting, cost of seam bolts and any extra G.I. hook bolts, nuts and washers, required.

Asbestos cement roofing: Providing and fixing 6 mm asbestos roofing with GI J or L hooks, bolts and nuts 8mm Dia GI plain & bitumen washer complete including cutting to proper size, lapping finishing & providing cut outs in sheeting etc.

Measurements: The length and breadth shall be measured correct to a cm. Area shall be worked out in some correct to two places of decimal. The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof. Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

Rate: The rate shall include the cost of all the materials and labour involved in all the operations described.

Polycarbonate Multiwall Sheets: Polycarbonate Multiwall Sheet Roofing: These shall be of the thickness specified in the description of the item and as approved by engineer in charge. The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The sheets shall not show signs of rust or white powdery deposits on the surface.

Material: Polycarbonate sheet shall confirm IS: 14443: 1997.

Laying and Fixing: The sheets shall be laid and fixed as per the manufacturer's specification, unless otherwise shown in the working drawings or as directed by the Engineer-in-Charge.

Finish: The roof when completed shall be true to lines and slopes and shall be leak proof.

Measurements: The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal. The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof. Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

Rate: The rate shall include the cost of all the materials and labour involved in all the operations described.

➤ **CEMENT CONCRETE GOLA:**

Gola: A chase of 75 mm wide and 75 mm deep shall be cut in the parapet wall just above the junction of mud phuska or lime concrete with parapet wall and it shall be filled with cement concrete 1:2:4 (1 cement: 2 coarse sand: 4 stone aggregate 10 mm and down gauge) the external face finish with a slope of 1: 0.75 and the exposed surface of the gola shall be plastered with cement mortar 1: 3 (1 cement: 3 fine sand). Expansion joint at every 3.5 to 4.5 metres shall be provided and filled with bitumen filler. The bitumen filler shall be prepared by mixing bitumen, cement and coarse sand in the ratio of 80: 1:

0.25 (80 kg of hot bitumen: 1 kg of cement and 0.25 cum of coarse sand). (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Curing: The finished surface shall be cured for at least 7 days.

Measurements: The length of the finished gola shall be measured at its junction with the wall face correct to a cm. No deduction shall be made in measurements for gaps for water outlets.

Rate: The rate shall include the cost of all materials and labour involved in all the operations described above including the cost of bitumen filler in expansion joint. The rate includes for all turnings and roundings at all the corners and risers.

KHURRAS: The khurras shall be constructed before the brick masonry work in parapet wall is taken up and it shall be of size 45 cm x 45 cm unless otherwise specified in the description of the item and shall be made of cement concrete 1:2:4 mix (1 cement: 2 coarse sand: 4 graded stone aggregate 20 mm nominal size) or other mix as stipulated in the description of the item.

Laying: A PVC sheet of size 1 m x 1 m x 400 micron (alternatively, aluminum foil of 32 SWG) shall be laid under the khurra and then cement concrete shall be laid over it to average thickness of 50 mm with its top surface lower than the level of adjoining roof surface by not less than 50 mm.

The concrete shall be laid to a size greater than the stipulated size of the khurra in such a way that the adjoining terracing shall overlap the concrete on its three edges by not less than 7.5 cm. The concrete will slope uniformly from the edges to the outlet, the slope being as much as possible and in no case less than 20 mm cement concrete at the outlet. The concrete shall be continued at the same slope through the width of the wall into the outlet opening to ensure a water tight joint.

The khurras and the sides of the outlet shall then be rendered with 12 mm coat of cement plaster 1:3 mix (1 cement: 3 coarse sand) or other mix as stipulated in the description of the item. This shall be done when the concrete is still green and shall be finished. The sides of the khurras and sides of the outlet opening shall be well rounded. The size of the finished outlet opening shall be 10 cm wide and by 20 cm high or as directed by the Engineer-in-Charge. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Measurements: Khurras shall be counted in numbers.

Rate: The rate is for each completed khurra of the specified size and is inclusive of the cost of all materials and labour in forming the khurras and outlet opening as described above, except for iron gratings which shall be paid for separately.

➤ **PLAIN/SEMI PERFORATED PARTICLE BOARD TILES CEILING:**

Frame: The frame work shall consist of anodized aluminium T sections for main runners /cross runners of size specified in the item with anodic coating of 15 micron and perimeter wall angle of anodized aluminium section of size specified by the Engineer-in-charge with anodic coating of 15 micron fixed to the wall with M.S. screws 50 mm long and PVC raw plugs. The frame work shall be executed in a manner so as to form a grid of 600 mm x 600 mm as specified in the item. The frame work shall be suspended from ceiling by level adjusting hangers made of 6 mm dia. M.S. rods fixed to slab by means of MS ceiling cleats. The ceiling cleats shall be fixed to the slab by means of mechanical dash fasteners 6 mm dia and 50 mm long. MS hangers and ceiling cleats shall be painted with a coat of yellow zinc chromate primer and two coats of synthetic enamel paint.

Ceiling Tiles: Ceiling tiles shall be of 12 mm plain/semi perforated or with design BWP type phenol formaldehyde synthetic resin bonded particle board conforming to IS 3087 of required size or Zypsum false ceiling.

Fixing of Ceiling Tiles: The ceiling tiles shall be placed over the aluminium frame and fixed to the frame with help of 25 mm long CP brass screws with minimum 2 screws on each side of the grid. The CP brass screws shall be counter sunk star head screws.

Measurements: Length & breadth of the finished ceiling shall be measured correct to a centimetre. The area shall be calculated in square metre correct to two decimal places. No deduction shall be made for making openings for electrical, air conditioning, fire fighting fixtures nor shall extra payment be made either for extra materials or labour involved in making such openings.

Rate: The rate shall include the cost of all the materials and labour involved in all the operation described above including scaffolding etc.

9) PLASTERING & POINTING

➤ CEMENT PLASTER:

The cement plaster shall be 12 mm, 15 mm or 20 mm thick as specified in the item.

Scaffolding: For all exposed brick work or tile work double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose.

Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not be allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purposes shall be filled and made good before plastering.

Note: In case of special type of brick work, scaffolding shall be got approved from Engineer-in-charge in advance.

Preparation of Surface: The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned off and care shall be taken that none of the retarders is left on the surface.

Mortar: The mortar of the specified mix using the type of sand described in the item shall be used. It shall be as specified in Subhead 3.0. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used. (50:50 ratio of River sand and crusher/Robo Sand is proposed).

Application of Plaster: Ceiling plaster shall be completed before commencement of wall plaster. Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 × 15 cm shall be first applied, horizontally and vertically, at not more than 2 metres intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally, the surface shall be finished off true with trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive troweling or over working, all corners, angles and junctions shall be truly vertical or horizontal as the case.

Curing: Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered. The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer-in-

Charge may approve. The dates on which the plastering is done shall be legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

Finish: The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work precedes with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Measurements: Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

➤ **CEMENT WATER PROOFING COMPOUND:**

It shall be used for cement mortar for plastering or concrete work.

Water Proofing Compound: Integral cement water proofing compound conforming to IS: 2645 and of approved brand and manufacture, enlisted by the Engineer-in-Charge from time to time shall be used.

The contractor shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the description of the item. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

Measurement: It shall be measured by weight.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

10) FLOORING

➤ **FLOORING WORK:**

General:

Scope: This section shall cover all flooring and tiling work as shown in the drawing. This section will cover all flooring work as shown in the drawing. No work under this section shall be started until specifically allowed by the engineer in charge and until all other major works .Such as plastering, embedding of conduit and pipes, channels window fixing etc, have been completed. Approved sample shall be retained up to the end of the project.

Base Concrete: Flooring shall be laid on base concrete where so provided. The base concrete shall be provided with the slope required for the flooring. Floors in verandah, courtyard kitchens, and baths shall have slope ranging from 1: 36 to 1: 48 depending upon locations as decided by the Engineer-in-Charge. Floors in water closet portion shall have slope of 1: 30 or as decided by the Engineer-in-Charge to drain off washing water. Plinth masonry off-set shall be depressed so as to allow the base concrete to rest on it.

If the base is of lean cement concrete, the flooring shall commence within 48 hours of the laying of base, failing which, the surface of base shall be roughened with steel wire brushes without disturbing the concrete. Before laying the flooring the base shall be wetted and smeared with a coat of cement slurry at 2 kg of cement spread over an area of one sqm so as to get a good bond between sub-grade and flooring.

Laying: Panels: Flooring of specified thickness shall be laid in the pattern including the border as given in the drawings or as directed by the Engineer-in-Charge. The border panels shall not exceed 450 mm in width and the joints in the border shall be in line with panel joints. The panels shall be of uniform

size and no dimension of a panel shall exceed 2 m and the area of a panel shall not be more than 2 sq m. The joints of borders at corners shall be mitered for provision of strips.

Laying: Flooring with Strips: Normally cement concrete flooring shall be laid in one operation using glass/aluminum/PVC/brass strips/stainless steel strips or any other strips as enquired as per drawing or instructions of the Engineer-in-Charge, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4 mm thick glass strips or 2 mm PVC strips or 2 mm aluminum or brass strips shall be fixed with their tops at proper level, giving required slopes. Use of glass and metallic strips shall be avoided in areas exposed to sun. Cost of providing and fixing strips shall be paid for separately.

Concreting: Cement concrete shall be placed in the panels and be leveled with the help of straight edge and trowel and beaten with thapy or mason's trowel. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given. Beating shall cease as soon as the surface is found covered with a thin layer of cream of mortar. The evenness of the surface shall be tested with straight edge. Surface of flooring be true to required slopes. While lying concrete, care shall be taken to see that the strips are not damaged /disturbed by the labourers. The tops of strips shall be visible clearly after finishing with cement slurry. Laying of Flooring without Strips: Laying of cement concrete flooring in alternate panels may be allowed by the Engineer-in-Charge in case strips are not to be provided.

Shuttering: The panels shall be bounded by angle iron or flats. The angle iron/flat shall have the same depth as the concrete flooring. These shall be fixed in position, with their top at proper level giving required slopes.

Finishing: The finishing of the surface shall follow immediately after the cessation of beating. The surface shall be left for some time till moisture disappears from it or surplus water can be mopped up. Use of dry cement or cement and sand mixture stiffening the concrete to absorb excessive moisture shall not be permitted. Excessive trowelling shall be avoided. (50:50 ratio of River sand and crusher/Robo Sand is proposed).

Fresh cement shall be mixed with water to form a thick slurry and spreaded @ 2 kg of cement over an area of one sqm of flooring while the flooring concrete is still green. The cement slurry shall then be properly processed and finished smooth.

Curing: The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened. Covering with empty gunnies bag shall be avoided as the colour of the flooring is likely to be bleached.

Rate: The rates shall include the cost of all material & labour involved in all the operations described above, unless otherwise specified in the description of the item.

➤ **TERRAZO TILE FLOORING:**

Terrazo Tiles: Terrazo tiles shall generally conform to IS: 1237-Edition. Unless otherwise specified, the tiles shall be supplied with initial grinding and grouting of wearing layer.

The size of tiles shall be as shown in the drawings or as required by the Engineer-in-Charge. Half tiles for use with the full tiles shall be such as to make two half tiles when joined together, match with the dimensions of one full tile.

Tolerance: Tolerances on length and breadth shall be plus or minus one millimetre, and tolerance on thickness shall be plus 5 mm. The variation of dimensions in any one delivery of tiles shall not exceed 1 mm on length and breadth and 3 mm on thickness.

The tiles shall be manufactured in a factory under pressure process subjected to hydraulic pressure of not less than 140 kg per square centimetre and shall be given the initial grinding with machine and grouting of the wearing layer before delivery to site. The wearing layer shall be free from projections,

depressions, cracks, holes, cavities and other blemishes. The edges of wearing layer may be rounded. The proportion of cement to aggregate in the backing of tiles shall be not leaner than 1:3 by weight. Where colouring material is used in the wearing layer, it shall not exceed 10 per cent by weight of cement used in the mix. The finished thickness of the upper layer shall not be less than 5 mm for size of marble chips ranging from the smallest up to 6 mm and also, not less than 5 mm for size of marble chips ranging from the smallest up to 12 mm, and not less than 6 mm for size of marble chips varying from the smallest up to 20 mm.

Laying: Base concrete or RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with cement mortar of specified proportion and in conformity with provisions in relevant para of chapter on 'Mortar'. Cement mortar 1:4 (1 Cement: 4 coarse sand) bedding shall be used. Average thickness of the bedding mortar shall be 20 mm and the thickness at any place shall not be less than 10 mm. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Cement mortar bedding shall be spread, tamped and corrected to proper levels and allowed to harden for a day before the tiles are set. If cement mortar is laid in bedding the terrazo tiles, these shall be set immediately after laying the mortar. Over this bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 4.4 kg of cement per square metre over such an area as would accommodate about twenty tiles. Tiles shall be washed clean and shall be fixed in this grout one after another, each tile being gently tapped with a wooden mallet till it is properly bedded, and in level with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1 mm and in straight lines or to suit the required pattern. The joints shall be properly cleaned before filling with cement grout of matching colour.

The surface of the flooring during laying shall be frequently checked with a straight edge of length at least 2 metre, so as to obtain a true surface with the required slope. Where full tiles or half tiles cannot be fixed, tiles shall be cut (sawn) from full tiles to the required size and their edges rubbed smooth to ensure a straight and true joint. Tiles which are fixed in the floor adjoining the wall shall enter not less than 12 mm under the plaster, skirting or dado. The junction between wall plaster and tile work shall be finished neatly and without waviness. After the tiles have been laid, surplus cement grout that may have come out of the joints shall be cleared off.

Curing, Polishing and Finishing: The day after the tiles are laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface. The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No. 60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No. 120).

The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer-in-Charge.

For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding	— coarse grade stone (No. 60)
Second grinding	— medium grade (No. 80)
Final grinding	— fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing. After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre sprinkled with water and rubbed hard with a 'namdah' block (pad of woollen rags). The Following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean. If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

Measurements: Terrazo tile flooring shall be measured as laid in square metre correct to two places of decimal. For length and breadth dimensions correct to a cm before laying skirting, dado or wall plaster shall be taken. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metres. Nothing extra shall be paid for use of cut tiles nor for laying the floor at different levels in the same room or courtyard. Terrazzo tile flooring laid in floor borders and similar band shall be measured under the item of terrazo tile flooring. Nothing extra shall be paid in respect of these and similar bands formed of half size or multiply of half size standard tiles or other uncut tiles. Treads of stairs and steps paved with tiles without nosing, shall also be measured under flooring. Moulded nosing shall be paid in running metre except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description. Extra shall, however, be paid for such areas where the width of treads does not exceed 30 cm.

Rate: The rate shall include the cost of all materials and labour involved in all the operations described above. Where cement mortar bedding is used in place of lime mortar the rate will be adjusted accordingly.

VACCU DEWATERED CONCRETING/TREMIX FLOORING

Preparation

The surface to receive flooring shall be clean, free from dirt and free from foreign material.
Any undulations or mortar remaining on the floor shall be trimmed.
Base course shall be trimmed.
The base shall be cleaned and watered before laying the floor.
Work includes at all depths and heights.
The finished surface shall be kept wet for a maximum period of one week.

CONCRETING

General

Concreting shall have a concrete base of M25 of specified thick as per BOQ.
Flooring shall have hard top on the concrete base.
Flooring shall be laid in strips, the size of which is mentioned on the drawings.

Materials

Cement	PPC	
Sand	<u>50:50 ratio of River sand and crusher/Robo Sand</u>	Aggregate Max. Size 10 to 20mm
Water	Potable	
Floor hardener	@5kG/Sqm	

Execution

Mix cement, sand and aggregates as per specified grade thoroughly with water to get an appropriate consistency.
Prepared concrete shall be laid immediately after mixing.

The base shall be free from water and other foreign materials, dust and dirt.

A coat of cement slurry of the consistency of thick cream shall be brushed on the surface of the base course.

The concrete shall then be spread over this base evenly and leveled carefully.

Low areas shall be filled with concrete and humps removed. Devaccumisation shall be done for removing the voids.

The whole concrete surface shall be leveled, compacted by ramming and trowelling.

Prepared surface shall be allowed to set.

Hardner screed

Hard top to be prepared as per the specifications with Nitohardner and one part of dry cement.

The hard top shall be provided over concrete base immediately after it is set, compacted and leveled with a steel trowel.

The surface shall be trowelled to bring the hardener coat to a leveled surface.

Excessive trowelling shall be avoided.

After the initial set, further compaction shall be done by steel trowelling.

Final brushing shall be made before the floor top becomes too hard.

CURING

Curing shall commence as soon as the surface is hard enough to receive the water.

The surface shall be covered with sacks or sand and shall be kept continuously wet for a period of at least one week.

Mode of measurement

Length and breadth shall be measured correct a cm before laying skirting, dado or wall plaster. The area as laid shall be calculated in sqm correct to two decimal places. The thickness of the under layer shall be measured correct to mm. The thickness of top layer shall not be less than that specified. In case of skirting the length shall be measured as finished and height shall be measured from the finish level of the floor correct to 5mm.

No deduction shall be made, nor extra paid for voids not exceeding 0.20 square metres. Deduction for ends of dissimilar materials or other articles embedded shall not be made for area not exceeding 0.10 square metres. Nothing extra shall be paid for laying the floor at different level in the same room or courtyard. Areas, where tiles of different types or decorative types are used shall be measured separately.

Cement concrete paver block & tactile flooring:

Base concrete: It shall be as per design & drawing.

Laying: The paver block & tactile tile of required size & shape made of cement concrete of M30 grade made by block making machine with strong vibratory compaction level in required pattern over and including 40 mm thick compacted bed of course sand filling joints with sand etc all complete as per direction of engineer in charge. Colour shall be guaranteed against wearing for minimum 10 years. On completion of flooring the vertical joints shall be fully filled with sand or mortar as specified in item. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Rate: The rates shall include the cost of all material & labour involved in all the operations described above, unless otherwise specified in the description of the item.

The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

➤ **CEMENT CONCRETE FLOORING WITH METALLIC HARDENER TOPPING:**

Base Concrete: It shall be as specified.

Under Layer: Cement concrete flooring of specified thickness and mix (mentioned in item for under layer) shall be laid as under layer. The top surface shall be roughened with brushes while the concrete is still green and the forms/strips shall be kept projecting up 12 mm over the concrete surface, to receive the metallic hardening compound topping.

Topping: This shall consist of 12 mm thick layer of mix 1:2 (1 cement: 2 stone aggregate 6 mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener: 4 cement) by weight. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pacca platform. This dry mixture shall be mixed with stone aggregate 6 mm nominal size or as otherwise specified in the ratio of 1 : 2 (1 cement : 2 stone aggregate) and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete. The mixture so obtained shall be laid in 12 mm thickness, on cement concrete floor within 2 to 4 Hours of its laying. The topping shall be laid true to provide a uniform and even surface. It shall be firmly pressed into the bottom concrete so as to have good bond with it. After the initial set has started, the surface shall be finished smooth and true to slope with steel floats.

Curing: The curing shall be done for a minimum period of ten days. Curing shall not be commenced until the top layer has hardened.

Measurement: Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

Rate: The rates shall include the cost of all material & labour involved in all the operations described above, unless otherwise specified in the description of the item.

➤ **KOTA STONE FLOORING:**

Kota Stone Slabs: The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the drawings or as instructed by the Engineer-in-Charge. The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work, the contractor shall get the samples of slabs approved by the Engineer-in-Charge.

Dressing: Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane. The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm as specified in the description of the item. Tolerance of ± 2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

Polishing and Finishing: Slight unevenness at the meeting edges of slabs are to be removed by chiseling care fully and then finished polished & cured in the same manner as described under terrazzo tile flooring except that (a) first polishing with coarse grade carborundum stone shall not be done, (b) cement slurry with or without pigment shall not be applied on the surface before polishing.

The finished surface shall be an even plane, level or sloped as specified clear without patches meeting the approval of the engineer in charge.

Rate: The rates shall include the cost of all material & labour involved in all the operations described above, unless otherwise specified in the description of the item.

➤ **KOTA STONE IN RISERS OF STEPS, SKIRTING AND DADO:**

Kota Stone Slabs and Dressing shall be as specified above and except that the thickness of the slabs shall be 25 mm or as specified in the description of the item. The slabs may be of uniform size if required.

Preparation of surfaces: In case of risers, skirting or dado, the surfaces shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly and washed with water and kept wet before skirting/riser/dado is commenced. In case of treads the surface shall be same as specified in flooring. Laying shall be as specified in except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs. Curing, Polishing and Finishing shall be as specified above except that first polishing with coarse grade carborundum stone shall not be done.

Measurements: Length shall be measured along the finished face of riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread of floor to the top (the underside of tread in the case of steps). This shall be measured correct to a mm in the case of risers of steps and skirting and correct to a cm in the case of dado. The area shall be calculated in square metre correct to two places of decimal. Lining of pillars etc. shall also be measured under this item.

Rate: The rate shall include the cost of all materials and labour involved in all the operations described above.

➤ **PRESSED CERAMIC TILES IN SKIRTING AND DADO:**

The tiles shall be of approved make and shall generally conform to IS: 15622. The tiles shall be pressed ceramic covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility. The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze on more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze, however, any glaze if unavoidable shall be permissible on only up to 50 per cent of the surface area of edges. The glaze shall be free from welts, chips, craze, specks, crawlings or other imperfections detracting from the appearance when viewed from a distance of one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be specified by the Engineer-in-Charge. There may be more than one colour on a tile.

Preparation of Surfaces: The joints shall be raked out to a depth of at least 15 mm in masonry walls. In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

Laying: 12 mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals. The tiles should be soaked in water, washed clean, and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and jointed. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/cut size of tile shall be adjusted at bottom to take care of slope of the flooring. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edges rubbed smooth. Skirting /dado shall not project from the finished "surface of wall" by more than the tile thickness; undulations if any shall be adjusted in wall.

Curing and Finishing: The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work

shall then be kept wet for 7 days. After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

Measurements: Length shall be measured correct to a cm. Height shall be measured correct to a cm in the case of dado and 5 mm in the case of riser and skirting. The area shall be calculated in square metre, correct to two places of decimal. Length and height shall be measured along the finished face of the skirting or dado including curves where specials such as coves, internal and external angles and beads are used. Where cornices are used the area of dado shall be measured excluding the cornices. Nothing extra will be paid for cutting (sawn) the tiles to sizes. Areas where coloured tiles or different types of decorative tiles are used will be measured separately to be paid extra over and above the normal rate for white tiles.

Rates: The rate shall include the cost of all material and labour involved in all the operations described above, for tiles of sizes up to 0.14 sqm. Unless otherwise specified in the description of the item. The specials such as coves, internal and external angles and beading shall be measured and paid for separately. The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

➤ **PRESSED CERAMIC TILE FLOORING (VITRIFIED TILE FLOORING):**

Vitrified tiles shall be of approved make and shall generally conform to IS: 15622. They shall be flat, and true to shape and free from blisters crazing, chips, welts, crawling or other imperfections detracting from their appearance. The tiles shall be tested as per IS: 13630. Classification and Characteristics of pressed ceramic tiles shall be as per IS: 13712.

Measurements: Length shall be measured correct to a cm. Height shall be measured correct to a cm in the case of dado and 5 mm in the case of riser and skirting. The area shall be calculated in square metre, correct to two places of decimal. Length and height shall be measured along the finished face of the skirting or dado including curves where specials such as coves, internal and external angles and beads are used.

Where cornices are used the area of dado shall be measured excluding the cornices. Nothing extra will be paid for cutting (sawn) the tiles to sizes. Areas where coloured tiles or different types of decorative tiles are used will be measured separately to be paid extra over and above the normal rate for white tiles.

Rates: The rate shall include the cost of all material and labour involved in all the operations described above, for tiles of sizes up to 0.14 sqm. Unless otherwise specified in the description of the item. The specials such as coves, internal and external angles and beading shall be measured and paid for separately. The rate shall not include cost of cornices which shall be measured and paid for in running meters separately.

➤ **GRANITE FLOORING:**

Granite: A. Granite Standard: Granite shall comply with ASTM C 615, "Standard Specification for Granite Dimension Stone" for material characteristics, physical requirements, and sampling for selection of granite.

General: All granite shall be of standard architectural grade, free of cracks, seams, or starts, which may impair its structural integrity or function. Color or other visual characteristics indigenous to the particular material and adequately demonstrated in the sampling or mock-up phases will be accepted provided they do not compromise the structural or durability capabilities of the material. Texture and finish shall be within the range of samples approved by the Design Professional.

Packing and Loading: Finished granite shall be carefully packed and loaded for shipment using all reasonable and customary precautions against damage in transit. No material which may cause staining or discoloration shall be used for blocking or packing.

Site Storage: Upon receipt at the building site or storage yard, the granite shall be tacked on timber or platforms at least 3" above the ground, and extreme care shall be taken to prevent staining during storage. If storage is to be for a prolonged period, polyethylene or other suitable plastic film shall be placed between any wood and finished surfaces, and shall be used also as an overall protective covering.

Stone Installation: Proceed with the installation of the stonework in accordance with Drawings and using skilled mechanics capable of proper handling of the setting of the stone and able to field cut where necessary with sharp and true edges. Set stone with joints uniform in appearance and stone edges and faces aligned to tolerances indicated. Clean surfaces that are dirty or stained. Scrub with fiber brushes, and then rinse with clear water.

Provide expansion, control, and pressure-relieving joints of widths and at locations shown on Drawings

Protection of Finished Work: After the granite work is installed, the granite shall be properly and adequately protected from damage. Boxing or other suitable protection shall be provided wherever required, but no lumber which may stain or deface the granite shall be used. All nails used shall be non-corrosive.

All granite work in progress shall be protected at all times during construction by use of a suitable strong, impervious film or fabric securely held in place.

Measurements: Length shall be measured along the finished face of flooring, riser, skirting or dado correct to a cm. Height shall be measured from the finished level of tread of floor to the top (the underside of tread in the case of steps). This shall be measured correct to a mm in the case of risers of steps and skirting and correct to a cm in the case of dado. The area shall be calculated in square metre correct to two places of decimal. Lining of pillars etc. shall also be measured under this item.

Rate: The rate shall include the cost of all materials and labour involved in all the operations described above.

11) DISTEMPERING PAINTING & FINISHING

➤ WHITE WASHING WITH LIME:

Scaffolding: Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed.

For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

Preparation of Surface: Before new work is white washed, the surface shall be thoroughly brushed free from mortar droppings a foreign matter. In case of old work, all loose particles and scales shall be scrapped off and holes in plaster as well as patches of less than 50 cm area shall be filled up with mortar of the same mix. Where so specifically ordered by the Engineer-in-Charge, the entire surface of old white wash shall be thoroughly removed by scrapping and this shall be paid for separately. Where efflorescence is observed the deposits may be brushed clean and washed. The surface shall then be allowed to dry for at least 48 hours before white washing is done.

Preparation of Lime Wash: The lime wash shall be prepared from fresh stone white lime (Narnaul or Dehradun quality). The lime shall be thoroughly slaked on the spot, mixed and stirred with sufficient water to make a thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 40 gm of gum dissolved in hot water, shall be added to each 10 cubic decimeter of the cream. The approximate quantity of water to be added in making the cream will be 5 litres of water to one kg of lime.

Application: The white wash shall be applied with brushes to the specified number of coats. The operation for each coat shall consist of a stroke of the brush given from the top downwards, another

FINISHING from the bottom upwards over the first stroke, and similarly one stroke horizontally from the right and another from the left before it dries. Each coat shall be allowed to dry before the next one is applied. Further each coat shall be inspected and approved by the Engineer-in-Charge before the subsequent coat is applied. No portion of the surface shall be left out initially to be patched up later on.

For new work, three or more coats shall be applied till the surface presents a smooth and uniform finish through which the plaster does not show. The finished dry surface shall not show any signs of cracking and peeling nor shall it come off readily on the hand when rubbed.

Measurements: Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals.

Rate: The rate shall include all material and labour involved in all the operations described above.

➤ **COLOUR WASHING:**

The mineral colours, not affected by lime, shall be added to white wash. Indigo (Neel) shall however, not be added. No colour wash shall be done until a sample of the colour wash of the required tint or shade has been got approved from the Engineer-in-Charge. The colour shall be of even tint or shade over the whole surface. If it is blotchy or otherwise badly applied, it shall be redone by the contractor.

For new work: The priming coat shall be of white wash with lime or with whiting as specified in the description of the item. Two or more coats shall then be applied on the entire surface till it represents a smooth and uniform finish.

For old work: After the surface has been prepared a coat of colour wash shall be applied over the patches and repairs. Then a single coat or two or more coats of colour wash, as stipulated in the description of the item shall be applied over the entire surface. The colour washed surface shall present a uniform finish. The finished dry surface shall not be powdery and shall not readily come off on the hand when rubbed.

➤ **DRY DISTEMPERING**

Materials: Dry distemper of required colour (IS: 427) and of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer-in-Charge before application of the distemper. The dry distemper colour as required shall be stirred slowly in clean water using 6 deciliters (0.6 litre) of water per kg of distemper or as specified by the makers. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable overnight) before use. The mixture shall be well stirred before and during use to maintain an even consistency. Distemper shall not be mixed in larger quantity than is actually required for one day's work.

Preparation of Surface: New plastered surfaces shall be allowed to dry completely, before applying, distemper. In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt, etc. Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used.

The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

Priming Coat: A priming coat of whiting shall be applied over the prepared surface in case of new work, if so stipulated in the description of the item. No white washing coat shall be used as a priming coat for distemper.

The treated surface shall be allowed to dry before distemper coat is given.

Application: In the case of new work, the treatment shall consist of a priming coat of whitening followed by the application of two or more coats of distemper till the surface shows an even colour. For old work, the surface prepared shall be applied one or more coats of distemper till the surface attains an even colour.

The application of each coat shall be as follows:

The entire surface shall be coated with the mixture uniformly, with proper distemper brushes (Ordinary white wash brushed shall not be allowed) in horizontal strokes followed immediately by vertical ones which together shall constitute one coat.

The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush marks. Enough distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

➤ **OIL EMULSION (OIL BOUND) WASHABLE DISTEMPERING:**

Materials: Oil emulsion (Oil Bound) washable distemper (IS 428) of approved brand and manufacture shall be used. The primer where used as on new work shall be cements primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared.

The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice for a fortnight's work, and the same shall be kept in the joint custody of the contractor and the Engineer-in-Charge. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the Engineer-in-Charge.

Preparation of the Surface: For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster of paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

Application:

Priming Coat: The priming coat shall be with distemper primer or cement primer, as required in the description of the item.

But if distempering is done after the wall surface is dried completely, Oil bound distemper is not recommended to be applied, within six months of the completion of wall plaster. However, newly plastered surfaces if required to be distempered before a period of six months shall be given a coat of alkali resistant priming Paint conforming to IS 109 and allowed to dry for at least 48 hours before distempering is commenced.

For old work no primer coat is necessary.

Distemper Coat: For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with

brushes in horizontal strokes followed immediately by vertical ones which together constitute one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade.

Rate: The rate shall include the cost of all labour and materials involved in all the above operations (Including priming coat) described above.

➤ **CEMENT PRIMER COAT:**

Cement primer coat is used as a base coat on wall finish of cement, lime or lime cement plaster or on non-asbestos cement surfaces before oil emulsion distemper Paints are applied on them. The cement primer is composed of a medium and pigment which are resistant to the alkalis present in the cement, lime or lime cement in wall finish and provides a barrier for the protection of subsequent coats of oil emulsion distemper Paints.

Primer coat shall be preferably applied by brushing and not by spraying. Hurried priming shall be avoided particularly on absorbent surfaces. New plaster patches in old work should also be treated with cement primer before applying oil emulsion Paints etc.

Preparation of the Surface: The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing.

The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of paris mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

Application: The cement primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil emulsion Paint is applied.

➤ **CEMENT PAINT:**

Material: The cement Paint shall be (conforming to IS: 5410) of approved brand and manufacture. The cement Paint shall be brought to the site of work by the contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the Engineer-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the Engineer-in-Charge.

Preparation of Surface: For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly.

Preparation of Mix: Cement Paint shall be mixed in such quantities as can be used up within an hour of its mixing as otherwise the mixture will set and thicken, affecting flow and finish. Cement Paint shall be mixed with water in two stages. The first stage shall comprise of 2 parts of cement Paint and one part of water stirred thoroughly and allowed to stand for 5 minutes. Care shall be taken to add the cement Paint gradually to the water and not vice versa. The second stage shall comprise of adding further one part of water to the mix and stirring thoroughly to obtain a liquid of workable and uniform consistency. In all cases the manufacturer's instructions shall be followed meticulously.

The lids of cement Paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement Paint rapidly becomes air set due to its hygroscopic qualities.

In case of cement Paint brought in gunny bags, once the bag is opened, the contents should be consumed in full on the day of its opening. If the same is not likely to be consumed in full, the balance quantity should be transferred and preserved in an airtight container to avoid its exposure to atmosphere.

Application: The solution shall be applied on the clean and wetted surface with brushes or spraying machine. The solution shall be kept well stirred during the period of application. It shall be applied on the surface which is on the shady side of the building so that the direct heat of the sun on the surface is avoided. The method of application of cement Paint shall be as per manufacturer's specification. The completed surface shall be watered after the day's work. The second coat shall be applied after the first coat has been set for at least 24 hours. Before application of the second or subsequent coats, the surface of the previous coat shall not be wetted. For new work, the surface shall be treated with three or more coats of water proof cement Paint as found necessary to get a uniform shade. For old work, the treatment shall be with one or more coats as found necessary to get a uniform shade.

Precaution: Water proof cement Paint shall not be applied on surfaces already treated with white wash, colour wash, distemper dry or oil bound, varnishes, Paints etc. It shall not be applied on gypsums, wood and metal surfaces. If water proofing cement is required to be applied on existing surface, previously treated with white wash, colour wash etc., the surface shall be thoroughly cleaned by scrapping off all the white wash, colour wash etc. completely. Thereafter, a coat of cement primer shall be applied followed by two or more coat of water proof cement.

➤ **EXTERIOR PAINTING ON WALL:**

Material: The paint shall be (Textured exterior paint/Acrylic smooth exterior paint/premium acrylic smooth exterior paint) of approved brand and manufacture. This paint shall be brought to the site of work by the contractor in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the contractor and the Engineer-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

Preparation of Surface: For new work, the surface shall be thoroughly cleaned off all mortar dropping, dirt dust, algae, and fungus or moth, grease and other foreign matter of brushing and washing, pitting in plaster shall make good, surface imperfections such as cracks, holes etc. should be repaired using white cement. The prepared surface shall have received the approval of the Engineer in charge after inspection before painting is commenced.

Application: Base coat of water proofing cement paint, before pouring into smaller containers for use, the paint shall be stirred thoroughly in its container, when applying also the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. Dilution ratio of paint with potable water can be altered taking into consideration the nature of surface climate and as per

recommended dilution given by manufacturer. In all cases, the manufacturer's instructions & directions of the Engineer-in-charge shall be followed meticulously.

The lids of paint drums shall be kept tightly closed when not in use as by exposure to atmosphere the paint may thicken and also be kept safe from dust. Paint shall be applied with a brush on the cleaned and smooth surface. Horizontal strokes shall be given, First and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks.

Painting: Paints, oils, varnishes etc. of approved brand and manufacture shall be used. Only ready mixed Paint (Exterior grade) as received from the manufacturer without any admixture shall be used. If for any reason, thinning is necessary in case of ready mixed Paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-Charge shall be used. Approved Paints, oil or varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the contractor and the Engineer-in-Charge. The empties shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

Commencing Work: Painting shall not be started until the Engineer-in-Charge has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm. Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work. The rooms should be thoroughly swept out and the entire building cleaned up, at least one day in advance of the Paint work being started.

Preparation of Surface: The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

Application: Before pouring into smaller containers for use, the Paint shall be stirred thoroughly in its containers, when applying also; the Paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over with Paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner. Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid. No left over Paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed. No hair marks from the brush or clogging of Paint puddles in the corners of panels, angles of moldings etc. shall be left on the work. In painting doors and windows, the putty round the glass panes must also be painted but care must

be taken to see that no Paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need not be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters. On painting steel work, special care shall be taken while painting over bolts, nuts, and rivets overlaps etc. The additional specifications for primer and other coats of Paints shall be as according to the detailed specifications under the respective headings.

Brushes and Containers: After work, the brushes shall be completely cleaned of Paint and linseed oil by rinsing with turpentine. A brush in which Paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use shall be kept closed and free from air so that Paint does not thicken and also shall be kept safe from dust. When the Paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

Measurements: The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimeter (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated. Painting up to 10 cm in width or in girth and not in conjunction with similar painted work shall be given in running meters and shall include cutting to line where so required.

➤ **PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES:**

Primer: The primer for wood work, iron work or plastered surface shall be as specified in the description of item.

Primer for plaster/wood work/Iron & Steel/Aluminum surfaces shall be as specified below:

S. No.	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS: 3536
2.	Resinous wood and plywood	Aluminum primer conforming to IS: 3585
3.	(A) Aluminum and light alloys chromate primer (B) Iron, Steel and Galvanized steel Red Oxide Zinc chromate	Conforming to IS: 104. Primer conforming IS: 2074
4.	Cement/Conc./RCC/brick work, Plastered surfaces, non-asbestos surfaces to receive Oil bound distemper or Paint finish	Cement primer conforming to IS: 109

The primer shall be ready mixed primer of approved brand and manufacture.

Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg: 0.7 kg: 1 liter.

Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg: 1 litre: 1 litre. The specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

(a) White Lead: The White lead shall be pure and free from adulterants like barium sulphate and whiting. It shall conform to IS 103.

(b) Red Lead: This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall conform to IS 102.

(c) Raw Linseed Oil: Raw linseed oil shall be lightly viscous but clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30-degree C shall be between 0.923 and 0.928.

Note: The oil shall be mellow and sweet to the taste with very little smell. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall conform in all respects to IS 75. The oil shall be of approved brand and manufacture.

(d) Double Boiled Linseed Oil: This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30-degree C. It shall dry with a glossy surface. It shall conform in all respects to IS 77. The oil shall be of approved brand and manufacture.

Turpentine: Mineral turpentine i.e. petroleum distillate which has the same rate of evaporation as vegetable turpentine shall be used. It shall have no grease or other residue when allowed to evaporate. It shall conform to IS 533.

All the above materials shall be of approved manufacture and brought to site in their original packing in sealed condition.

Preparation of Surface Wooden Surface: The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material conforming to IS 345 with same shade as Paint shall be used where specified. The surface treated for knotting shall be dry before Paint is applied. After obtaining approval of Engineer-in-Charge for wood work, the priming coat shall be applied before the wood work is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty.

Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack.

Iron & Steel Surface: All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed. All dust and dirt shall be thoroughly wiped away from the surface. If the surface is wet, it shall be dried before priming coat is undertaken.

Plastered Surface: The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

Application: The primer shall be applied with brushes, worked well into the surface and spread even and smooth.

➤ **WALL PAINTING WITH PLASTIC EMULSION PAINT:**

The plastic emulsion Paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These Paints are to be used on internal surfaces except wooden and steel.

1 Plastic Emulsion Paint as per IS 5411 of approved brand and manufacture and of the required shade shall be used.

Painting on New Surface:

Application: The number of coats shall be as stipulated in the item. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces. The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions. The surface on finishing shall present a flat velvety smooth finish. If necessary, more coats will be applied till the surface presents a uniform appearance.

Precautions:

- (a) Old brushes if they are to be used with emulsion Paints, should be completely dried of turpentine or oil Paints by washing in warm soap water. Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the Paint from hardening on the brush.
- (b) In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.
- (c) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.
- (d) Washing of surfaces treated with emulsion Paints shall not be done within 3 to 4 weeks of application.

Painting on Old Surface: Preparation of Surface: This shall be done, except that the surface before application of Paint shall be flattened well to get the proper flat velvety finish after painting.

➤ **PAINTING WITH SYNTHETIC ENAMEL PAINT:**

Synthetic Enamel Paint (conforming to IS: 2933) of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of ordinary Paint of shade to match the top coat as recommended by the same manufacturer as far the top coat shall be as Painting on New Surface.

Application: The number of coats including the undercoat shall be as stipulated in the item.

(a) Under Coat: One coat of the specified ordinary Paint of shade suited to the shade of the top coat shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of Wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

(b) Top Coat: Top coats of synthetic enamel Paint of desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

Painting on Old Surface:

Preparation of Surface: Where the existing Paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old paint is blistered and flaked it will be necessary to completely remove it. Such removal shall be paid for separately and the painting shall be treated as on new surface.

Finishing: Painting: The number of coats as stipulated in the item shall be applied with synthetic enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If, however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

➤ **PAINTING WITH ALUMINIUM PAINT:**

Aluminum Paint shall be (conforming to IS: 2339) of approved brand and manufacture. The Paint comes in compact dual container with the paste and the medium separately.

The two shall be mixed together to proper consistency before use.

Preparation of Surface Steel Work (New Surfaces) : All rust and scales shall be removed by scraping or brushing with steel wire brushes and then smoothened with sand paper. The surface shall be thoroughly cleaned of dust.

Steel Work or C.G.S. sheets (Old Surfaces):

Application: The number of coats to be applied shall be as given in the item. Each coat shall be allowed to dry for 24 hours and lightly rubbed down with fine grade sand paper and dusted off before the next coat is applied. The finished surface shall present an even and uniform appearance. As aluminum paste is likely to settle in the container, care shall be taken to frequently stir the Paint during used. Also the Paint shall be applied and laid off quickly, as surface is otherwise not easily.

➤ **FRENCH SPIRIT POLISHING:**

Pure shellac conforming to IS 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade. Readymade polish conforming to IS 348 can also be used.

Polishing New Surface:

Preparation of Surface: The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

Application: The number of coats of polish to be applied shall be as described in the item. A pad of woolen cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to give an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

Measurements: The length and breadth shall be measured correct to a cm. The area shall be calculated in sq.m. (correct to two places of decimal), except otherwise stated

Rate: Rates shall include cost of all labour and materials involved in all the operations described above.

Polishing Old Surface:

Preparation of Surface: If the old polished surface is not much soiled it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled, then it will be necessary to remove the entire polish and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to be done like new work and will be paid for as such.

➤ **BEES WAXING OR POLISHING WITH READY MADE WAX POLISH:**

The polishing shall be done with bees waxing prepared locally or with readymade wax polish of approved brand and manufacture, as stipulated in the description of item. Where a bee waxing is to be prepared locally, the following specifications for the same shall apply. Pure bees wax free from paraffin or stearine adulterants shall be used. Its specific gravity shall be 0.965 to 0.969 and melting point shall be 63-degree C. The polish shall be prepared from a mixture of bee's wax, linseed oil, turpentine and varnish in the ratio of 2: 1.5: 1: 0.5 by weight. The bees wax and boiled linseed oil shall be heated over a slow fire. When the wax is completely dissolved the mixture shall be cooled till it is just warm and turpentine and varnish added to it in the required proportions and the entire mixture shall be well stirred. **Waxing New Surface:** Preparation of Surface: Preparation of surface shall be as described in with the exception that knotting, holes and cracks shall be stopped with a mixture of fine saw dust formed of the Wood being treated, beaten up with sufficient bees wax to give it cohesion.

Application: The polish shall be applied evenly with a clean soft pad of cotton cloth in such a way that the surface is completely and fully covered. The surface is then rubbed continuously for half an hour. When the surface is quite dry, a second coat shall be applied in the same manner and rubbed continuously for one hour or until the surface is dry. The final coat shall then be applied and rubbed for two hours (more if necessary) until the surface has assumed a uniform gloss and is dry, showing no sign of stickiness. The final polish depends, largely on the amount of rubbing which should be continuous and with uniform pressure with frequent changes in the direction.

Waxing Old Surfaces: Preparation of Surface: The wood work shall be cleaned of all smoke and grease by washing with lime water. The surface shall then be washed with soap and completely dried.

Application: The polish shall be applied in the manner specified. In this case one or two coats shall be applied as necessary to get uniform gloss, instead of three coats in the case of new work.

12) MISCELLANEOUS ITEM

➤ **FIRE FIGHTING DOORS:**

General: The doors shall be of approved proprietary make such as "NAVAIR" shall be so designed so as to provide 1-hour fire resistance when tested as per IS: 3614 and BS: 2750 and the manufacturer must produce a certificate of C.B.R.I. Roorkee to that effect.

Frame/Panels: The main frame, panels, head and runners etc. shall be of heavy timber of at least 100mm X 75 mm for frame and 45 mm for door panel and fire retardant plywood confirming to IS: 5509 shall be used. The doors shall be single or double leaf, as specified. When closed, there shall be no gap between the leaves or at hinges between the frame and door panel etc. So that no smoke can pass through. The doors shall be installed strictly as per manufacturer's printed instructions.

Fittings/Door closer: All fittings used in the manufacturing of the door shall be heavy duty type. The door shall be fitted with heavy duty concealed type automatic door closers, of approved make.

Seal: A heat activated intumescent seal confirming to BS: 476 (Part-8) shall be provided on all edges of door to check the spread of smoke in case of fire.

Paint: The door frame and panel shall be treated with ready mixed Fire Resistant paint as per IS: 162:1950 (BS: 162:1950 (BS: 476-part I)).

Hold Fast: Mild steel hold fasts for use with wooden doors shall be made from mild steel flats not less than 5mm thick and shall be in accordance to IS: 7196-1974. Hold fasts shall be fixed in cement concrete blocks as per drawing as directed by Engineer in Charge.

➤ **BISON PANEL**

Bison Panel is cement bonded particle board which represent a significant advance in building board technology. It meets all specifications and environmental regulations for standards of durability, safety and economy.

Introduction: Bison Panel is basically Cement bonded wood particle board. The properties of the board are determined by basic materials Wood and Cement. Cement is weather – termite and fire proof, rot and fungus resistant. Wood is comparatively light in weight, elastic and can easily be machined. Board strength is obtained by reinforcing the concrete by wood fibers or flakes. By covering wood particles with cement, they are protected. Thus, resulting in a perfect reciprocal effect of the two basic materials cement and wood viz. Strength and durability of cement and workability of wood.

Measurements: Width and height of plain trellis work and trellis shutters shall be measured overall correct to a cm. The area shall be calculated in square metres nearest to two places of decimal.

Rate: It includes the cost of materials and labour required in all the operations described above.

13) EXTERNAL DEVELOPMENT

➤ **FACTORY MADE CEMENT CONCRETE INTERLOCKING PAVER BLOCK**

Base: Interlocking paver block to be fixed on the bed 50 mm or specified otherwise thick of coarse sand of approved specification and filling the joints with the sand of approved type and quality or as specified and as directed by Engineer-in-charge. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Interlocking Paver Block: Factory made precast paver block of M-30 or otherwise specified grade to be used. Paver blocks to be of approved brand and manufacturer and of approved quality. Minimum strength as prescribed by manufacturer and as per direction of Engineer-in-Charge for the grade specified to be tested as per method mentioned in specification of subhead cement concrete of CPWD Specification 2009 Vol. I.

Measurement & Rates: Area provided with paver block to be measured in sqm. Correct up to two places of decimal. The rate includes the cost of the material, labour, tools etc. required in all the operations described above.

➤ **KERB STONE (PRECAST)**

Laying: Trenches shall first be made along the edge of the wearing course of the road to receive the kerb stones of cement concrete of specified grade. The bed of the trenches shall be compacted manually with steel rammers to a firm and even surface and then the stones shall be set in cement mortar of specified proportion.

The kerb stones with top 20 cm. wide shall be laid with their length running parallel to the road edge, true in line and gradient at a distance of 30 cm. from the road edge to allow for the channel and shall project about 12.5 cm. above the latter. The channel stones with top 30 cm. wide shall be laid in position in chamber with finished road surface and with sufficient slope towards the road gully chamber. The joints of kerb and channel stones shall be staggered and shall be not more than 10 mm.

Wherever specified all joints shall be filled with mortar 1:3 (1 cement: 3 coarse sand) and pointed with mortar 1:2 (1 cement: 2 fine sand) which shall be cured for 7 days. The necessary drainage openings of specified sizes shall be made through the kerb as per drawings or as directed by the Engineer-in-Charge for connecting to storm water drains. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Finishing: Berms and road edges shall be restored and all surplus earth including rubbish etc. disposed off as directed by the Engineer-in-charge. Nothing extra shall be paid for this.

Measurements: It shall be measured in cubic meters with Length of the finished work (for specified width and height of stone) shall be measured in running meter along the edge of the road correct to a cm.

Rate: The rate shall include the cost of all the materials and labour involved in all the operations.

➤ **SUB-GRADE: PREPARATION AND CONSOLIDATION**

In sub-grade composed of clay, fine sand or other soils that may be forced up into the coarse aggregate during rolling operation, an insulation layer of suitable thickness of granular materials or over size brick aggregate not less than 10 cm thick shall be provided for blanketing the sub-grade, which shall be paid for separately, unless otherwise specified. In slushy soils or in areas that are water logged, special arrangements shall be made to improve the sub-grade and the total pavement thickness shall be designed after testing the properties of the sub grade soil. Necessary provision for the special treatment required shall be made in the project and paid for separately. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

Preparation of Sub-Grade: The surface of the formation for a width of sub-base, which shall be 15 cm more on either side of base course, shall first be cut to a depth equal to the combined depth of sub-base and surface courses below the proposed finished level (due allowance being made for consolidation). It shall then be cleaned of all foreign substances. Any ruts or soft yielding patches that appear due to improper drainage conditions, traffic hauling or from any other cause, shall be corrected and the sub-grade dressed off parallel to the finished profile.

Consolidation: The sub-grade shall be consolidated with a power road roller of 8 to 12 tonnes. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as elastic mass (the roller shall pass a minimum of 5 runs on the sub grade). All undulations in the surface that develop due to rolling shall be made good with material or quarry spoils as the cases may be and the sub-grade is rerolled.

Surface Regularity: The finished surface shall be uniform and conform to the lines, grades and typical cross section shown in the drawings, when tested with the template and straight edge, the variation shall be within the tolerances specified.

➤ **SUPPLYING AND STACKING OF MATERIALS:**

Aggregates/Red Bajri: The item of work shall specify stone aggregate/brick aggregate/red bajri, as the case may be.

Stacking: Ground where stacks are proposed to be made shall be cleared, leveled or dressed to a uniform slope and all lumps, depressions etc. shall be removed. The stacked metal shall be free from vegetation and other foreign matter. Coarse aggregates stack shall be made at places as directed by the Engineer-in-Charge. All rejected stone metal shall be removed from the site.

The aggregate shall be stacked in convenient units of one metre top width, 2.2 m bottom width, 60 cm height and of length in multiples of 3 m for new roads. Where berm width is limited or for repair works, it shall be stacked in units of 40 cm top width 1.4 m bottom width, 50 cm height and length in multiples of 3 m. Template of steel shall be used for making the stacks and shall always be kept at site for check measurements. The Engineer-in-Charge may permit stacking in different sizes and height ranging between 45 to 75 cm for new roads and 40 to 60 cm for repair work, in case the site conditions so demand. In a particular reach of road as decided by the Engineer-in-Charge, the quantity of stacked material shall be comparable to the theoretical quantity required for W.B.M. to be laid in that reach.

The stacks shall be uniformly distributed along the road and shall be numbered serially. The number plate shall be planted on each stack, which shall remain in position until the stack is used in the work. A register showing daily consumption of stacks shall be maintained at site of work. The collection of stone metal shall be for completed length of one km (for each layer of W.B. macadam) or as directed by the Engineer-in-Charge in writing.

Measurements: Length, breadth and height shall be measured correct to a cm. The total quantity so arrived shall be reduced by 7.5% to arrive at the net quantity for payment, in cases of aggregates. No such reduction shall be made in case of fine aggregate i.e. Red Bajri & screening etc.

Binder:

Stacking: Specified binder shall be brought to the site of work in the sealed original containers.

Binder brought in damaged containers shall not be allowed. The material shall be stacked in fenced enclosures, as directed by the Engineer-in-Charge, on one side of the roadway. The material shall be purchased from reputed firms or their authorised dealer. All the drums brought to site shall be serially numbered and used in the same order. The materials shall be brought in at a time in adequate quantities to suffice for the whole work or for at least a fortnight's work.

For major bituminous road works, supply of bitumen in bulk may be taken for economic reasons, or if the contingencies of the work so require. Sufficient storage arrangement shall be made at site for at least ten days' requirement. Materials shall be kept in the joint custody of the contractor and the representative of the Engineer in- Charge. The empty containers shall not be removed from the site of work, till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge. A few drums may be removed before completion of work for heating bitumen and mixing aggregates etc. with the permission to the Engineer-in-Charge. Empty drums required to be returned to stores shall be in good condition. Recovery rate for non-return of the empty drums or for the damaged drums shall be as decided by the Engineer-in-Charge.

Measurements: The materials shall be recorded as per standard weights of different type of container as intimated by manufacturers. The material shall be weighed where containers are found leaking.

Rate: The rate shall include the cost of all labour and materials involved in all the operations described above.

➤ **CEMENT CONCRETE PAVEMENT UNDER CONTROLLED CONDITIONS:**

Materials:

Cement: Cement used on work shall be as per sub head cement concrete of CPWD specifications-2009 (Vol. -I).

Water: Water used on work shall conform to SH: cement concrete of CPWD, Specification 2009- Vol. I.

Coarse Aggregate: These shall be crushed or broken from hard stones obtained from Approved quarry. These shall be clean strong, durable of fairly cubical shape and free from soft, friable, thin elongated

and laminated disintegrated pieces. These shall also be free from dirt, organic deleterious and any other foreign matter and adherent coatings and shall satisfy the physical requirements. Under quality control. Fine Aggregate: This shall be coarse sand conforming to CPWD Specification 2009 Vol. I.

Mix Design: The mix shall be approved by Engineer-in-Charge so as to obtain the following mean strength that exceeds the minimum specified flexural strength by 1.64 times the designed standard deviation. Minimum works beam flexural strength at 28 days = 300 kg/sqm. for M-30 or specified in item Designed standard deviation = 60 kg/sqm. for M-30 or for specified grade(s) Design flexural strength at 28 days = $300 + 60 \times 1.64 = 398.4$ kg/sqm. (f + 1.64 s) says 400 kg.

Water cement ratio by weight = 0.5

Minimum slump not more than 25 mm

For the purpose of tendering the contractor shall base his rate on the assumption that the quantity of cement used for one cum. of finished concrete shall be 340 kg. or M - 30. If the actual quantity of cement required to be used as a result of the laboratory test is different from that assumed above, necessary adjustment in the cost due to short cement used shall be made on the basis of issue rate of cement including storage charges plus 2.5% for handling charges. However, under no circumstances the quantity of cement to be used shall either exceed 350 kg. /cum or fall below 330 kg. per cum of finished concrete.

Statistical Field Check: Samples of concrete shall be taken at the mixer and works beams, made, cured and tested in accordance with IS 1199 and IS 516. When a mix is used for the first time, it is important to get a large number of results, as soon as possible, in order to establish the level of control and then suitability of the mix proportions. A sample of concrete shall be taken at random on eight separate occasions during each of the first five days of using that mix. From each sample two beams shall be made one for test at 7 days and the other for test at 28 days.

The work beam results shall be examined both individually and in consecutive (but not overlapping) sets of four, for which the average and the range of each set are calculated. The mix Proportions shall be modified to increase the strength, if in the first ten consecutive (but not overlapping) sets any of the following conditions are not satisfied.

(I) Each sample has test strength not less than the minimum specified strength i.e. 30 kg/sq. cm. (or otherwise specified in item).

OR (II)

(a) Not more than two individual results (Not more than one of first twenty) of the 40 beams tests shall fall below the minimum work beam strength but they shall not be less than 80% of the specified beam strength of 30 kg. /sq. cm (or otherwise specified in item) or the minimum specified strength minus 1.35 times the standard deviation whichever is greater.

(b) No value of the range in any set shall exceed 3 times the designed standard deviation.

(c) The average for all samples (10 sets) shall not be less than the minimum specified strength i.e. 30 kg/sq. cm (or otherwise specified in item) plus 1.64 times the designed standard deviation 60 kg. /sq.cm M-30.

If either of these conditions are not satisfied, the mix shall be modified and the procedure described above shall be repeated till results satisfying the above criteria are obtained. Subsequently samples shall be taken at the rate of one for every 30 cubic meter of concrete laid. Eight beam specimens shall constitute one sample. A set of 4 specimens shall be tested after 7 days and another set of 4 specimens shall be tested after 28 days. These test results shall be checked individually and in sets of four as the work progresses. If at any stage it is found that either of conditions, if the overall average strength minus 1.64 times the standard deviation is more than the specified beam strength (30 kg/sq.cm) (or

otherwise specified in item) the concrete shall be accepted. But if it is less than the concrete work corresponding to these 40 beams tests shall be rejected and the mix proportion shall be modified forth with for further work. The rejected work shall be replaced by the contractor immediately at his own cost and expense.

Slump Test: The test shall be carried out as per IS 1199. A slump test shall be carried out at each mixer at least one in fifty batches mixed or more frequently if directed by the Engineer-in-Charge. Any batch from which slump test is being made shall not be transferred to the place of lying till the slump test has been completed. Not only the batch which gives a slumps in excess of that specified shall be rejected but the concrete already laid immediately preceding the batch tested up to the nearest last transverse joint may be rejected by the Engineer-in-Charge or his subordinate, if he is satisfied that such preceding batches were substandard in this respect. The decision of the Engineer-in-Charge in this respect shall be final and binding on the contractor. Such rejected concrete shall be removed by the contractor immediately and replaced with proper slump concrete at his cost and expense.

Steel Forms: All side forms shall be of mild steel. The steel forms shall be of M.S. Channel sections and their depth shall be equal to the thickness of the pavement. The side forms shall have a length of at least 3.0 metres except on curves of less than 4.5 metres radius where shorter lengths may be used. When set to grade and stacked in place the maximum deviation of the top surface of any section from a straight line shall not exceed 3 mm. The method of connection between sections shall be such that the joint formed shall be free from play or movement in any direction. The use of bent, twisted or worn out forms shall not be permitted. At least three stake pockets for bracing pins or stakes shall be provided for each 3.0 M length of forms. Bracing and supports must be ample to prevent the springing of forms under pressure of concrete or weight or thrust of the machinery (like screed vibrator) operating on the forms. Support to the forms shall be sufficiently rigid to hold them in position during the entire operation of laying and compacting and finishing and that they shall not at any time deviate more than 3 mm from straight edge 3 metres in length. Forms which show a variation from the required rigidity of the alignment and levels shown on the plans shall be reset or removed as directed. The length and number of pins or stakes shall be such as to maintain the forms at the correct line and grade.

The supply of forms shall be sufficient to permit their remaining in place for at least 12 hrs. after the concrete has been placed or longer, if in the opinion of the Engineer-in-Charge, it is necessary. The top line of the forms is not to vary from the correct level or alignment and the levels and alignment of the forms are to be checked and corrected as necessary immediately prior to the placing of concrete. The top edges and faces of the forms are to be carefully cleaned and maintained in clean condition. While removing the steel forms, care shall be taken to withdraw them gradually, any damage to the bull nosed edges shall be made good while the concrete is still green.

Setting of Forms

(a) Setting of forms shall be according to the slab plan subject to the approval of Engineer-in-Charge and concreting shall not commence until the setting of forms is approved.

(b) Forms shall be set for at least 50 metres in advance of the point where the concrete is being laid and shall not be removed until at least 12 hrs. of placing of the concrete or longer if in the opinion of Engineer-in-Charge is necessary.

(c) After setting, the working faces shall be thoroughly oiled by using approved oil before concrete is placed against them.

(d) The pavement joints of overlay layer would overlap with the joints of underlay cement concrete.

Batching and Mixing: As detailed in SH: 5 of reinforced cement concrete work of CPWD specifications 2009.

Placing of Concrete: As detailed in SH: 5 of reinforced cement concrete work of CPWD specifications 2009.

Compaction of Concrete: Compaction shall be carried out by electrically (or) diesel operated needle and screed vibrators as stipulated hereafter. Needle vibrator should be used all over the area for obtaining initial compaction of concrete. These should be of diameter not less than 4.5 cm. If the vibrator is pneumatic the pressure must not be below 4 kg/sq.cm. If electrically operated, they should have a minimum frequency of 3500 impulses per minute.

There should be at least three needle vibrators working in any bay. A vibrating, screed consisting of a steel or timber section weighing not less than 15 kg. per metre with a tamping edge of not less than 7 cm width and having a vibrator mounted thereon shall follow needle vibrators to obtain full compaction. The face of the wooden tamping edge of the screed shall be lined with M.S. Plate rigidly fixed by means of counter sunk screw. Where screed vibrators are used for compaction, a standby unit shall always be maintained ready for use, should the other one go out of order? Where electrically driven vibrators are employed, a standby diesel pneumatic unit shall be kept ready for use in case of power failure. At the discretion of the Engineer-in-Charge, for compaction at edges and joints, vibrators may be supplemented by hand tamping and rodding for securing satisfactory results. Under no circumstances, honey combing of concrete at joints or elsewhere shall be permitted. When using screed vibrator for compaction it should not be dragged over the concrete. During the initial passes it shall be lifted to the adjacent forward position in short steps, subsequently, it shall be slowly slid over the surface with its axis slightly tilted away from the direction of sliding and the operation repeated until a close, dense surface is obtained. Concreting shall be carried out in one operation between the expansion joints and construction joints without any break at the dummy joints.

Concrete shall be deposited on the base as near the joints as possible without touching them. It shall then be shoveled against the sides, maintaining equal pressure and deposited approx. 50 mm higher than the depth of the joints, care being taken that it is worked well around the joints. The concrete shall not be dumped from the bucket directly upon or against the joints. Workmen shall not be allowed to walk on freshly laid concrete and proper cat walk shall be provided with independent supports beyond concreting bays.

Finishing of Concrete: During compaction, any low or high spots shall be made up by adding or removing concrete. After longitudinal floating has been completed but while concrete is still plastic, the slab surface shall be tested for trueness with a 3 m straight edge. Any depressions or high spots showing departure from the true surface shall be immediately rectified. High spots shall be cut down and refinished. Depressions shall be enlarged to about 8-10 cm and filled up with fresh concrete, compacted and finished. The straight edge testing the refloating is to continue until the entire surface:

- (a) is free from observable departure from the straight edge,
- (b) Conforms to the required levels and across section, and
- (c) Shall conform to the specified surface when the concrete has hardened.

The foregoing work is to be carried out while the concrete is still plastic and workable.

Belting: Just before concrete becomes non-plastic, the surface shall be belted with a two ply canvas belt not less than 20 cm wide and at least 1 metre longer than the width of the slab. Hand belts shall have suitable handles to permit controlled uniform manipulation. The belt shall be operated with short strokes transversed to the centre line of the pavement and with rapid advance parallel to the centre line.

Booming: After belting and as soon as the surplus water, if any, has risen to the surface, the pavement shall be given a broom finish with an approved steel or fiber broom not less than 45 cm wide. The

broom shall be pulled gently over the surface of the pavement from edge to edge. Adjacent strokes shall be slightly overlapped. Brooming shall be perpendicular to the centre line of the pavement and so executed that the corrugations formed shall be uniform in character and width and not more than 1.5 mm deep. Brooming shall be completed before the concrete reaches such a stage that the surface is likely to be torn or unduly roughened by the operation. The broomed surface shall be free from porous or rough spots; irregularities, depressions, and small pockets such as may be caused by accidental disturbing of particles of coarse aggregates embodied near the surface. The brooming shall be of uniform pattern all through.

Edging: After belting/brooming has been completed but before the initial setting of concrete, the edges of the slab shall be carefully finished with an edger of 6 mm radius, and the pavement edges shall be left smooth and true to line.

Honey Combing: The side forms shall not be removed until 12 hours or such longer period as the Engineer-in-Charge may decide after the laying of concrete. As soon as the side forms are removed, any minor honey combed area shall be filled with mortar composed of one part of cement and two parts of fine aggregate. Major honey combing areas or segregated concrete or other defective work or areas damaged by removal of the forms or concrete damaged by rain or due to any other reason whatsoever shall be considered as defective work and shall be removed and replaced by the contractor at his own expense. The total area of honey combed surface shall not exceed 4 per cent of the area of the slab side. However, no individual honeycomb patch shall exceed 0.1 sqm. Engineer-in-Charge's decision as to whether the concrete is defective or not shall be final and binding.

Surface Accuracy: After the concrete has sufficiently hardened after about 12 hours and not later than 24 hours, the surface shall be tested again for high spots. All high spots shall be marked and those exceeding 3 mm shall be ground down immediately. Care shall be taken to see that the grinding does not in any way damage the concrete surface. The final surface finish is to be such that when tested with a profilograph/roughness indicator/or a 3-metre-long straight edge or an equivalent mechanical unevenness indicator placed anywhere within the same or adjoining slab in any direction on the surface, there shall be no variation greater than 3 mm. If the surface irregularity exceeding 3 mm still remains despite grinding as per para the concrete shall be removed to its full depth. The area of concrete to be removed shall be complete slab between the nearest joints, where the defective slab is less than 4.5 metres from the expansion joint, the whole area up to the expansion joint shall be removed to the full depth. The concrete so removed shall not be reused in the work. Fresh concrete shall be laid in the manner already described in above paras and shall again be subject to test for surface accuracy and other quality control measures. Nothing extra shall be paid on this account. Every slab shall bear an impression not exceeding 3 mm in depth comprising the number allotted to the slab and the date on which it is laid. This impression shall be formed by the contractor when the concrete is green so as to leave permanent mark on setting.

Initial Curing: Immediately after completion of the finishing operations, the surface of the pavement shall be entirely covered with wetted burlap, cotton or jute mats. The mats used shall be of such length (or width) that as laid they shall extend at least 45 cm beyond the edges of the slab. The mats shall be placed so that the entire surface and both edges of the slab are completely covered. This covering shall be placed as soon as, in the judgment of the Engineer-in-Charge the concrete has set sufficiently to prevent damage to the surface prior to being placed, the mats shall be thoroughly saturated with water and shall be placed with the wettest side down. The mats shall be so placed and weighed down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained full wetted and in position for 24 hours after the concrete has been placed or until the concrete is sufficiently hard to be walked on without suffering damage. Water shall be gently sprayed so as to avoid damage to the fresh concrete. If it becomes necessary to remove a mat for any reason,

the concrete slab shall not be exposed for a period of more than half an hour. Worn burlap or burlap with holes shall not be permitted. Burlap reclaimed from previous use other than curing concrete shall be thoroughly washed prior to use for curing purposes. If burlap is obtained in strips, shall be laid to overlap by at least 150 mm. Burlap shall be placed from suitable bridges. Walking on freshly laid concrete to facilitate. Placing burlap shall not be permitted.

Final Curing: Upon the removal of the burlaps, the slab shall be thoroughly wetted and then cured as follows: - All joints shall be filled with filler in order to prevent the edges of joints from getting damaged and entry of clay materials into the joints during final curing. Exposed edges of the slab shall be banked with a substantial berm of earth. Upon the slab shall then be laid a system of transverse and longitudinal dykes of clay about 50 mm high immediately covered with a blanket of sandy soil free from stones to prevent the drying up and cracking of clay. The rest of slab shall then be covered with sufficient sandy soil so as to produce a blanket of earth not less than 40 mm deep after wetting. The earth covering shall be thoroughly wetted while it is being placed on the surface and against the sides of the slab and kept thoroughly saturated with water for 21 days and thoroughly wetted down during the morning of the 22nd day and shall thereafter remain in place until the concrete has attained the required strength and permission is given by the Engineer-in-Charge. Thereafter the covering shall be removed and the pavement cleaned and swept. If the earth covering becomes displaced during the curing period, it shall be replaced to the original depth and resaturated.

Construction Joints: Construction joints shall be provided as shown in the drawing and also at places where concreting is stopped due to unforeseen circumstances. The joints shall be straight and vertical through the full thickness of the slab. While concrete in adjacent bay is still green, flats of suitable size shall be drawn along the edge and a groove of size 10 mm × 25 mm deep shall be neatly formed and finished.

The edges of the groove shall be full nosed. After curing of concrete is complete, this groove shall be thoroughly cleaned of all sand dust and shall be perfectly dried and filled with hot poured sealing compound conforming to grade B of IS 1834. Before filling with sealing compound the faces of concrete of the joint shall be coated with primer of approved brand to a depth of 25 mm at the rate of 2.6 liters per 10 square meters. Bitumen emulsion shall not be used as primer.

Dummy Joints: The joints shall be 10 mm wide and shall extend vertically from the surface of the slab to a depth equal to 1/3rd of the thickness of the slab but not less than 4 cm in any case. The joint may be formed by depressing into the soft but compacted concrete a high tensile M.S. or other approved Tee of flat bar of depth not less than required depth of the joint plus 25 mm. The bar used for forming the groove shall be coated with soft soap or other suitable lubricant to facilitate its removal when the steel Tee or flat is removed joints shall be neatly formed with proper tools and mortar/fine material from the slab itself. No additional cement mortar (rich or otherwise) shall be used.

(B) ELECTRICAL WORK

Detailed Specification:

1. SCOPE OF WORK:

The scope of work to be carried out under this contract comprises of the supply, installation, testing and commissioning of Electrical work complete as listed out in Schedule of Quantities. The general character and scope of work to be carried out under this contract is presented in drawings and specifications. The contractor shall carry out and complete the said work under this contract in every respect in conformity with the contract documents and with direction of and to the satisfaction of the Owner and Consultant/ Architect. The contractor shall furnish labour, materials, equipment, transportation and incidentals necessary for the completion of work as described in the Tender Documents.

2. FEES AND PERMITS:

The Contractor shall obtain all permits/licences and pay for any and all fees required for the installation, inspection and the commissioning of the work.

3. DRAWINGS:

The Drawings prepared by the consultants are indicative only of the general arrangement of the installation work. The Contractor shall follow these drawings and specifications in preparing his shop drawings and subsequent installation. He shall check the drawings of other trades to verify space for his installation.

Shop drawings shall be provided of the Main and Sub-Main Switchboards, Distribution Boards, Cable Trays, Reactive Power Compensation Panel, and any other switchboards and panels, wherever applicable and approval shall be obtained from the Consultant / Developer before commencing fabrication or procurement.

Any equipment or switchboard manufactured without the written consent of the Consultant / Developer prior to the approval drawings shall be liable for rejection.

Drawings show general run of cables, approximate locations of outlets and equipment, utility symbols and schematic diagrams of no dimensional significance. Refer to the Architectural drawings for locations and also obtain approval from the Consultant / Developer wherever dimensions are not shown, or locations cannot be determined from the drawings. Do not scale drawings to obtain locations

4. MEASUREMENTS OF WORK:

Payment for Conducting, cables, earth strips and wires etc. will be made on linear measurements and will be measured upto and including the bends.

5. TESTING:

On completion of the installation the testing will be done in conformity with the stipulated performance specifications. Any shortcoming detected in the system/ materials/ workmanship shall be rectified by the contractor to the entire satisfaction of the consultant without any extra cost to the owner. The installation shall be tested again after removal of the defects and shall be commissioned only after approval by the competent inspecting authority and the Consultant/Owner.

The Contractor shall notify the Consultant at least 7 working days before testing of each system. The Consultant reserves the right to be present when such tests are being made.

If the Electrical Inspectorate requires manufacturer's test reports for any equipment used in the project, the Contractor shall obtain such approvals at no extra cost to the client. Such approved reports shall be handed over to the Consultant / client.

Calibration certificates shall be obtained from the Meter and Relay Testing Department of the Electricity Board for all relays and meters used in the project at no extra cost to the client

6. COMPLETION CERTIFICATE:

On completion of the installation a certificate in an approved form shall be furnished by the contractor. The contractor shall be responsible for getting the entire installation duly approved by the Electrical Inspector or other concerned authorities, if any, and shall bear all expenses in connection with the same.

7. SCOPE OF WORK

The scope of work to be carried out under this contract briefly comprises of:

INTERNAL WORK:

Supply, Installation, connecting, testing and commissioning of the following:

- i. Installation of conduits Recessed/Embedded/On surface
- ii. Submains and Circuting
- iii. Lighting fixtures
- iv. Emergency conversion kits
- v. All allied miscellaneous work related to internal lighting.

b) The contractor shall carry out and complete the work under this contract in every respect in confirming with the current rules and regulations of the local Electricity Authority, stipulations of the Indian Standard Institution, and with the directions of and to the satisfaction of the owner. The contractor shall furnish all labour, material, appliances, equipment, transportation and incidentals necessary for providing, installing, testing and commissioning of the whole electrical installation as specified herein and shown as drawings.

This also includes any materials, appliances, equipment and incidental work not specifically mentioned herein or noted on the drawings/documents as being furnished or installed but which are customary to make the installation in working order. The work shall include all incidentals and jobs connected with Electrical installation such as earthing work and cutting chases/holes and making good the same and grouting and equipment.

All Civil works in connection with the Electrical Installation including supply, laying and fixing of necessary inserts, hooks, brackets and sleeves etc

On completion of the work and before issuing of virtual completion certificate the contractor shall submit to owner "As installed drawings" showing all the details of work done by him.

The contractor shall have a valid contracting licence before starting the work and till the completion of work.

INTERNAL WIRING

System of Wiring

The system of wiring shall consist of PVC insulated copper stranded conductor flexible wires in metallic / non metallic (Rigid heavy Duty ISI -marked fire retarded PVC Conduits of minimum 2mm Wall thickness and Sizes starting from 25 mm diameter conduits and shall be concealed or surface mounted above false ceiling as called for

Essential/non-essential/UPS distribution each will have a completely independent and separate distribution system starting from the main, switchboard upto final wiring for each system. As for example, conduit carrying non-essential wiring shall not have essential or UPS wiring. Wiring for essential and UPS supply will have their own conduit system. No mixing of wiring is allowed.

General

Prior to laying and fixing of conduits, the contractor shall mark the conduit route, carefully examine the working drawings prepared by him and approved by the Consultant indicating the layout, satisfy himself about the non interference in the route, sufficiency of number and sizes of conduits, location of junction boxes, sizes and location of switch boxes and other relevant details. Any discrepancy found shall be brought to the notice of the Owner's site representative. Any modifications suggested by the contractor should get written approval before the actual laying of conduits is commenced.

In laying of conduits it is important that not more than two right angle bends are provided for each circuit without a pull box. No junction box shall be provided in the entire length of conduit run for

drawing of wires. Only switch outlets, lighting fixture outlets, equipment power outlets and socket outlets shall be considered for drawing of wires.

Metal Conduits & Accessories

Conduits

Conduits and Accessories shall conform to latest edition of Indian Standards IS-9537 part 1 & 2. 16/14 (16 gauge upto 32mm diameter & 14 gauge above 32 mm diameter) gauge screwed GI or

MS conduits as specified on schedule of quantities shall be used. These shall be solid drawn or reamed by welding, and finished with galvanized or stove enameled surface.

No steel conduit less than 20 mm in diameter shall be used.

All conduit accessories shall be of threaded type, and under no circumstances pin grip type or clamp grip type accessories shall be used.

Bends, couplers etc. shall be solid type in recessed type of works and may be solid or inspection type as required, in surface type of works.

Saddles for surface conduit work on wall shall not be less than 0.55 mm (24 gauges) for conduits upto 25 mm dia and not less than 0.9 mm (20 gauges) for larger diameter. The corresponding widths shall be 19 mm & 25 mm.

The minimum width and the thickness of girder clips used for fixing conduits to steel joists, and clamps shall be as per Table indicated below

Size of Conduit	Width	Thickness
(i) 20 mm	19 mm	0.9 mm (20 SWG)
(ii) 25 mm	19 mm	0.9 mm (20 SWG)
(iii) 32 mm & above	25 mm	1.2 mm (18 SWG)

Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only.

Only approved make of conduits and accessories shall be used.

Conduits shall be delivered to the site of construction in original bundles and each length of conduit shall bear the label of the manufacturer.

Note: Whatever materials required to be billed by the Contractor should come on site with proper Challan Numbers and quantity mentioned in each such Challan.

Shaft which supports sheaves, Gears, coupling and other member which transmit torque shall be provided with tight fitting keys of sufficient strength and quality.

OUTLETS

The switch box or regulator box shall be made of metal on all sides, except on the front. In the case of cast boxes, the wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes, the wall thickness shall not be less than 1.2 mm (18 gauge) for boxes upto a size of 20 cm x 30 cm, and above this size 1.6 mm (16 gauge) thick MS boxes shall be used. The metallic boxes shall be duly painted with anticorrosive paint before erection.

Where a large number of control switches and/or fan regulators are required to be installed at one place, these shall be installed in more than one outlet box adjacent to each other for ease of maintenance.

An earth terminal with stud and 2 metal washers and terminal block shall be provided in each MS box for termination of protective conductors and for connection to socket outlet/metallic body of fan regulator etc.

A metal strip shall be welded/screwed, to the metal box as support if tumbler type of control switches, sockets and/or fan regulators in flush pattern.

Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern.

The fan regulators can also be mounted on the switch box covers, if so stipulated in the tender specifications, or if so directed by the Engineer-in-charge.

Except where otherwise stated, 3 mm thick phenolic laminated sheets shall be fixed on the front with brass screws, or aluminium alloy/ cadmium plated iron screws as approved by the Engineer-in-charge.

JOINTS

All jointing shall be subject to the approval of the Owner's site representative. The threads and sockets shall be free from grease and oil. End termination of conduit on GI boxes shall be by means of hexagon check nuts & spring washer on both sides of the conduit. The joints in conduits shall be free of burrs to avoid damage to insulation of conductors while pulling them through the conduits. Rubberised bushes shall be used in the conduit entry and exit from DBs, switch boxes etc, so that wires are protected from damage to insulation of the incoming and outgoing wires

The conduit work of each circuit or section shall be completed before the cables are drawn in.

Conduit pipes shall be joined by means of screwed couplers and screwed accessories only.

Threads on conduit pipes in all cases shall be between 13 mm to 19 mm long, sufficient to accommodate pipes to full threaded portion of couplers or accessories.

Cut ends of conduit pipes shall have no sharp edges, nor any burrs left to avoid damage to the insulation of the conductors while pulling them through such pipes.

The Engineer-in-charge, with a view to ensuring that the above provision has been carried out, may require that the separate lengths of conduit etc., after they have been prepared, shall be submitted for inspection before being fixed.

No bare threaded portion of conduit pipe shall be allowed, unless such bare threaded portion is treated with anticorrosive preservative or covered with approved plastic compound.

RECESSED OR EXPOSED CONDUITS

All conduits shall be as per Schedule of Quantities/As per approved drawings.

Above false ceiling, in no case, open wiring shall be allowed. Wiring will be done in recessed conduit or surface steel conduit.

FIXING OF CONDUIT

The outer surface of conduit including all bends, unions, tees, junction boxes etc. forming part of the conduit system, shall be adequately protected against rust when such system is exposed to weather, by being painted with 2 coats of red oxide paint applied before they are fixed.

Where conduit pipes are to be laid along the trusses, steel joists etc. the same shall be secured by means of saddles or girder clips or clamps as required by the Engineer-in-charge.

In long distance straight run of conduit, inspection type couplers at reasonable intervals shall be provided, or running threads with couplers and jam nuts shall be provided.

For fixing the conduits in RCC works conduit pipes shall be laid in position and fixed to the steel reinforcement bars by steel binding wires before the concreting is done. The conduit pipes shall be fixed firmly to the steel reinforcement bars to avoid their dislocation during pouring of cement concrete and subsequent tamping of the same.

Fixing of standard bends or elbows shall be avoided as far as practicable, and all curves shall be maintained by bending the conduit pipe itself with a long radius, which will permit easy drawing in of conductors.

Location of inspection / junction boxes in RCC work should be identified by suitable means to avoid unnecessary chipping of the RCC slab subsequently to locate these boxes.

For conduits in RCC works Suitable inspection boxes to the minimum requirement shall be provided to permit inspection and to facilitate replacement of wires, if necessary.

These shall be mounted flush with the wall or ceiling concrete. Minimum 65 mm depth junction boxes shall be used in roof slabs and the depth of the boxes in other places shall be as per IS 2667 : 1988.

In chase the conduit pipe shall be fixed by means of staples, J- hooks, or saddles, at not more than 50cm apart. Junction boxes shall be provided at suitable locations.

In RCC, the conduit pipes shall be laid in position and fixed to the steel reinforcement bars firmly by steel binding wires before the concreting is done. Steel fish wire shall be laid in conduit if supplying & drawing of wire is not included in the scope of work. Cost of fish wire shall be paid extra.

FLEXIBLE CONDUITS

Flexible conduits shall be made of heavy gauge MS strip galvanized after making the spiral. Both edges of the strip to have interlocking to avoid opening up. Flexible conduit shall be heat resistant, lead coated steel, water leak, fire and rust proof. The flexible conduit shall be heat resistant on continuous temperature upto 150 deg. C and intermittent temperature upto 200 deg. C. The flexible conduit shall be corrosion resistant as per IS-3480 & BS-731.

EARTHING REQUIREMENTS

The entire system of metallic conduit work, including the outlet boxes and other metallic accessories, shall be mechanically and electrically continuous by proper screwed joints, or by double check nuts at terminations. The conduit shall be continuous when passing through walls or floors.

A protective (loop earthing) conductor(s) shall be laid inside the conduit between the metallic switch boxes and distribution switch boards and terminated with proper earth lugs/ terminals. Only PVC insulated copper conductor cable of specified size green in colour shall be allowed.

The protective conductors shall be terminated properly using earth studs, earth terminal block etc. as the case may be.

Gas or water pipe shall not be used as protective conductor (earth medium).

PVC Conduit and Accessories

PVC Conduit

All non-metallic conduit pipes and accessories shall be of suitable material complying with IS 2509 : 1973 and IS 3419 : 1989 for rigid conduits and IS 9537 (Part 5) : 2000 for flexible conduits. The interior of the conduits shall be free from obstructions. The rigid conduit pipes shall be ISI marked, and shall be heavy duty with minimum wall thickness of 2.0 mm rigid tubes which are unscrewed without coupling and with plain ends. All conduits used shall be ISI-marked and shall not be less than 25 mm diameter.

PVC shall be ISI marked, rigid "Medium class" and not less than 2mm thick. All PVC conduit accessories shall be grip type. Saddles for fixing conduits shall be heavy gauge non-metallic type with base

PVC conduit shall be used for all concealed / embedded installation.

PVC Conduit Accessories

The conduit wiring system shall be complete in all respect including accessories.

Accessories used for conduit shall be of an approved brand and type complying to relevant IS code.

All accessories used shall be of standard white or black colour, identical to conduit used.

Plain conduits shall be jointed by slip type of couplers with manufacturer's standard sealing cement.

Rigid conduit accessories shall be normally of grip type.

Flexible conduit accessories shall be of threaded type.

All conduit entries to outlet boxes, trunking and switchgear are to be made with adaptors female thread and screwed male bushes.

PVC-switch and socket boxes with round knockouts are to be used. The colours of these boxes and the conduits shall be the same.

Standard PVC circular junction boxes are to be used with conduits for intersection, Tee-junction, angle-junction and terminal. For the drawing-in of cables, standard circular through boxes shall be used.

Samples of accessories shall be submitted for approval prior to installation.

All jointing of PVC conduits shall be by means of adhesive jointing. Adequate expansion joints shall be allowed to take up the expansion of PVC conduits.

Bends in Conduit

Where necessary, bends or diversions may be achieved by means of bends and / or circular cast iron boxes with inspection cover and with adequate and suitable inlet and outlet screwed joints. In case of recessed system each junction box shall be provided with a cover properly secured and flush with the finished wall surface.

No bends shall have radius less than 7.5 cms or three times the outside diameter of the conduits. For metallic conduits, bends of defined radius shall be made by compactly filling fine sand inside the conduit length, to avoid non-uniform shape, once the bend is done. Proper jigs shall be used to ensure that the Enameling /Galvanising of the Conduit is not damaged.

Fixing of Conduits

All conduits, shall be installed so as to avoid exposure to steam, hot water or any other process pipes. After the conduits, junction boxes, outlet boxes and switch boxes are installed in position, their outlets shall be properly plugged or covered so that water, mortar, rodents and insects, insects or any other foreign matter does not enter into the conduit system. Surface conduits shall be fixed by means of heavy gauge GI saddles secured at intervals not more than 1000 mm, and on either side of couplers or bends or similar fitting saddles shall be fixed at a distance of 300 mm from centre of each fitting. For conduit fixing suitable PVC/Nylon fasteners shall be used.

Conduit pipes shall be fixed on surface of wall/ ceiling by saddles, secured to suitable approved plugs with screws at an interval of not more than 75 cm in vertical run and not more than 50cm in horizontal run. On either side of the couplers or bends or similar fittings, saddles shall be fixed at a distance of not more than 30cm from the center of such fittings.

The outer surface of conduit including all bends, unions, tees, junction boxes etc. forming part of the conduit system, shall be adequately protected against rust when such system is exposed to weather, by being painted with 2 coats of red oxide paint applied before they are fixed.

Recessed conduiting shall be done by making chase in the masonry by chase cutter, the conduit shall be fixed in the chase by means of GI hooks not more than 600 mm apart. After fixing of conduit the chase shall be filled with cement mortar after fixing of chicken mesh and brought to the original finish level of the surface to the entire satisfaction of Owner

In chase the conduit pipe shall be fixed by means of staples, J- hooks, or saddles, at not more than 50cm apart. Junction boxes shall be provided at suitable locations.

In RCC, the conduit pipes shall be laid in position and fixed to the steel reinforcement bars firmly by steel binding wires before the concreting is done. Steel fish wire shall be laid in conduit if supplying & drawing of wire is not included in the scope of work.

Switch outlets and Junction Boxes

All outlet boxes for switches, sockets and other receptacles shall be rust proof and shall be of 1.6 mm thick mild steel sheets with HOT dipped galvanizing (or as specified in SOQ), having smooth external and internal surfaces to true finish. All outlet boxes for receiving plug sockets and switches shall be fabricated to approved sizes. All boxes shall have adequate number of knock out holes of required diameter and earthing terminal screws. Outlet boxes shall generally be of 50mm depth subject to maximum depth of 65 mm.

The thickness of the walls and base of PVC boxes shall not be less than 2 mm. The clear depth of PVC boxes shall not be less than 60 mm.

PVC boxes shall comply with the requirements laid down in IS 14772 : 2000. These boxes shall be free from burrs, fins and internal roughness.

Inspection Boxes

50 mm dia inspection boxes and pull boxes shall have smooth external and internal finish to facilitate removal and replacement of wires, where required.

Fish Wire

To facilitate subsequent drawing of wires in the conduit, GI fish wires of 2.0 mm (14 SWG) shall be provided alongwith the laying of recessed conduit.

Conductors

All PVC insulated copper conductor flexible, as specified in SOQ, wires shall conform in all respects to Standards as listed under sub-head Indian Standards and shall be IS approved and ISI marked.

The conductor resistance of wire/ cable used in wiring should not be more than the maximum specified value given in table below duly corrected with correction factor for the ambient temperature at the time of measurement of resistance.

Table D-14: for Maximum permissible resistance of conductor

Nominal Sectional Area	Cross	Maximum Resistance of conductor at 200C		
		Copper		Aluminium
		Plain	Tinned	
mm2		ohm/km	ohm/km	ohm/km
0.5		36.0	36.7	-
0.75		24.5	24.8	-
1.0		18.1	18.2	-
1.5		12.1	12.2	18.1
2.5		7.41	7.56	12.1
4		4.61	4.70	7.41
6		3.08	3.11	4.61
10		1.83	1.84	3.08
16		1.15	1.16	1.91
25		0.727	-	1.20
35		0.524	-	0.868
50		0.387	-	0.641
70		0.268	-	0.443
95		0.193	-	0.320
120		0.153	-	0.253
150		0.124	-	0.206
185		-	-	0.164
240		-	-	0.125
300		-	-	0.100

Table D-15: for Temperature Correction Factors For Conductor Resistance To Correct the Measured Resistance At T0 C To 200 C

Temperature of Conductor at Time of measurement t0C	Temperature Correction Factor k	Temperature of Conductor at Time of measurement t0C	Temperature Correction Factor k
5	1.064	14	1.025
6	1.059	15	1.020
7	1.055	16	1.016
8	1.050	17	1.012
9	1.046	18	1.008
10	1.042	19	1.004
11	1.037	20	1.000
12	1.033	21	0.996
13	1.029	22	0.992
23	0.988	37	0.936

24	0.984	38	0.933
25	0.980	39	0.929
26	0.977	40	0.926
27	0.973	41	0.923
28	0.969	42	0.919
29	0.965	43	0.916
30	0.962	44	0.912
31	0.958	45	0.909
32	0.954	46	0.906
33	0.951	47	0.903
34	0.947	48	0.899
35	0.943	49	0.896
36	0.940	50	0.893

Bunching of Wires

Wires carrying current shall be so bunched that the outgoing and return wires are drawn into the same conduit. Wires originating from two different phases shall not run in the same conduit. All wires shall have ferrules for identification. Lighting and power circuits shall be separate. Each Power/ Light Circuit's Neutral shall be individual per Circuit and shall not be looped from any other Circuit.

Drawing Conductors

The drawing and jointing of PVC insulated copper conductor wires shall be executed with due regard to the following precautions. While drawing wires through conduits, care shall be taken to avoid scratches and kinks which may cause breakage of conductors. There shall be no sharp bends. Wire reel stands to be used for pulling of wires to avoid kinks. Care shall be exercised while drawing the wires from reels, by taking appropriate measures to ensure that wires are not spread on ground, causing dust and dirt accumulation on the new wires.

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into metallic Conduits are given below :

Maximum permissible number of 1100 volt grade PVC insulated wires that may be drawn into rigid non-metallic or PVC Conduits are given below :

Nominal cross sectional area of conductor in sq.mm	20 mm		25mm		32 mm		38 mm		51 mm	
	Straight	Bend	Straight	Bend	Straight	Bend	Straight	Bend	Straight	Bend
1.5	5	4	10	8	18	12	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-
4	3	2	6	5	10	8	-	-	-	-
6	2	-	5	4	8	7	-	-	-	-
10	2	-	4	3	6	5	8	6	-	-

16	-	-	2	2	3	3	6	5	10	7
25	-	-	-	-	3	2	5	3	8	6
35	-	-	-	-	-	-	3	2	6	5

Size of wires Nominal Cross section Area (Sq. mm.)	Maximum number of wires within conduit size(mm)				
	20	25	32	40	50
1.5	7	12	16	--	--
2.5	5	10	14	--	--
4	4	8	12	--	--
6	3	6	8	--	--
10	--	4	5	6	--
16	--	3	3	6	6
25	--	--	2	4	6
35	--	--	--	3	5

Insulation shall be removed by insulation stripper only. Few Strands of wires shall not be cut/reduced for convenience in connecting into terminals. The terminals shall have sufficient cross sectional area to take all strands and it's connecting brass screws shall have flats ends. All looped joints shall be connected through terminal block/connectors. The pressure applied to tighten terminal screws shall be just adequate, neither too much nor too less. All light points shall be terminated through a connector.

Conductors having nominal cross sectional areas exceeding 10 sq.mm shall always be provided with cable sockets. At all bolted terminals brass flat washer of large area and approved steel spring washer shall be used. Brass nuts and bolts with brass washers shall be used for all connections.

Only licensed wiremen (Before doing the work or before appointing him on site contractor has to submit his wiring licence to Owner) and cable jointers shall be employed to do jointing work. Before entrusting cable jointing work to any technician, or before appointing Cable Jointers or Wiremen on Site, Contractor has to submit such Technicians' / Wireman's / Cable Jointer's licence to Owner.

All wires and cables shall be embossed with the manufacturer's label with ISI mark and shall be brought to site in original packing. For all internal wiring. PVC insulated wires of 1100 volts grade (I) shall be used.

The sub-circuit wiring for point shall be carried out in loop system and no joints shall be allowed in the length of the conductors. No wire shall be drawn into any conduit until all defective work of conduit installation of any nature that may cause injury to wire is completed. Care shall be taken while pulling out the wires so that no damage occurs to conduits/wire itself, the conduits shall be thoroughly cleaned of moisture, dust, dirt or any other obstruction. Joints

All joints shall be made at main switches, distribution boards, socket outlets, lighting outlets and switches boxes only. No joints shall be made in conduits and in junction boxes. Conductors shall be continuous from outlet to inlet.

No bare conductor in phase and/or neutral or twisted joints in phase, neutral, and/ or protective conductors in wiring shall be permitted.

If the length of final circuit or submain is more than the length of a standard coil, thus necessitating a through joint, such joints shall be made by means of approved mechanical connectors in suitable junction boxes.

Termination of multi-stranded conductors shall be done using suitable crimping type thimbles.

Mains and Sub-Mains

Mains and sub-mains cable or wires where called for shall be of the rated capacity and approved make. Every main and sub main wires shall be drawn into an independent adequate size of conduit. Earthing shall be in conformity with relevant IS codes and calculations shall be submitted for verification.

An independent earth wire of the proper rating shall be provided for every single phase sub-main. For every 3 -phase sub-main, 2 Nos. earth wires of proper rating shall be provided along with the sub-main. The earth wires shall be drawn along with circuit wires through conduit. Where mains and sub-mains cables are connected to switchgear, sufficient extra lengths of cable shall be provided to facilitate easy connections and maintenance. Where ever necessary, powder-coated 1.6 mm thick sheet steel covering (also called trunking) shall be provided to cover the group of conduits and cables entering and exiting the Wall mounted/Floor mounted Sub DBs, DBs, and FDBs ,so that the Installation looks neat .The colour of such sheet steel covering (trunking) shall be matching with the colour of the SDBs, DBs and FDBs

Sub main & Circuit Wiring

Sub main Wiring

Sub main wiring shall mean the wiring from one main/distribution switchboard to

Another linear measurement shall be made along the length of conduit from edge of Main switch to edge of DB.

(b) Circuit Wiring

Circuit wiring shall mean the wiring from the distribution board to the 1st tapping

Point inside the switch box, from where point wiring starts.

Linear measurement shall be made along the length of conduit from edge of DB to edge of switched board.

Note: (a) Measurement shall be done in linear basis in metres with minimum unit as 1 cm

Wire used for connection inside of DB or Meter board or switched board of length upto 0.3 metre on each end is included in the cost of submain/ Circuit wiring. If connection wire is more then 0.3 metre in length beyond edge of DB, switch board, extra length may be paid separately as supply and drawing of wires in existing conduit.

Point wiring:

Point wiring means wiring from switch box to connector or ceiling rose for light/ fan/ call bell/ exhaust fan/ twin control light/ group control light and from Distribution board to switch box for light plug point/ power plug point.

The wiring system for point wiring shall be looping system. Phase/ live conductors shall be looped in the switch box, neutral wire/ earth wire shall be looped in the switch box for the 1st point and from point outlets for subsequent points. In wiring no joints will be permitted any where, except in switch box or point outlets, where jointing or wires will be allowed with use of suitable connector.

Points are categorized based on length of live conductor as under:

S.No	Category	Length
1	Short point	Up to 3 metre
2	Medium point	Beyond 3 metre and up to 6 metre
3	Long point	Beyond 6 metre and up to 10 metre
4	Extra Long point I	Beyond 10 metre and up to 15 metre
5	Extra Long point II	Beyond 15 metre and up to 20 metre
6	Extra Long point III	Beyond 20 metre and up to 25 metre

Capacity of Circuits

Minimum size of wiring:

Light Wiring: 1.5 sq.mm.

Power Wiring: 4.0 sq.mm.

Power circuit rated: More than 1 KW, Size as indicated in DB schedule.

(i) Lighting circuit shall feed light/fan/ call bell points. Each circuit shall not have more than 800 Watt connected load or more than 10 points whichever is less. However, in case of CFL points where load per point may be less, number of points may be suitably increased.

(ii) Power circuit in will have only one outlet per circuit.

Load Balancing

Balancing of circuits in three phase installation shall be as planned by the Consultants in the tender drawings and shall be checked by the contractor before the commencement of wiring and shall be strictly adhered to.

Colour Code of Conductors

Colour code shall be maintained as indicated by the Consultant for the entire wiring installations. Red, yellow, blue shall be for three phases, black for neutral and green with yellow band shall be for earthing.

Colour Code of Conduits

All the exposed conduits shall be Colour coded at every 5 mtr as indicated by the Consultant for the entire wiring installations.

Red for fire/Emergency system, Blue for ELV system and, Orange for power.

Measurement:

Point wiring: The length of Points shall be measured along live conductor from top of switch board to junction box in which connector of that point is provided. Based on the length of point, it will be put into the suitable category of points i.e. short or medium or long etc. Then points will be counted in numbers category wise.

Twin control points shall be counted as two points from point outlet to control switch board to either side.

Group control points shall be measured from switch board to first point outlet as one point and from first point outlet to next point outlet as second point and so on.

Multiple controlled call bell point shall be measured from the call bell to the nearest connector meant for connection to bell push as one point, from that connector to the next one and so on, shall be treated as separate points.

The light, fan, call bell, twin control, group control points of length more than 10 metres shall be measured as long point and in addition extra length of point wiring beyond 10 metre shall be measured in actual length and size of conduit and actual number and size of wires drawn in conduit and paid separately. Loose wire for connection will not be measured.

The light/ power plug points of length more than 25 metres shall be measured as Extra long point III and in addition extra length of point wiring beyond 25 metre shall be measured in actual length and size of conduit and actual number and size of wires drawn in conduit and paid separately. Loose wire for connection will not be measured.

Rate

Cost of all wire, conduit, junction box, switches, sockets, conductor etc. material, labour and machinery used in execution of work of point wiring/ circuit / submain wiring including cost of necessary testing included in the cost of item.

SWITCHES, RECEPTACLES (MODULAR), LIGHTING FIXTURES & LIGHTING CONTROL EQUIPMENT

Switches

All switches shall be enclosed type flush mounted, suitable for 240 volts AC. All switches shall be fixed inside the switch boxes on adjustable flat M S strips/plates with tapped holes and brass machine screws, leaving ample space at the back and sides for accommodating wires.

Switch controlling the light point shall be connected to the phase wire of the circuit and load on each switch shall be restricted to maximum 800 watts & maximum 1500 watts per circuit. All wiring accessories shall be BIS approved. Perfect alignment shall be maintained while fixing of the back boxes.

Socket Outlet

Socket outlets shall be of the 6/16A three/Six pin shutter type. The switch controlling the socket outlet shall be on the phase wire of the circuit and not more than two socket outlets of 6/16 amps shall be connected on one circuit. An earth wire shall be provided along with the circuit wires and shall be connected to earthing screw inside the box.. All sockets shall be shuttered type.

- a. Every socket outlet shall be controlled by an individual switch unless mentioned otherwise.
- b. The switch controlling the socket outlet shall be on the 'Live' side of the line.
- c. Socket outlet shall normally be fixed at any convenient height above the floor level as desired by the Architect. The switch for socket outlet shall be kept along with the socket outlet. However, in special case, if desired by the Architect the socket outlet can be placed at the normal switch level. 16 amps socket outlet in the kitchen of Hostel building shall be fixed at any convenient height above working platform or as specified in drawings / schedule of equipments.

In a room containing a fixed bath or shower, there shall be no socket outlet and there shall be no provision for connecting a portable appliance.

Any stationary appliance connected permanently in the bath room shall be controlled by an isolator switch or circuit breaker having outlets at such location where water / moisture does not effect.

Generally, switches and outlets shall be planned at a minimum distance of 1.5 Metre away from any water supply outlet, so that splashed water may not affect the live installation.

- d. Where socket outlets are placed at lower level, they shall be enclosed in a suitable metallic box with the system of wiring adopted or shutter type sockets shall be provided as specified.
- e. In an earthed system of supply, a socket outlet and plug shall be of three pin type, the third terminal shall be connected to earth.
- f. Conductors connecting electrical appliance with socket outlet shall be flexible twin cord with an earthing cord which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance.
- g. Use of shutter type of interlocking type of socket is required for any special installation, the items should be separately and specifically listed in the Schedule of Quantities of that particular work.

Lighting Fixtures & Accessories

The light fixtures and fittings shall be assembled and installed in position complete and ready for service, in accordance with details, drawings, manufacturer's instructions and to the satisfaction of the Project Manager.

Scope:

Scope of work under this section shall include Supplying installing inspection at suppliers/manufacture's premises at site, receiving at site, safe storage, transportation from point of storage to point of erection, erection and commissioning of light fittings, fixtures and accessories including all necessary supports, brackets, down rods and painting etc as required.

Standards:

The lighting and their associated accessories such as lamps, reflectors, housings, ballasts etc., shall comply with the latest applicable standards, more specifically the following:

General and safety requirements for Luminaires:

Part-1 Tubular fluorescent lamps	-	IS – 1913 (Part-1)
Industrial lighting fittings with metal reflectors	-	IS - 1777
Decorative lighting outfits	-	IS - 5077
Bayonet lamp holders	-	IS - 1258
Bi-pin lamp holders for tubular fluorescent lamps	-	IS - 3323
Electronic Ballasts for fluorescent lamps –		
General & Safety requirement	-	IS – 13021 (Part-1)
Electronic Ballasts for fluorescent lamps –		
Performance requirement	-	IS – 13021 (Part-2)
Ballast for HP MV lamps	-	IS - 6616
Tubular Fluorescent lamps	-	IS - 2418 (Part-1 to 4)
Luminaries – General requirement	-	IS – 10322 (Part-1)
Luminaries – Constructional requirement	-	IS – 10322 (Part-2)
Luminaries – Screw and Screw less termination	-	IS – 10322 (Part-3)
Luminaries – Methods of Tests	-	IS – 10322 (Part-4)
Particular requirement –		
General purpose Luminaries	-	IS – 10322 (Part-5/Sec-1)
Particular requirement –		
Recessed Luminaries	-	IS – 10322 (Part-5/Sec-2)
Particular requirement –		
Luminaries for Road and Street lighting	-	IS – 10322 (Part-5/Sec-3)
Particular requirement –		
Portable General purpose		
Luminaries	-	IS – 10322 (Part-5/Sec-4)
Particular requirement –		
Flood Lighting	-	IS – 10322 (Part-5/Sec-5)
High pressure mercury vapour lamps	-	IS – 9900 (Part-1)
Tungsten filament general electric lamps	-	IS -418

Light Fittings-General Requirements:

Fittings shall be designed for continuous trouble free operation under atmospheric conditions without reduction in lamp life or without deterioration of materials and internal wiring. Degree of protection of enclosure shall be IP-65 for outdoor fittings except bulkhead fitting. Bulkhead fitting shall be provided with IP-54 protection.

Fittings shall be so designed as to facilitate easy maintenance including cleaning, replacement of lamps/ ballasts.

All fittings shall be supplied complete with lamps. All mercury vapour and sodium vapour lamp fittings shall be complete with accessories like ballasts, power factor improvement capacitors, starters, etc. Out door type fittings shall be provided with weather proof junction boxes (IP-55) and IP-54 Control gear boxes. All fluorescent and CFL fittings shall be provided with electronic ballast as per schedule of quantities.

Each fitting shall have a terminal block suitable for loop-out connection by 1100 V PVC insulated copper conductor wires upto 4 sq.mm. the internal wiring should be completed by the manufacturer by means of standard copper wire and terminated on the terminal block.

All hardware used in the fitting shall be suitably plated or anodized and passivated.

Earthing: Each lighting fitting shall be provided with an earthing terminal. All metal or metal enclosed parts of the housing shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity throughout the fixture.

Painting/Finish: All surfaces of the fittings shall be thoroughly cleaned and degreased and the fittings shall be free from scale, rust, sharp-edges, and burns.

The housing shall be powder coated/stove-enamelled or anodised as required. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg. over 12 mm dia mandrel.

Metal used in BODY of lighting fixtures shall be not less than 22 SWG or heavier if so required to comply with specification of standards. Sheet steel reflectors shall have a thickness of not less than 20 SWG. The metal parts of the fixtures shall be completely free from burns and tool marks. Solder shall not be used as mechanical fastening device on any part of the fixture.

Light Fittings – Special Requirements

Box Channel Type Industrial Fittings

Box type slim line channel must be in screwless construction manufactured from M.S. CRCA sheet steel powder coated with MS CRCA cover, powder coated white. Light reflection surface in Box/Channel type fittings shall be in a POLYESTER PRECOATED STEEL having a reflection factor of not less than 80%. SCREWLESS DESIGN & CONSTRUCTION Light fixtures shall be preferred due to their ease of maintenance, especially for box/channel for box/channel type fixtures.

Moisture Proof Industrial Fittings

Surface mounted totally enclosed moisture proof fixtures must be in polycarbonate body and diffuser with transparent prismatic interior and smooth exterior and frosted end. Fixture must be completely sealed with polyurethane double gasket to achieve IP 65 protection. Fixture is complete with CRCA steel white powder coated / enameled finish reflector.

18 W / 36 W Fluorescent and 36 W CFL Low Glare Light Fittings

Recessed mounted, modular fluorescent lighting fixture made of CRCA Sheet steel powder coated (white) housing, electro chemically brightened and anodised reflector, three dimensional cross louvers with concave contours, fresnel top at louver saddle to increase efficiency. The luminance of <200 cd/M2 at 63 degree viewing angle in all directions so as to confirm Cat-2 classification of CIBSELG3

High-bay Industrial Fittings

Industrial Highbay luminaries shall be provided with pressure die cast housing along with all accessories, orthocyclically wound opien construction ballast, capacitor & semi parallel ignitor connected to terminal block and mounted on the gear plate. The gear shall have side entry for ease in maintenance. The spun aluminium reflector is suitable for narrows well as wide beam distribution as specified in schedule of quantities. The luminaire will be suitable for metal halide lamp HPI BU + 250 W which has 25500 lumens or similar 400W lamp and 2.5 minutes restrike time (when operate with son gear).

Accessories for Light Fittings - Reflectors

The reflectors shall be made of CRCA sheet steel/aluminium /Silvered glass/Chromium plated sheet copper as specified. The thickness of reflectors shall be as per relevant standards. Reflectors made of steel shall have stove enameled/ vitreous enameled/epoxy coating finish. Aluminium used for reflectors shall be anodized/epoxy stove enameled /mirror polished. The finish for the reflector shall be as specified. The reflectors shall be free from scratches / blisters and shall have a smooth and glossy surface having optimum light reflecting coefficient. Reflectors shall be readily removable from the housing for cleaning and maintenance without use of tools.

Lamps

TLD

Lamp shall be environment friendly low pressure mercury discharge lamp with mercury content less than or equal to 5 mg. The lamp shall have minimum lumen maintenance of 85 and CRI of 85. The lamp must comply to ROSH (Restriction of Hazardous substances) and covered by WEEE. Lamp should be fully re-cyclable. The lamp should be low on maintenance with life of 40 K hours in case of electromagnetic ballast and 65 K hours in case of HF ballast upto 10% failure. The discharge glass shall be lead free.

TLD Lamps shall be minimum tri-phosphor type and have bi-pin bases. Colour spectrum of light shall be equivalent to "PHILIPS color 84 or color 86 color 82 or "OSRAM color 21 or color 11 or color 41 (as required at site)".

The fluorescent Tubes (TLD) should have cool daylight colour designation. But Architects reserve the right to prescribe either Cool Daylight or Bright White or Incandescent Colour Designations for TLD. NO extra payment will be made over the quoted rate of bidder for this. The 36 W fluorescent tubes will have Nominal Luminous Flux of not less than 3350 lumens whether so mentioned in the Schedule of Quantities or not.

T 5 – High Efficiency ECO-Friendly Lamps

T-5 lamp shall be environment friendly low pressure mercury discharge lamp with mercury content less than or equal to 3 mg. lamp should have lowest CO2 emission compared to any other comparable light source (40% less than a TL-D standard lamp, 26% less than TL-D / 80). T-5 lamp shall be 100% lead free. T-5 lamp shall be designed for operation with electronic gear and well suited for dimming. Maximum lumen output to be reached at approx 35oC in free burning position. T-5 lamp can be ignited from -15oC to + 50oC. Lamp should be fully recyclable and must comply to ROSH (Restriction of Hazardous substances) and shall be covered by WEEE. T-5 shall have 16 mm in diameter service life of TL-5 lamp should be 10% more than TL-D lamps. T-5 lamp shall have lumen efficacy of up to 104 Lumens / W and shall have excellent colour rendering to En 12464 (Ra 80 to 89).

Compact fluorescent lamp shall have same luminous flux and power consumption as fluorescent tubes but less than half the length and more compact than U-shaped and circulator lamps. CFL shall be suitable for use with conventional control gear & standers and for HF electronic control gear. CFL lamp shall be non integral type of OSRAM / GE / PHILIPS/ Havells Sylvania only.

High Frequency Electronic Ballast

High frequency electronic ballast shall be used with fluorescent / Compact Fluorescent Lamps wherever specified in the schedule of quantities. High frequency electronic ballast shall comply to the following:

IEC 927, IEC 928 for $\leq 10\%$ total harmonic distortion.

EMI / RFI – Confirming to FCC / VDE Class A/B.

Line Transient as per IEEE C62.41.

Ballast Crest Factor C1.7%.

No Stroboscopic Effect

Constant Wattage / Light output between $240\text{ V} \pm 10\%$.

Circuit protection for surge current and inrush current.

Short circuits, open lamp protection

PF > 0.99 for fluorescent / T5 lamp and 0.95 for CFL.

Deactivated lamp protection

Suitable for use with single and twin lamps

RFI < 30 MHz EN 55015

Total Harmonic Distortion (THD) $\leq 10\%$

Immunity to interference EN 61547

Safety EN 60928 / IEC 928 / IS 13021 (Part I)

Performance EN 60929 / IEC 929 / IS 13021 (Part II)

Vibrations & Bump tests IEC 68-2-6 FC

IEC 9001

Quality Standard ISO 9001

Environmental Standard ISO 14001

DC Operation EN 60924

Emergency Lighting Operation VDE 0108

TESTING

General

At the completion of the work, the contractor shall carry out the pre-commissioning as well as commissioning checks as given below on the entire installation and records be maintained for reference of any statutory authority, Client or their representatives.

Pre - Commissioning Checks

Note - Pre- Commissioning checks are to be carried out by Electrical contractor in presence of Project Management Team.

Sr. No.	Component	Points to be checked
1	Wires	Correct identification of each wire by continuity check and providing correct ferrules as per approved drawings. Correct colour coding and correct connection by proper copper lugs.

		Wires are dressed and bunched properly. Connections are properly tightened. Not more than two wires are connected on any one side of terminal. IR values of the circuit are measured and recorded.
2	Switch boxes & Receptacles	Wires are connected properly as per wiring diagram. Correct colour coding and correct connection by proper copper lugs is done. Wires are dressed and bunched properly. Connections are properly tightened. Not more than two wires are connected on any one side of terminal. Earthing connection is made properly. Functional check is OK IR values of the circuit are measured and recorded.
4	Light fittings	Correct colour coding and correct connection by proper copper lugs is done. Connections are properly tightened. Not more than two wires are connected on any one side of terminal. Earthing connection is made properly. IR values of the circuit are measured and recorded.
7	Earthing	The resistance value of each earth electrode are measured and recorded. Total resistance of earthing system should be as per the design value and in any case, shall not be more than 1 Ohm as per IS-3043. Continuity test for earth continuity conductors with ELV tester.

Commissioning Checks

Note –Commissioning checks are to be made in following sequence starting from Transformer / DG to main panel to last light fitting. All results of testing and observations are to be preserved for record and reference by any statutory authority.

Sr. No.	Component	Points to be checked
4	Switch boxes & Receptacles	All rectification points are attended and correctly rectified. Check the voltage with test lamp. Switch on the circuit.
6	Light fittings	All rectification points are attended and correctly rectified. Switch on the circuit.
8	Earthing	Check if all earth electrodes in earth pits for it's correct installation and connection to earth grid. Check if all protective conductors from the earth electrodes to grid and from grid up to all electrical equipment are made correctly.

		Remove the protective conductor / grid connection with earth electrode and measure earth electrode resistance by using earth megger. Repeat above procedure for all electrodes. Ensure that total earth resistance of the installation is less than 1 mega- ohms.

APPENDIX - I

LIST OF INDIAN STANDARDS (IS)

IS : 374	Ceiling fans and regulators (3rd revision)
IS: 694	PVC insulated Electric cable for working voltage upto and including 1100 volts.
IS : 732	Code of practice for electrical wiring and installation
IS : 1255	Code of Practice for installation and maintenance of Power Cables upto and including 33 KV rating (Second Revision)
IS : 1258	Bayonet lamp holders(Third revision)
IS : 1293	Three pin plugs and sockets outlets rated voltage upto and including 250 volts and rated current upto and including 160 amps.
IS : 1554 (Part - I)	PVC insulated (Heavy Duty) electric cables for working voltages upto and including 1100 volts.
IS : 1646	Electrical installation fire safety of buildings (general) Code of practice.
IS : 1885	Glossary of items for electrical cables and conductors
IS : 1913	General and safety requirements for fluorescent lamps luminaries Tubular.
IS : 2026 - Part I to IV)	Power Transformers/ Dry Type Transformers
IS : 2071	Methods of high voltage testing
IS : 2309	Protection of building and allied structures against lightning
IS : 2551-	Danger notice plate.
IS : 3043	Code of practice for earthing.
IS : 3427	AC Metal enclosed switch gear and control gear for rated voltages above 1 KV and upto and including 52 KV.
IS : 3480	Flexible steel conduits for electrical wiring.
IS : 3837	Accessories for rigid steel conduit for electrical wiring.
IS : 4146	Application guide for voltage transformers
IS : 4615	Switch socket outlets.
IS : 5133 (Part -I)	Boxes for the enclosure of electrical accessories.
IS : 5216 (Part-I)	Guide for safety procedures and practices in electrical work.
IS : 5424	Rubber mats for electrical purposes.
IS: 5578 & 11353-	Marking and arrangement of bus bars
IS: 7098 - (Part - II)	Cross linked polyethylene insulated PVC sheathed cables. For working voltages from 3.3 KV upto and including 33 KV
IS : 8130 -	Conductors for insulated electric cables and flexible cords
IS : 8623 - (Part -I)	Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V D C.

IS : 8623 - (Part -II)	Bus Bar trunking system
IS : 8828 -	Miniature Circuit Breakers
IS : 9537 -	Rigid Steel Conduits for electrical wiring (Second Revisions)
IS : 10810 -	Methods of test for cables.
IS : 12640 -	Earth Leakage Circuit Breakers
IS : 13947 (Part-II)	Air Circuit Breakers
IS : 13947- (Part-)	Molded Case Circuit Breakers
IS : 13947 - (Part-)	Degree of protection provided by enclosures for LV switchgear and control gear.
IS : 13947 (Part-)	General requirement for switchgear and control gear for voltage not exceeding 1000 Volts.
IS : 156	Insulating mats for electrical purposes.
IS : 1651 & 1652	Stationary cells and batteries lead acid type

APPENDIX - II

ABBREVIATIONS

The following abbreviations have been used in the accompanying Specifications, drawings and Schedule of Quantities.

CU	stands for copper.
GI	stands for Galvanised Iron (Mild Steel)
V	stands for Volts
KV	stands for Kilo Volts
HV	stands for High Voltage (3.3 KV and above)
MV	stands for Medium Voltage (110 V ,230 V ,415 V, 600 V, 110 V)
LV	stands for Low Voltage (32 V & Below)
HT	stands for High Tension
LT	stands for Low Tension
SF6	stands for Sulphur Hexa Fluoride Gas
VCB	stands for Vacuum Circuit Breaker
PVC	stands for Polyvinyl Chloride
AMP	stands for Amperes
KWH	stands for Kilowatt Hours
KW	stands for Kilo Watts
BIS	stands for Bureau of Indian Standards
IS	stands for Indian Standards?
IEC	stands for International Electro Technical Commission
IEE	stands for Institution of Electrical Engineers - London
IEEE	stands for Institution of Electrical & Electronics Engineers
NEC	stands for National Electrical Code
ACB	stands for Air Circuit Breaker
RCCB	stands for Residual Current Circuit Breaker
MCB	stands for Miniature Circuit Breaker
MCCB	stands for Moulded Case Circuit Breaker
SP	stands for Single Pole
DP	stands for Double Pole
TP	stands for Triple Pole
TPN	stands for Triple Pole and Neutral
4 Pole	stands for 3 phase and neutral of same capacity (size)
MDB	stands for Main Distribution Board

SDB	stands for Sub Distribution Board
FDB	stands for Final Distribution Board
MCC	stands for Motor Control Centre

TECHNICAL SPECIFICATIONS FOR PLUMBING WORKS

Fire Hydrant System and Sprinkler System

1 Scope of work

- 1.1 Work under this section shall consist of furnishing all labour, materials, equipment and appliances necessary and required to completely install wet riser fire hydrant and sprinkler system as required by the drawings and specified hereinafter or given in the Schedule of Quantities.
- 1.2 Without restricting to the generality of the foregoing, the work shall include but not limited to the following:-
- a) Piping for wet riser hydrant systems and for yard hydrants.
 - b) Landing valves, canvas hose pipes, hose reels, hose cabinets & connections to mains.
 - c) Fully automatic sprinkler system
 - d) Isolation valves, non-return valves, installation valves, flow control switches and accessories.

2. General

- 2.1 All materials shall be new of the best quality conforming to the specifications and subject to the approval of the Project Manager.
- 2.2 Pipes and fittings shall be fixed truly vertical, horizontal or in slopes as required in a neat workmanlike manner.
- 2.3 Pipes shall be fixed in a manner as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts, passages etc.
- 2.4 Pipes shall be securely fixed to walls, and ceilings by suitable clamps at intervals specified. Only approved type of anchor fasteners shall be used for RCC ceilings and walls.
- 2.5 Valves and other appurtenances shall be so located that they are easily accessible for operations, repairs and maintenance.
- 2.6 The rules and regulations of Local Fire Authority as per the statutory regulations applicable for obtaining the occupation certificate from the Local Development / Fire Authority.
- 2.7 Drawings issued with the tenders are schematic and indicate the concept. Contractor shall make his shop drawings on basis of Architectural and Interior design drawings issued by the Engineer-in-Charge. Work will be executed only as per approved shop drawings.
- 2.8 It is the contractor's responsibility to ensure the competence of design to meet the above requirements.

3 Pipes

All pipes within and outside the building in exposed locations and shafts including connections buried under floor shall be M.S. pipes confirming to IS : 1239 Heavy Class

4 Pipe Fittings

Pipes and fittings means tees, elbows, couplings, flanges, reducers etc. and all such connecting devices that are needed to complete the piping work in its totality.

Screwed fittings shall be approved type malleable or cast iron with reinforced ring on all edges of the fittings suitable for screwed joints.

Forged steel fittings of approved type with "V" groove for welded joints.

Fabricated fittings shall be not being permitted for pipe diameters 50 mm and below. When used, they shall be fabricated, welded and inspected in workshops whose welding procedures have been approved by the TAC as per TAC rule 4102 for sprinkler system and applicable to hydrant and sprinkler System under the supervision of Project Manager. For "T" connections, pipes shall be drilled and reamed. Cutting by gas or electrical welding will not be accepted.

5 Jointing

5.1 Screwed (50 mm dia pipes and below)

Joint for black steel pipes and fittings shall be metal to metal thread joints. A small amount of red lead may be used for lubrication and rust prevention. Joints shall not be welded or caulked.

5.2 Welded (65 mm dia and above)

Joints between M.S. and pipes and fittings shall be made with the pipes and fittings having "V" groove and welded with electrical resistance welding in an approved manner. Butt welded joints are not acceptable.

5.3 Flanged

- a) Flanged joints shall be provided on:
- b) Straight runs not exceeding 30 m on pipe lines 80 mm dia and above.
- c) Both ends of any fabricated fittings e.g. bend tees etc. of 65 mm dia or larger diameter.
- d) For jointing all types of valves, appurtenances, pumps, connections with other type of pipes, to water tanks and other places necessary and required as per good engineering practice.
- e) Flanges shall be as per I.S. with appropriate number of G.I. nuts and bolts, 3 mm insertion neoprene gasket complete.

5.4 Unions

Approved type of dismountable unions on pipes lines 65 mm and below in similar places as specified for flanges.

6 Excavation

- 6.1 Excavation for pipe lines shall be in open trenches to levels and grades shown on the drawings or as required at site. Pipe lines shall be buried to a minimum depth of 1.2 meter or as shown on drawings.
- 6.2 Wherever required contractor shall support all trenches or adjoining structures with adequate timber supports.
- 6.3 On completion of testing and pipe protection, trenches shall be refilled with excavated earth in 15 cms layers and consolidated.

- 6.4 Contractor shall dispose off all surplus earth within a lead of 200 m or as directed by Project Manager.

4 Anchor Thrust Blocks

- a) Contractor shall provide suitably designed anchor blocks in cement concrete to encounter excess thrust due to water hammer & high pressure.
- b) Thrust blocks shall be provided at all bends & tees & such other location as determined by the Project Manager.
- c) Exact location, design, size and mix of the concrete block shall be approved by the Project Manager prior to execution of work.

7 Valves

7.1 Gunmetal Valves

- 7.1.1 Valves 65 mm dia & below shall be heavy gunmetal full way valves or globe valves conforming to I.S. 778-1971 class II with female screwed ends. Valves shall be carry I.S. certifications mark.
- 7.1.2. All valves shall be approved by the Project Manager before they are allowed to be used on work.

7.2 C.I. Iron Butterfly Valves/Sluice Valves

- 7.2.1 All valves 80 mm dia and above shall be C.I. double flanged butterfly valves. Each sluice valve shall be provided with wheel for valves in exposed positions and cap top for underground valves. Contractor shall provide suitable operating keys for Sluice Valves with cap tops.
- 7.2.2 Butterfly valves shall be of best quality conforming to I.S.13095 of class specified and sluice valves shall conform to IS: 780.

7.3 Non-return valves (Check Valves)

Non-return valves shall be cast iron double flanged with cast iron body and gunmetal internal parts conforming to IS: 5312.

7.4 Air valves

25 mm dia screwed inlet cast iron single acting air valve shall be provided on all high points in the system or as shown on drawings.

7.5 Orifice Flanges

Orifice flanges fabricated from 6 mm thick stainless steel plate shall be provided to reduce pressure on individual hydrants to restrict the operating pressure to 3.5 kg/cm² and allow a discharge of 560 lpm. The contractor shall submit design of the orifice flanges for approval before installation.

7.6 Drain Valve

50 mm dia black steel pipe to IS: 1239 (heavy class) with 50 mm gunmetal fullway valve shall be provided for draining any water in the system in low pockets.

7.7 Pressure Gauge

Pressure gauge shall be provided near all connections to hydrant system and isolation valves of sprinkler system and where required. Pressure gauge shall be 100 mm dia gunmetal Bourden type with gunmetal isolation cock, tapping and connecting pipe and nipple. The gauge shall be installed at appropriate level and height for easy readability.

8 Hydrant/valve chambers

- 8.1 Contractor shall provide suitable brick masonry chambers in cement mortar 1:5 (1 cement: 5 coarse sand) on cement concrete foundations 150 mm thick 1:5:10 mix (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) 15 mm thick cement plaster inside and outside finished with a

floating coat of neat cement inside with cast iron surface box approved by fire brigade including excavation, back filling complete. (50:50 ratio of River sand and crusher/Robo Sand is proposed for all RCC structures).

- 8.2 Valve chambers shall be of following size: -
for depths 100 cms and beyond 120x120 cms.

9 Fire brigade connections

As shown on drawings separate gunmetal 2-3 way collecting head Fire brigade connection each with two or three 63 mm instantaneous type inlets with built in check valves and 150 mm dia inlet/outlet connected to the fire and sprinkler main as given in BOQ shall be provided. Both shall be installed on a stand post and provided with horizontal C.I. reflux valve and location to be approved by Project Manager. Etched gunmetal label plates with 80 mm high letters shall be fixed along with necessary enclose cabinet. The plates should be firmly fixed to the FB connection and any support system.

10 Fire hydrants

10.1 External hydrants

- 10.1.1 Contractor shall provide stand post type external hydrants. The hydrants shall be controlled by a cast iron sluice valve installed in underground lockable chambers. Hydrants shall have instantaneous type 63 mm dia outlets. The hydrants valve shall be single outlet conform to I.S.5290 with C.I duck foot bend and flanged riser of required height to bring the hydrant to correct level above ground.

- 10.1.2 Contractor shall provide for each external fire hydrant two numbers of 63 mm dia. 15 m long controlled percolation type hose pipes with gunmetal male and female instantaneous type couplings machine wound with G.I. wire (hose to I.S. 636 Type 2 and couplings to I.S. 903 with M.S. certification), gunmetal branch pipe with nozzle to I.S. 903.

10.2 Internal hydrants

- 10.2.1 Contractor shall provide on each landing and other locations as shown on the drawings one single headed gunmetal oblique landing valves with 63 mm dia outlet mounted on a common 80 mm inlet conforming to I.S.5290-1969. Landing valve shall have flanged inlet and instantaneous type outlets as shown on the drawings.

- 10.2.2 Instantaneous outlets for fire hydrants shall be of standard pattern approved and suitable for fire brigade hoses.

- 10.2.3 Contractor shall provide for each internal fire hydrant station two numbers of 63 mm dia. 15 m long rubberized fabric linen hose pipes with gunmetal male and female instantaneous type coupling machine wound with G.I. wire (hose to I.S. 636 Type 2 and couplings to I.S. 903 with I.S. Certification), fire hose reel conforming to IS:884, gunmetal branch pipe with nozzle I.S. 2871 and Fire man's axe conforming to IS: 926.

- 10.2.4 Each hose box shall be conspicuously painted with the letters "FIRE HOSE".

11 Fire hose reels

Contractor shall provide standard fire hose reels with 20 mm dia high pressure Dunlop or equivalent rubber hose 36.5 m long with gunmetal nozzle and control valve, shut off valve, all mounted on circular hose reel of heavy duty mild steel construction and cast iron brackets. Hose reel shall be connected directly to the wet riser. Hose reel shall conform to IS: 884-1969 and rubber hose to IS: 5132.

12 Hose Cabinets

All internal fire hydrants shall be enclosed in M.S. glazed cabinet. Hose cabinets shall be fabricated from 16 gauge M.S. sheet of fully welded construction with hinged double front door partially glazed

with locking arrangement stove enameled fire red paint with "FIRE HOSE" written on it prominently. (Sizes are as given in the Bill of Quantities).

13 Pipe protection

a) All pipes above ground and in exposed locations shall be painted with one coat of zinc chromate primer and two or more coats of synthetic enamel paint of approved shade.

b) Pipes in chase or buried underground shall be painted with two coats of zinc chromate primer and wrapped with one layer of 4 mm thick PYPKOAT multilayer sheet as per standard manufacturer's specifications.

14 Pipe Supports

All pipe clamps and supports shall be galvanised steel. When fabricated from M.S. steel sections, the supports shall be factory galvanised before use at site. Welding of galvanised clamps and supports will not be permitted.

Pipes shall be hung by means of expandable anchor fasteners of approved make and design (Dash Fasteners or equivalent). The hangers and clamps shall be fastened by means of galvanised nuts and bolts. The size/diameter of the anchor fastener and the clamp shall be suitable to carry the weight of water filled pipe and dead load normally encountered.

Pipe Spacing Table

		<----- Pipe commercial dia. - ----->							
		----->							
S.No.	Pipes & Position	15/20	20/25	32/40	50	75/80	100/110	150/160	200
1	Vertical								
1.1	GI /MS	2.4	2.4	3	3.6	4.5	4.5	5.4	5.4
1.2	CI Pipes IS 1729/3989	x	x	<----- 3 m ----->					>
1.3	CI Heavy Duty IS 1536	x	x	<----- 3.6 m ----->					>
1.4	uPVC SWR Systems	x	x	0.5	0.7	0.9	0.9	1.0	
1.5	uPVC Water Supply								
1.6	Polybutylene	<--- As per manufacturer's Recommendations --->							>
1	Horizontal								
1.1	GI /MS	2.0	2.0	2.4	3.0	3.6	4.0	4.5	4.5
1.2	CI Pipes IS 1729/3989			<----- 3 m ----->					
1.3	CI Heavy Duty IS 1536					3.0	3.6	3.6	4.5
1.4	uPVC SWR Systems				1.2	1.8	1.8	1.8	
1.5	uPVC Water Supply								
1.6	Polybutylene	<-As per manufacturer's recommendations-->							

15 Installation Valve

15.1 Installation valves shall be installed on the sprinkler circuits as shown on the drawings.

15.2 Contractor shall submit his detailed shop drawings showing the exact location, details of installation of the valve and alarm in all its respects.

15.3 Installation valve shall comprise of a cast iron sluice valve with gunmetal trim, pressure gauge, double seated clapper check valves as alarm valve with pressure gauge, test valve and orifice assembly and drain pipe with pressure gauge, bye pass on check valve to regulate differential pressure and false alarm, turbine water gong including all accessories necessary and required and as supplied by original equipment manufacturer and required for full and satisfactory performance of the system

16 Sprinkler Heads

16.1 Sprinkler heads shall be quartzoid bulb type with gunmetal body fully approved and having current certification of the fire laboratory of the C.B.R.I. Roorkee, Underwriter's laboratory (UL) and under the approved certified list of the Fire Office Committee (FOC) of U.K. or NFPA of USA. Any one of the certification as acceptable to the local fire authorities obtained prior to the procurement and approved and accepted by the Project Manager.

16.2 Sprinkler heads shall be installed in conformity with approved shop drawings and in co-ordination with electrical fixtures, ventilation ducts, cable galleries and other services along the ceiling.

16.3 Following type of sprinklers shall be used:

S.No.	Type of Sprinkler	Temp rating
a)	Pendent /Upright type	68°C
b)	Sidewall	68°C

16.4.1 Spacing and coverage of sprinkler shall be in accordance with risk classification of area in which they are installed, design density and TAC regulation.

17 Spare Sprinklers

17.1 Provide a lockable enamel painted steel cabinet including following type of spare sprinklers

a)	Pendent /Upright type	20
b)	Sidewall	10

17.2 The cabinet should also contain one pair of wrenches (of each size of the same are different) for the sprinklers.

17.3 Spare sprinklers shall be of the same specifications as that of the original sprinklers specified.

18 Testing

18.1 All piping in the system shall be tested to a hydrostatic pressure of 1.5 times the working pressure or 14 kg/sq.cm(whichever is more) without drop in pressure for at-least 2 hours.

18.2 Rectify all leakages, make adjustments and retest as required and directed drill.

19 Annunciation Panel

- Provide one solid state electronic annunciation panel, fully wired with visual display unit to indicate:
- low condition in any flow indicating valve
- The panel should give a visual and audible alarm for any of the above conditions.
- The panel should be standard manufacturer's factory made. All details shall be submitted with the tender.

20 Cables

- 20.1 Contractor shall provide control cables from supervisory valves and switches to the annunciation panels.
- 20.2 All control cables shall be copper conductor PVC insulated armoured and PVC sheathed 1100 volt grade.
- 20.3 All cables shall have stranded conductors. The cables shall be in drums as far as possible and bear manufacturer's name.
- 20.3 All cable joints shall be made in an approved manner as per standard practice.
- 20.4 Cable Trays
- 20.5 All cables shall be routed in approved locations in coordination with all other services in a proper manner.
- 20.6 Cable trays shall be of galvanized steel and hung from the ceiling by galvanised rods supported by appropriate size and type of expandable expansion fasteners drilled into the slabs and walls by an electric

21 Cable Trays

- 21.1 All cables shall be routed in approved locations in coordination with all other services in a proper manner.
- 21.2 Cable trays shall be of galvanized steel and hung from the ceiling by galvanised rods supported by appropriate size and type of expandable expansion fasteners drilled into the slabs and walls by an electric drill.

22 Measurement

- 22.1 Mild steel pipes shall be measured in linear metres of the finished length correct upto one cm. and shall include all fittings, flanges, welding, jointing, clamps for fixing to walls or hangers, anchor fasteners, painting and testing complete in all respects.
- 22.2 Sluice and fullway valves, check valves, installation valves, air valves & flow switches shall be measured by numbers and shall include all items necessary and required for fixing and as given in the specifications and bill of quantities.
- 22.3 Fire hydrants, hose reels, fire brigade connections, orifice flanges shall be measured by number and include all items given in the specifications and bill of quantities.
- 22.4 Fire hose and boxes specified shall be measured by number and include all items given in specifications and Bill of Quantities.
- 22.5 Cables and cable trays shall be measured in linear metre correct upto cm shall include clamps, hangers, anchor fasteners complete in all respects.

Hand Appliances

1 Scope of work

- 1.1 Work under this section shall consist of furnishing all labour, material, appliances and equipment necessary and required to install fire extinguishing hand appliances.
- 1.2 Without restricting to the generality of the foregoing the work shall consist of the following: -
Installation of fully charged and tested fire extinguishing hand appliances CO₂ foam, dry chemical powder type as required by these specifications and/drawings.

2 General requirements

- 2.1 Fire extinguishers shall conform to the following Indian Standard Specifications and shall be with ISI approved stamp as revised and amended up to date :-

- 2.2 Fire extinguishers shall be installed as per Indian Standard "Code of Practice for Selection, Installation and Maintenance of Portable First Aid Appliances" I.S.2190-1962.
- 2.3 Hand appliances shall be installed in readily accessible locations with the appliance brackets fixed to wall by suitable anchor fasteners.
- 2.4 Each appliance shall be provided with an inspection card indicating the date of inspection, testing, change of charge and other relevant data.
- 2.5 All appliances shall be fixed in a true workmanlike manner truly vertical and at correct locations.

3 Measurement

Fire extinguishers shall be measured by numbers and include installation and all items necessary and required and given in the specifications.

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