INTERFACE MANAGEMENT DOCUMENT

Annexure VI to General Scope of Work

Major Equipment in CE Contract

S.No.	Items
1	Power cables from highest size upto 120 sq mm cross sectional area
2	All Electrical Panels
3	Fire Fighting Pumps
4	Fire Alarm Panel
5	UPS
6	Sandwich type Bus Duct

Annexure VII to General Scope of Work

(TO BE SUBMITTED WITH THE TECHNICAL PACKAGE AS PER FOT- APPENDIX13)

MINIMUM LIST OF TOOLS & TEST EQUIPMENT

(Refer clause no. 7.2 of Annexure V to General Scope of work and Chapter 13 of GS)

MINIMUM LIST OF TOOLS & TEST EQUIPMENT (For each schedule of each Lot)		
S.No.	**DESCRIPTION**	**QUANTITY**
1	VACUUM VLEANER (With Extension)	1 for each Station
2	AIR BLOWER	1 for each Station
3	LED TORCH	2 for each Station
4	TESTER	2 for each Station
5	CRIMPING TOOL suitable for installed sizes of cable	1
6	HACKSAW	1 for each Station
7	TOOLS KIT	1 for each Station
8	MAGNET	1 for each Station
9	ROPE NYLON 50 METER	1 for each Station
10	HAND HELD DRILL MACHINE	1 for each Station
11	PLIER SET	1 for each Station
12	ALUMINIUM LADDER	1 for each Station
A)	4 FEET (A Type)	1 for each Station
B)	20 TO 36 FEET EXTENDABLE	1 for each Station
13	FIRST AID BOX with medicines	1 for each Station
14	KEY BOX suitable for 40 keys	1 for each Station
15	SCREW DRIVER SET consisting of at least-	1 for each Station
A)	SCREW DRIVER-6"	1 for each Station
B)	SCREW DRIVER-8"	1 for each Station

C)	SCREW DRIVER-10"	1 for each Station
D)	SCREW DRIVER-12"	1 for each Station
16	SPANNER KIT consisting of at least-	1 for each Station
A)	D end SPANNER-6/7 TO 22/23,24/27,30/32	1 for each Station
B)	Ring SPANNER-6/7 TO 22/23,24/27,30/32	1 for each Station
17	CROW PLIER	1 for each Station
18	TORQUE WRENCH	1 for each Station
19	PIPE WRENCH suitable for 150 mm pipe	1 for each Station
20	ADJUSTABLE WRENCH	1 for each Station
21	HAMMER (2 Kg)	1 for each Station
22	CHISEL FLAT	1 for each Station
23	ALLEN KEY set	1 for each Station
24	SCISSOR	1 for each Station
25	SPIRIT LEVEL	1 for each Station
26	HYDRAULIC OPERATED HANDLING TRUCK SUITABLE FOR HANDLING ALL SIZES OF AIR CIRCUITS BREAKERS	1 for each Station
27	DRILLE MACHINE	1 for each Station
28	TESTING EQUIPMENT	
A	VIBRATION METER	1 for each Station
B	NOISE LEVEL METER	1 for each Station
C	ANEMOMETER	1 for each Station
D	TECHOMETER	1 for each Station
E	MEGGER	1 for each Station
F	TONG TESTER	1 for each Station
G	PITOT TUBE	1 for each Station
H	AIR FLOW MANOMETER	1 for each Station

I	DRY AND WET BULB THERMOMETER	1 for each Station
J	DIGITAL MULTI METER	1 for each Station
K	DIGITAL ENERGY METER	1 for each Station
L	GAUGE PRESSURE METER	1 for each Station
M	DIGITAL THERMOMETER	1 for each Station

Note:

1. The above list is indicative and not exhaustive. If any additional Tools & Test Equipment are required the same may be indicated by the Firm in their Technical Offer. However, nothing extra will be paid for any additional Tools & Test Equipment indicated by the firm.
2. The cost of Tools & Test Equipment listed above for maintenance during DLP has to be included in the quoted prices. Nothing extra will be payable for such Tools & Test Equipment.
3. If any additional Tools & Test Equipment apart from the ones mentioned above are required during the DLP period the same will be arranged by the contractor, without any Extra Payments.
4. This will not absolve the contractor of his responsibility to fulfill the DLP obligations as per relevant clauses of bid conditions.
5. Contractor has to ensure availability of above Tools & Test Equipment along with Test certificates, calibration certificates etc. as per clause 7.2 of Annexure-V of Employers Requirements given in General Scope of work of Technical Specifications and Chapter 13 of GS.
6. The requirement given above is indicative and minimum in nature (for guidance purpose only). Prior approval of engineer-in-charge will have to be taken before supply of Tools & Test Equipment along with details regarding the make & model no. of items specified above.

6. INTERFACING WITH E&M CONTRACTIOR IN UNDERGROUND STATIONS (E&M) & ECS

6.1 GENERAL

Different consultants/ Contractors are assigned for the design and construction of various E&M facilities, including lighting, pumps, escalators, elevators,DG sets etc in the stations. These Consultants/Contractors are collectively referred to as E&M/ECS.

Underground Traction Contractor is responsible for supply and erection of various equipment in the Auxiliary Substations at the stations to step down the 33 KV Auxiliary power to 415 V AC and supply to the Station Auxiliaries. Underground Traction Contractor shall interface with E&M for various items of work.

6.2 ITEMS OF INTERFACE

The mains items of Interface are

- Supply and erection of Low voltage Switch Board (LVSB)
- Connection between Secondary of Auxiliary Transformer and the LVSB
- Low Voltage Protection
- Auxiliary Transformer Differential Protection
- Transformer door Interlock
- Lighting and Ventilation in ASS
- Earthing in ASS
- Ventilation/cooling requirements if any.

6.3 INTERFACE REQUIREMENTS

The interface requirements are described in Table 6.3.

Table 6.3				
Interfacing with E & M Contractors in Stations (E&M)				
Item No.	**Item Description**	**Underground Traction Contractor**	**E&M/ECS Contractors (E&M/ECS)**	**Remark**
1	Supply and erection of Low Voltage Switch Board (LVSB)		LVSB will be supplied and erected by E&M	
2	Connection between Secondary of Auxiliary transformer and the LVSB	Underground Traction Contractor shall ensure that facilities are available on the Transformer Secondary to receive cable or bus duct (Bus ducts will be used for transformers 1000 KVA and above)	Supply, erection and Connection by Bus duct or by cables will be done by E&M.	
3	Low Voltage Protection	Underground Traction Contractor shall ensure that the 415 V Breakers on the LVSB are provided with necessary protection relays to isolate faults on the LV side. CE shall also ensure that the tripping of 415 V Breakers shall also cause tripping of the corresponding HV breaker of the transformer, by inter tripping.	E&M shall provide the necessary protection relays on the 415 V Breakers and provide inter-tripping facilities (The HV Breaker will be provided by the CE).	
4	Auxiliary Transformer Differential Protection	Underground Traction Contractor will provide the necessary Differential protection relays, along with matching CT's for both HV. Contractor will interface with the LT contractor and provide the requirements & specifications of the LT CT. Contractor will do the necessary control cable connections between HV and LV.	E&M will supply & mount the relays and CT appropriately on the LV side. The connections of this LT CT are to be brought out at TB to be further taken for protection purposes.	
5	Transformer door interlock	Wiring and Interlock for transformer enclosure door will be provided by Contractor.		
6	Lighting and Ventilation in ASS	Contractor will advise to the E&M any special requirements or preferred location of lights, fans and exhaust fans.	E&M/ECS will provide Lighting and Ventilation arrangements.	
7	Earthing in ASS	Contractor will run an Earth Bus inside the ASS with suitable GI/copper flats. Various non-current-carrying metallic objects will be connected to the Earth Bus, by the Contractor. Connection between Earth Bus and MET's will be done by Contractor.	E&M will provide an Earth Mesh for the Station and provide risers to the ASS. E&M will provide at least 4 Main Earth Terminals (MET's) in the ASS, in addition to a separate Independent Met for SCADA	

			equipment in the ASS. Interconnection between ASS Earth and the Station Earth will be provided by the E&M.	
8	Ventilation in ASS	Contractor will advise to ECS any special requirements or preferred fans and exhaust fans, Cooling.	ECS will provide Ventilation arrangements.	
9	Cables support/path for power and control cables in tunnel/Box Section/Ramp	Contractor interface with the TBR to ensure correct and routing, openings etc.	E&M will provide cable paths/supports along the cable route, outside the ASS room, in accordance with cable route drawing.	

INTERFACE REQUIREMENTS BETWEEN TELECOM CONTARATORS

GSM/CDMA, AFC AND E&M/TRACTIONIOHE CONTRACTORS FOR STATIONS/DEPOTS/TUNNELS/RSS

Following requirement are listed for installation/provision by E&M/Tunnel/OHE contractors for Telecommunication work for Lighting, Air-conditioning, Cable tray/ladder, earthing. etc. requirements at Stations/Depot/Tunnels/RSS.

A. General Interface Requirement:-
   1. Cable Trays connectivity from TER to Various locations of Station and Tunnel as per Combined Services Drawing (CSD).
   2. During handover of TER availability of following item are to be ensured, as a minimum. AC power, Cable tray Risers, Air-conditioning. Lighting. AC pore sockets, data power tray connectivity.
   3. Telecom Data and Power trays to be marked with distinct color codes to avoid any ambiguity between telecom and other services trays.
   4. Cable tray junctions and T points should not have sharp bends and edges to avoid cable damage. The bending radius of minimum 1.5 m shall be provided.
   5. Data and power tray should have separation of at least 150mm between them at any place and if crossing is required there should be provision of a bridge to cross the cable tray. No electric tray closer than 300mm should be provided near Telecom Trays.

B. Lighting requirement
   6. Ac power points, indoor lighting facility and fire protection system to be done in TER, UPS, GSM/CDMA etc. Minimum 300 lux. Level of lighting at FFL to be provided with some lights with emergency supply.

C. Cable Tray installation requirement
   7. Data and Power cable trays are to be provided from TER to concourse, Platform, Road level areas. All Station Entrance/Exits, Technical Rooms, SCR, TOM, EFO, Security Room, ancillary Buildings, DG Room, Pump Room, Under croft in underground stations etc. Cable tray Risers/Droppers to be provided in TER and S&T shafts with connectivity from nearby Telecom trays provided.
   8. Cable Tray connectivity from Optical fiber cut-outs in platform beam is to be provided up to TER with draper up to floor level with route diversity.
   9. Data/Power Cable tray risers/droppers up to FFL to be provided in TER, TOM,EFO,SCR, Platform supervisory booth/Panel and any other Room with connectivity from nearby Telecom trays.
   10. Provision of Telecom Trays connectivity at Road level to be done for parking areas.

11. In case there is double height area at PF level, the provision of cable trays and mounting structures for GSM/CDMA antennas, CCTV cameras and PAS/PIDS/Clock equipment should be designed at appropriate height away from PF edge. Cable Trays should be provided in a manner so that minimum no of sleeves/cutouts is required for Telecom equipment installations.
12. Provision for Telecom Data and Power Cable/Cable tray connectivity to be done in all the utility buildings in Depots (All levels) with connectivity from the S&T trench.
13. Data/Power Tray Riser/Droppers in TER,DCC S&T shafts and other locations to be provided in connectivity of nearby telecom tray in Depots.
14. Data/power tray connectivity is to be provided in all utility building (All levels) including main gate in Depots from the pull pit connected with the trench. Data/Power Cable tray risers/droppers to be provided in TER, DCR etc.
15. Telecom Cable Tray connectivity for Platform Supervisory Booth/Panel (PSB/PSP) from the nearest S&T Tray.
16. Provision of cable trays connectivity is to be done on portals for installation of clocks, speakers, CCTV cameras in workshop, inspection bays and stabling yards etc in Depots.
17. For stations with radio base equipment, cable tray connectivity for two different locations (with route diversity) from TER to open sky at ground level to be provided for installation of GPS antennas.

D. Earthing requirement
18. At Elevated Stations/Depot, Provision & Extension of Main earth (<2ohm) to be done from Main Earth Mat location to TER, UPS (S&T) Room and SCR, Copper Bus bar with min 20 holes(10 per row) to be provided in TER, UPS (S&T) Room, SCR and DCC in Stations and Depots. Main earth extension with copper earth strip to be done in the GSM and CDMA rooms.
19. At underground stations, extension of Clean Earth (<1 ohm) & Main Earth (<2ohm) to be done from Earth Mat (Provided by Civil) to TER Copper Bus bar with min 20 holes (10 per row) to be provided in TER.
20. In tunnel main earth strips at cross passages for emergency telephones to be provided.

E. Air Conditioning Requirements.
21. Air conditioning to be installed for TER & UPS rooms. Drainage system of Air conditioning should be installed outside TER, & UPS rooms and only air outlet is to be provided inside rooms to maintain temperature nominal 25 degree continuous.
22. Clear height of 3 meter should be available in TER for telecom equipment installations. Installations of other contractors requirements (Air conditioners etc) shall be above 3 meter height.
23. There should not be any water flow or drainage pipe passing through TER.
24. Confirmation of Fire Safety Provisions.

F. TSS/RSS requirements.
25. For providing Telecom facilities at TSS/RSS (Outside the JMRC Premises) connectivity either by trench or by trenchless is to be provided by traction contractor along with their own cable route.
26. Telephone cabling inside the TSS/RSS building to be provided by E&M.

27. In RSS/TSS building control room, table for providing telephone, telephone rosette with connectivity required.
28. Provision of Cable trough/Trench with one bracket inside RSS boundary for laying telecom cable.
29. Provision of AC 230V for telecom (CCTV, CLOCK etc) requirements.

In addition to above following requirement to be installed/provided at underground stations & Tunnels.

30. Brackets/ hangers are to be provided on tunnel inner edge for laying of optical fiber cable emergency telephone cables GSM/CDMA Cables.
31. Cable tray connectivity is to be provided from Telecom brackets in tunnel to telecom cable trays in nearest S&T shaft.
32. Data/power cable tray connectivity is to be provided in mid shaft with connectivity from Telecom brackets in tunnel.
33. Provision of Temporary power and illumination in Tunnel to be provided for installation of emergency telephone and stand offs for LCX cable of GSM/CDMA/TETRA system Temporary lighting in Tunnel should not be provided in space reserved for GSM/CDMA/TETRA cables in Tunnel/

G. GSM/CDMA requirements.

34. During handover of GSM and CDMA names availability of following items are to be ---, as a minimum – AC power, Air-conditioning, Lighting, AC power supply cables, Earth (2ohm) copper strip with min 20 holes (10 per row).
35. GSM/CDMA cable trays are to be provided from GSM/CDMA Room to Concourse, Platform, under croft level areas and riser/droppers in S&T shafts etc. as per GSM/CDMA requirements.
36. Cable tray connectivity from GSM/CDMA from to open sky at ground level to be provided for installation of GPS antennas as per GSM/CDMA system requirements.
37. Provision of Power supply to be done in GSM and CDMA equipment Rooms as per GSM/CDMA operator equipment load requirements.
38. Clear height of 3.5 meter should be GSM/CDMA equipment installations.

7. INTERFACING WITH E&M CONTRACTORS IN STATIONS (E&M)

7.1 GENERAL

Different Consultants / Contractors are assigned for the design and construction

Various E &M facilities, including lighting, pumps, escalators, elevators, DG sets etc.

The stations. These Consultants / Contractors are collectively referred to as E&M.

Underground traction Contractor are responsible for supply and erection of various equipment in theAuxiliary Substations at the stations at step down the 33 kV Auxiliary powers to 415 VAC and supply to the Stations Auxiliaries. Contractor shall interface with E&M for various items of work.

7.2 ITEMS OF INTERFACE

The main items of Interface are:

- 415 V AC Distribution Board
- Connection from Transformer protection
- Low voltage protection
- Transformer door interlock
- Intertripping
- Lighting and Ventilation in ASS Rooms
- Earthing in ASS's
- Cable path for cables
- Secondary side connections of Auxiliary transformer.
- Differential & REF protections.

7.3 INTERFACE REQUIREMENTS

The Interface requirements are described in Table 7.3.

Table 7.3

Interfacing with E&M Contractors in Stations (E&M)

Item No.	Item Description	ROCS Contractor	E & M Contractors (E&M)	Remarks
1	Supply and erection of Low Voltage Switch Board (LVSB)		LVSB will be supplied and erected by E&M	
2	Connection between Secondary of Auxiliary Transformer and the LVSB	Contractor shall ensure that facilities are available on the Transformer secondary to receive cable or bus duct(Bus duct will be used for Transformer 1000 kVA and above)	E&M shall provide the necessary protection relays on the 415 V Breakers and provide inter-tripping facilities (The HV Breaker will be provided by the CE)	
3	Auxiliary Transformer Differential Protection	Contractor shall ensure that the 415 VBreakers on the LVSB are provided With necessary protection relays toisolate faults on the LV side. Contractor (CE) shall also ensure that the tripping of 415 V Breakers shall also cause tripping of the corresponding HV breaker of the transformer, by inter-tripping.	E&M shall provide the necessary protection relays on the 415 V Breakers and provide inter-tripping facilities (The HV Breaker will be provided by the CE)	
4	Auxiliary Transformer Differential Protection	Contractor will provide the necessary Differential protection relays, alongwith matching CT's for both HV and LV side will be handed over loose by the CE to E&M. CE will do the necessary Control cable connections between HV and LV side.	E&M will mount the relays and CTAppropriately on the LV side.	
5	Transformer door interlock	Wiring and interlock for transformerenclosure door will be provided by		
6	Lighting and Ventilation in ASS	Contractor will advise to the E&M any Special requirements or preferred location of lights, fans and exhaust fans.	E&M will provide Lighting and Ventilation arrangements	

7	Intercepting between main LV Circuit Breakers and the 33 kV MV Circuit Breakers of the Auxiliary Transformers	The intertripping circuits, as per requirements shown in specifications, will be provided Contractor for stations.		
8	Earthing in ASS	Contractor will run an Earth Bus inside The ASS with suitable GI/copper flats. Various non-current-carrying metallic objects will be connected to the Earth Bus, by the CE7 Connection between Earth Bus and MET's will be done by Contractor Connection between SCADA Equipments earth and the dedicated MET also be done by Contractor	E&M (or SBC) will provide an Earth Mesh for the Station and provide risers to the ASS. E&M will provide at least 4 Main Earth Terminals (MET's) in the ASS, in addition to a separate independent Met for SCADA equipments in the ASS Interconnection between ASS Earth and the Station Earth will be provided by the E&M.	
9	Viaduct Lighting	ContractorWill provide designs andGeneral Arrangements drawings for Viaduct lighting. ContractorWill lay the feeders along the Viaduct and connect up the luminaries and control gear, as per approved designs.	E&M will provide necessary outgoing feeder circuit breakers on the DB for Viaduct lighting, as per the designs.	Interfacing required with VDC also.

Table 8

Interfacing with E & M Contractors in Stations (E&M)

Item No.	Item Description	ROCS Contractor	E&M Contractor (E&M)	Remarks
1	Provision of cable Path-shafts, cable Supports for cables From RSS to Stations	Contractor will provide Necessary drawings & details for cable routing.	E&M contractor shall supply and install cable brackets/supports inside the cable gallery or shaft for the cables coming from RSS to the ASS	
2	Auxiliary Substances room facilities.	Contractor will provide ASS layout drawings showing equipment layout, access doors etc. Contractor will advise to the E&M any special requirements or preferred locations of lights, fans and exhaust fans.	E&M will provide ASS room complete in all respects, including lighting, ventilation, power sockets and Ventilators but excluding foundations for transformer and panels.	
3	415V AC Distribution Board		E&M will supply and install the 415 V AC Distribution Board in the ASS's. Incoming & Coupler Breakers and all outgoing feeders as per requirements at stations.	
4	LT Bus duct (Sand Witch type)/ 415V Cables from Transformer to MDB	Contractor will make all necessary arrangements in Transformer LT terminals and transformer enclosure For connection of Bus trunking adapter box and flexible links or 415V, 3.5Core multiple run cables directly without requiring any modifications inside transformer or transformer enclosure.	E&M will supply and install Bus Trunking, adapter box and flexible links Or 415V, 3.5Core multiple run cables	
5	CTs for transformer differential and REF protection	Contractor will supply and Install CTs on primary side inside 33KV CB panel including relays and interconnection with CTs on secondary side and integrate them as one system.	E&M contractor will supply and install CTs on secondary side and provide cable path for all cable connections inside the MDB. E&M contractor will associate with CE for testing and	

		Contractor will carry out testing & commissioning jointly with E&M contractor.	commissioning.	
6	33kV / 415 Auxiliary Transformer	Contractor will supply and install all protective devices for Auxiliary Transformer protection.		
7	Low Voltage protection	Contractor will co-ordinate the relay settings with LV side relays.	E&M Contractor will supply and interface with approved relay setting details to Contractor.	
8	Transformer door interlock	Wiring and all the interlock on HV & LV side for transformer enclosure door will be provided by Contractor	E&M Contractor will fix the lock provided by CE-Contractor in the MDB for transformer door Interlocking.	
9	Intertripping between main LV Circuit Breakers and the 33 KV MV Circuit Breakers of the Auxiliary Transformers	The intertripping circuits, as per requirements shown in specifications, will be provided by Contractor.	E&M contractor will interface with CE for connections, testing and commissioning.	
10	Earthing in ASS's	Various metallic objects in ASS will be connected through suitable G.I flats to the MET (Main Earth Terminal) by Contractor.	E&M Contractor will provide METs (Main Earth Terminals) for Body Earth and Transformer Neutrals inside the ASS and Interconnections between the ASS METs and Station earth Mat.	
		Connection from the transformer neutral to the MET for transformer neutrals will be provided through suitable G.I flats by Contractor		
		Contractorwill supply, install and connect cables.		

APPENDIX H			
INTERFACE BETWEEN AND E&M CONTRACTOR			
Item No.	Item Description	ROCS Contractor	E&M contractor
1	415 V AC supply for Switching post rooms	Provide load information and termination points and suitable MCB/MCCB on Distribution Board. Interface to ensure provision of suitable allocation of MCB/MCCB on DB of station E&M panel.	To lay the cable and terminate at designated point on Distribution Board of Switching post.
2	Ventilation and lighting in SP rooms	Provide information of total Ventilation and lighting requirements in SP rooms.	To install Ventilation and lighting in SP rooms.
3	Earthing of equipments in SP rooms	Provide information of total Earth risers and type, design of earthing required in SP rooms Connection from Earth risers to panels/equipments.	To provide Earthing as per design and Earth risers in SP rooms
END OF APPENDIX-H			

INTERFACE MANAGEMENT DOCUMENT FOR CIVIL, TUNNEL VENTILATION, ECS, E&M, POWER SUPPLY S&T, AFC, ESCALATORS, LIFTS AND TRACK CONTRACTS OF UNDERGROUND SECTION.

This document describes the interface responsibilities and obligations of civil contractor with other system contractors like Tunnel Ventilation, ECS, E&M, Power Supply, S&T, AFC, Escalators, Lifts and Track and vice versa. This document shall be made part of all these contracts so that clear responsibility of each contractor is defined in every contract. This document is for underground works only.

1. **ATTENDANCE ON OTHER CONTRACTORS**

(I) **Work Areas-** Civil to provide property leveled and debris free site storage space and works areas, access to and within the site, offloading and lowering areas for the use of all contractors. System contractors to advise requirements and date for handover to suit civil contractor's site program.

(II) **Cranes-** Civil to permit use of cranes on site by other contractors on a mutually agreed rental basis.

(III) **Scaffold-** Civil to permit other contractors the use of scaffolding erected at site but only to the timings advised by the civil contractor.

(IV) **Medical-** Civil to provide a first aid room at each station and the servies of a staff trained in First Aid. This will be for use by other system contractors also.

(V) **Water-** Civil to provide drinking water facilities and water supply points for the works at each end of the concourse and platform for the use of all contractors if they wish to use and may change at mutually agreed rates.

(VI) **Lighting-** Civil to provide general lighting to all areas and all rooms of the stations and tunnels required for a safe working environment as per lighting levels mentioned in SHE with uniformly distributed tube lights (Not by mere halogen lamps) is maintained at all times till permanent lighting becomes functional or ROD whichever is earlier. However, any shifting of light fittings provided by civil required by system contractor will be done by system contractor at his cost only.

(VII) **Power-** Civil to supply power distribution boards at each end of the concourse and platform and at 150m intervals along the tunnel length for the use of all contractors power capacity to suit the combined requirements of each contractor. The charge rate per unit of consumption is to be agreed with the system contractors. The power supply shall be maintained until 1 month after energization of the LV system at ASS level or the confirmation from the system contractor whichever is earlier.

(VIII) **Survey-** Civil to provide survey/setting out grid line and level references with in stations and tunnels.

(IX) **Cleaning-**Civil will be responsible for general site cleaning an d will identity common areas at each level for material to be deposited prior to removal Large items such as cable drums/heavy packing shall be cleared by the respective system contractors In case any system contractor fails to remove his material, the Engineer of Civil Contract after written notice of minimum one day to the system contractor remove his material, may instruct civil contractor to remove it and the cost of the same shall be borne by the system contractor. The decision of the Engineer of civil contractor shll be final and binding on civil as well as on the system contractor. Civil will hand over the rooms to respective system contractors in property cleaner condition and after providing proper lockable door without gap. Once technical room is handed over, the principal system contractor for that room will take over responsibility for cleaning the room.

(X) **Security-** Civil will be responsible for establishing a site security system to the approval of the Engineer. The system should ensure that no labour from any agency working at site may remove materials without written authorization from the civil security-in-charge. The system one approved by the Engineer of civil contract shall be binding on all system contracts.

(XI) **Safety-** Civil will be in overall charge of safety and will advise JMRC staff of and safety violation by system contractors requiring corrective action.

(XII) **Toilet-** Civil shall provide at his own cost adequate toilet facilities at ground level each station and 4 Nos of urinals at platform and 4 Nos. at concourse level at each station with adequate storage and pumping facilities to ensure hygienic conditions all times. These facilities shall be used by staff and labour of all system contractors also for which they shall pay only maintenance and running charges for usage mutually agreed rates. In case of disagreement in usage charges, the decision of Engineer of civil contractor shall be final and binding on civil as well as system contractors.

(XIII) **Drainage-** Civil contractor to provide and maintain temporary pumping arrangements until ROD or commissioning of permanent pumps whichever are earlier Civil and E&M contractors will coordinate to install permanent pumps such the drainage of the sup is not interrupted.

2. GENERAL INTERFACE REQUIREMENTS

(I) Civil to provide opening as per SEM drawings or Combined Services Drawing (CSD). Any change requested by system contractor in writing with the approval the Engineer of his contract before the work of opening is taken up by civil shall incorporated by civil. Any change in the opening size whether increase or reduction after this shall be the responsibility of the system contractor and he will do the sealing around the services including masonary/concrete work if required at cost.

Dimensions, locations, support details, interface with wall and veiling finishes acoustic requirements (if any)

(II) Civil to provide cutouts and recesses in slabs and walls for the passage of services as per the SEM drawings. Changes to the cutouts required after casting or block wall construction shall be to the account of the agency responsible for the change.

(III) Civil to design and build equipment foundations, Loads and other details are the given by respective contractor at least 90 days before these are required by him.

(IV) Change to any provisions with in the civil scope of work after completion, such as services opening, lifting/pulling hooks foundations, ducts, CE shall be to the account of the agency responsible for the change.

(V) Civil to prepare equipment delivery plans for major materials and plant of the system contractors showing temporary and permanent provisions in slabs and walls to permit future replacement of plant and to allow initial transport from ground level to final room location.

3. INTERFACE WITH INDIVIDUAL CONTRACTORS

A. CIVIL WITH TUNNEL VENT

(i) TVS contractor to supply the details of all loads, plant layouts equipment foundation for room sizes, knockout panels cutouts, recesses, shaft/gallery sizes and tunnel niche dimensions. Changes required to details incorporated in approved drawings to be provided well in advance of casting.

(ii) Civil to design and build rooms, room finishes, drainage, shaft, precast RCC slabs for covering the access hatch, galleries, cutouts, lifting/pulling hooks, walls for nozzles, niches in c&c tunnel roof, trackside knockout panels. Chequer plate infill around nozzles will be provided by the TVS contractor.

B. CIVIL WITH ECS

(i) ECS contractor to supply details of all loads, plant layouts, equipment foundations, room drainage requirements room sizes, pipe support pedestals, lowering hatches, cutouts, recesses, shaft/gallery sizes.

(ii) Civil to design and build rooms, room finishes, drainage, equipment foundations, pipe pedestals, shafts, cutouts, lifting/pulling hooks, canopy/slabs to cover access hatch as per drawing.

(iii) Civil to design and build architectural finishes in public areas with provision for ecs fixtures including cutouts in architectural finishes for passage of services and installation of fixtures.

(iv) S&T contractors to supply details of equipment located in station public area inc dimensions, locations support details, interface with wall and ceiling finishes acoustic requirements (if any).

C. CIVIL WITH E&M

(i) E&M contractor to supply details of all loads, plant layouts, equipment foundation room drainage requirements, room sizes, cutouts, recesses, cable gallery sizes, LV earthmat and earthing terminations.

(ii) Civil to design and build rooms, room finishes, drainage, equipment foundation shafts/galleries, cutouts & recesses in stations & tunnel cross passage lifting/pulling hooks earthmat, earthing risers through base slab to slab to earthing terminations.

(iii) E&M contractor to provide chequer plate/fire rated infill where openings in floot exceed the dimensions of the LV equipment.

(iv) Civil to design and build architectural finishes in public areas with provision for e&m fixtures including cutouts & provisions in architectural finishes for passage services and installation of fixtures.

D. CIVIL WITH POWER SUPPLY (ASS & ROCS)

(i) Power supply contractor to supply details of all loads, plant layouts, equipment foundations, room sizes (ASS, UPS, Sectioning room) cutouts, recesses cable gallery/shaft sizes cable ducts within slabs, lifting/pulling hooks, HV earthmat and earthing terminations.

(ii) Power supply contractor to make good any unused OCS bracket drill holes in the tunnel roof.

(iii) Civil to design and build rooms, knockout panels, room finishes, equipment foundations, shafts/galleries, cutouts, recesses, cable ducts within slab lifting/pulling hooks, earthmat, earthing risers through base slab to earthing terminations.

(iv) Power supply contractor to provide chequer plate/fire rated infill where opening floors or walls exceed the dimension of the HT equipment or due to any other reason.

(v) Civil to mark center line of track on the soffit of the tunnel.

E. CIVIL WITH S&T

(i) S&T contractors to supply details of all loads equipment layouts equipment foundations, room size & finishes details (SER, SMR, SCR, TER, UPS, mobile phone operators room), cutouts, recesses cable ducts within slabs, cable shafts clean earthmat and earthing terminations.

(ii) S&T contractors to supply details of equipment located in station public area in dimensions, locations support details interface with wall and ceiling finished acoustic requirements (if any).

(iii) Civil to design and build rooms, room finishes, equipment foundations, shafts/galleries, cutouts 7 recesses in stations and at tunnel cross passages, cable ducts within slabs, clean earthmat, earthing risers through base slab to earthing terminations. Civil to provide trenches in UPS room as per the drawings given by UPS contractor and shall provide trench covers with the required openings in the covers.

(iv) Civil to design and build architectural finishes in public areas with provision for coms fixtures including cutouts & provisions in architectural finishes for passage of services and installation of fixtures.

(v) Signaling contractors to provide false floor in SER Telecom contractor to provide false floor in TER. Civil to provide false floor in SCR and TOM.

F. CIVIL WITH AFC

(i) AFC contractor to supply details of all equipment layouts, equipment foundations, room sizes & finishes details (TOMS, EFO,SCR), cutouts recesses, cable ducts within slabs/screed.

(ii) AFC contractor to supply details of fare gates and barriers located in station public area in dimensions, locations, support details & interface with floor

finishes. The barriers will be provided by the AFC contractor to close the entire gap upto wall.

(iii) Civil to design and build rooms, room finishes, equipment foundations, cutouts & recesses, cable ducts within slabs, architectural finishes in public areas with provision for fare gates & barriers.

G. CIVIL WITH ESCALATORS

(i) Escalator contractor to supply shafts & pit dimensional data, and intermediate support details, earthing requirement, equipment loads cutout & recess details, lifting hook locations & details, services routes, delivery route and method of erection, ecp recess dimensions, SCR equipment layout.

(ii) Civil contractor to design and build escalator shaft with top and bottom supports, finishes meeting the escalator requirements at top/bottom and sides of escalator lifting hooks, pit, drainage and provision for cable and sides of escalator lifting hooks, pit, drainage and provision for cable and sprinkler pipe routing, ecp recess SCR layout and earthing terminals.

H. CIVIL WITH LIFTS

(i) Lift contractor to supply shaft dimensional data and details of cutouts, recesses, lifting beams, drainage, and provision for surface mounted fixtures.

(ii) Civil contractor to design and build lift shaft with cutouts recesses, provision for lifting beams, drainage rain shelter as per drawing and internal shaft plaster & plant finish.

I. CIVIL WITH TRACKWORK

(i) Civil to provide openings for rail lowering at least at every ultimate station or at alternate locations such that maximum hauling of rails is 2 Kms. The openings should be 20 m in length and 5 m in width unless agreed otherwise with the track work contractor. An area for rail storage at ground level and an access route from the public road thereto are to be provided by the civil contractor.

(ii) The timing for closure of these openings is to be agreed with the track work contractor and approved by the Engineer.

(iii) Track contractor to provide details for drainage of the track to the tunnel cross passage sumps and to station trackside drains.

(iv) Civil and track work contractors to jointly inspect the tunnels and station track areas before track concreting commences. The track work contractor is to hand over the tunnels after completing his work in the same condition as recorded in the joint survey.

(v) The track work contractor will be responsible for disposal of waste water resulting from his works such that the tunnels are maintained in an environmentally acceptable condition at all times.

TENTATIVE LIST OF

I/O POINTS

PROVIDED IN THE BMS BID

(FOR GUIDANCE PURPOSE ONLY)

Part-II E&M Specification

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E01LOW VOLATGE ELECTRICAL PANELS

1. DETAILED DESCRIPTION OF THE EQUIPMENT AND ITS APPLICATION IN DMRC: LOW VOLATGE ELECTRICAL PANELS

1.1 Metro stations namely Rail corridor stations, Under-ground stations as well as on-grade stations and Depot are provided with Electrical Panelsfor receiving and distribution of power supply to various usages as defined in various clauses at voltage level of 415 V/50 Hz. The usages are generally lighting, air conditioning system, ECS system, PD area and all other type E&M work which come under stations coverage. Switch boards and panels as per following list are provided for power supply distribution at metro stations and in depots.

1.2 The bidders shall refer the BOQ and drawing for incoming feeders, outgoing-feeders, indications, metering and protection details along with quantity and typeof each.

1.3 The panels are generally named as follows:

- Main Distribution Board (MDB)
- Sub-main Distribution Board (SMDB)
- Essential power panel (EPP)
- Emergency Power Panel (EMLP)
- Local Motor Control Panel (LMCP)
- Main Lighting Panel (MLP)
- Air conditioning Power panel (ACPP)
- Fire pump panel (FPP)
- Water pump panel (WPP)
- Passenger Amenities Panel (PAP)
- Light Distribution Boards (LDB)
- APFC Panel

1.4 The manufacturing , testing , installation and commissioning of complete 415 V, 3 phase, 4 wire and 50 Hz low voltage main switchboard is as defined in IEC/EN 61439-1, built up from compartments to house busbars , terminal blocks, internal and control wiring, instrumentation, relays, interlock and padlocking facility, emergency push buttons, equipment for BMS/ SCADA /RS 485/ Mod bus connectivity of communicable ACB/MCCB interface, indication lamps, control and auxiliary switches, contacts, control power supply, air circuit breaker, MCCB, MCB, CTs and PTs, APFCs and any other items considered necessary to deliver the functions of incoming and outgoing power supply as detailed in BOQ and drawing.

1.5 The equipments installed in each of the Electrical Panel are defined in the BOQ.

2. GOVERNING SPECIFICATIONS

Electrical Panels along with equipments shall conform to the latest standard or harmonize as per the respective standard as given below or specified along with the equipment in the specification.

In case of any conflict between specifications & the standards, the instructions/decision of the Engineer' or Employer's authorized representative shall be binding.

2.1 STANDARDS

Low voltage Electrical Panels shall satisfy the following requirements and shall also comply with standards in force when Electrical Panel units are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specification, the latest version of the standards shall be applicable)

STANDARD	DESCRIPTION
ISO STANDARD	
ISO 9001	Quality systems- model for quality assurance in design/development, production, installation and servicing
IEC STANDARD	
IEC 60228	Conductors of insulated cables
IEC 60255	Measuring relays and protection equipment
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60831	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V
IEC 60871	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V
IEC 60898	Electrical accessories – Circuit-breakers for over current protection for household and similar installations.
IEC 60947-6-1/EN 60947-6-1	Specification for low-voltage and control gear Multiple function equipment. Automatic transfer switching equipment.
IEC 60947-2/EN 60947-2	Specification for low-voltage switchgear and control gear circuit breakers.
IEC 60947-1	Specification for low-voltage switchgear and control gear. Contactors and motor-starters. Electromechanical contactors and motor-starters.
IEC 61008	Residual current operated circuit-breakers without integral over current protection for household and similar uses (RCCBs)
IEC 61439-3/EN 61439-3	Specification for low-voltage switchgear and control gear assemblies. Particular requirements for low-voltage switchgear and control gear assemblies intended to be installed in place.
IEC 61439	Specification for low-voltage switchgear and control gear assemblies
IEC 62262	Degrees of protection provided by enclosures for electrical equipment against mechanical impacts(IK code)
IEC 61641	Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault.
IEC 61869/BSEN 61869	Instrument transformers
IEC 61009	Specification current operated circuit-breakers without integral over current protection for household and similar uses (RCBOs)
IEC 62052-11, IEC 62053-21	Direct reading single/three phases meter (Digital Type) up to 600 V.
IS STANDARD	

IS 13779	ac Static Watt-hour Meters, Class 1 and 2
IS 13947-5-2	Low-Voltage Switchgear and Control gear, Part 5: Control Circuit Devices and Switching Elements, Section 2: Proximity Switches
IS 13947-5-1	Low-Voltage Switchgear and Control gear, Part 5: Control Circuit Devices and Switching Elements, Section 1: Electromechanical Control Circuit
IS 13947-4-1	Low-Voltage Switchgear and Control gear : Part 4 - Contractors and Motor-Starters
Is 13947-3	Low voltage switchgear and control gear, part 3: switches, disconnectors, switch-disconnectors and fuse combination units
IS 13947-2	Low-Voltage Switchgear and Control gear, Part 2: Circuit Breakers
IS 13947-1	Low-voltage switchgear and control gear, Part 1: General rules
IS 5553	Reactors – Specification
BS STANDARDS	
BS 381 C	Colour chart
BS 4800	Colour
BSEN60742/BS 3535/BS 61558	Isolating Transformers
BS 1432	Specification for Copper for electrical purpose high conductivity copper rectangular conductor with drawn or rolled edges.
BS 951	Electrical earthing. Clamps for earthing and bonding. Specification
BS 7430	Code of practice for protective earthing of electrical installations
BS EN 13601	copper and copper alloys - copper rod, bar and wire for general electrical purposes
IEC/BS EN 60947-4-1	Specification for low-voltage switchgear and control gear. Contactors and motor-starters. Electromechanical contactors and motor-starters.
BS EN 10025	Hot rolled products of structural steels
BS EN 50525	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U)

2.2 Abbreviations

ACB- Air Circuit Breaker

APFC-Automatic power factor correction

ALTS-Automatic Load transfer Switch

ATS- Automatic transfer switch

DB- Distribution board

EMC- Electromagnetic compatibility

LEP- Local Electrical Panel

LMCP- Local motor control panel

LT- Low Tension

LVDB-low voltage distribution board

ELECTRICAL PANELS- Low Voltage main switch board

BMS- Building management System

MCB- Miniature circuit breaker

MCCB-moulded case circuit breaker

MFM- Multi function meter

MPCB-Motor protection circuit breaker

RCCB- Residual current circuit breaker

RTU- Remote terminal unit

SELECTRICAL PANELS- Sub Main Distribution Board

TB- Terminal block

VFC- Volt free contact

3. TECHNICAL AND INSTALLATION REQUIREMENT

3.1 GENERAL AND TECHNICAL REQUIREMENTS OF ELECTRICAL PANELS

3.1.1 The Electrical Panel shall be same as low- voltage switchgear and control-gear assemblies defined in IEC 61439-1 or EN 61439-1 built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other equipment as defined in BOQ. All Type tests are from acceptable, accredited and independent testing laboratory.

3.1.2 All panels should be factory built of proven design with OEMs as well as switchboard manufacturer approved as covered by clause 3.10 of IEC 61439-1.

3.1.3 The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 for fault current ratings as defined in BOQ for a minimum time of 0.3 sec.

3.1.4 The degree of Ingress Protection for Electrical Panels shall be IP 54for underground and IP 42 for Elevated/Depot unless otherwise specified in BOQ,as defined in IEC 60529which shall not deteorate with time.

3.1.5 The Electrical Panels and the associated equipment, including switchgear and control gear assemblies shall be certified for the category of duty specified as per Annex A of IS/IEC 60947-1.

3.1.6 The main circuit as defined in vide clause 3.1.3 of IEC 61439-1 shall have an insulation voltage of 1000 V ACor as specified in the BOQ.

3.1.7 The ambient temperatureand ambient humidity for Electrical Panel shall be as per IEC 61439-1 (clause 7.1.1 and 7.1.2 of IEC 61439-1) and Switchgear shall be as per IEC 60947(Clause 6.1.1 and 6.1.3 of IEC 60947).

3.1.8 The secure service life of Electrical Panels shall be at least 30 years as defined in General Scope of Work. The design features to secure the service life of 30 years shall be submitted at the time of design approval.

3.1.9 The Electrical Panel shall have a rated short time withstand current of 70 kA, 65 kA, 50 kA and 35 kA for 1 second as per BOQ.

3.1.10 The Electrical Panels shall be a minimum of Form 4b Type 5 in accordance with BS EN 61439-2/IEC 61439-2&Eiema's Guide To Forms OfSepration.

3.1.11 **All materials like busbar supports etc used in the panels shall be Low Smoke Zero halogen and Thermosetting type.**

3.2 ELECTRICAL PANEL CONSTRUCTION

3.2.1 The panels shall be of the approved design to suit local conditions as prevailing at different metro stations.

3.2.2 The Electrical Panel (other than DB) shall be designed for indoor use in the form of free standing, floor mounting extendible, self contained, flush fronted cubicles and sectionalized as necessary to face easy transportation and erection, containing all the equipment indicated on the Drawing, BOQ and specified hereinafter.

3.2.3 The cubicle section shall be constructed of angle iron types frames or folded sheet steel or fully welded/bolted construction with all necessary removable covers. Removable lifting lugs shall be provided on the top of the cubicles. Cubicle sections shall be provided with bolts or devices for insuring that they are correctly aligned when being coupled together. The bus bar chamber shall be fitted with removable end cover plates secured by mild steel captive screws.

3.2.4 It shall be finished to provide a rigid shell type of enclosure in accordance with BS EN 10025.

3.2.5 The load bearing parts of the entire electrical panel assembly shall be 2 mm CRCA thick sheet whereas other partition parts shall be constructed of minimum 1.6 mm CRCA thick sheet steel.

3.2.6 The Electrical Panels shall be mounted on a robust base frame made up of steel channel with a minimum height of 100mm and the maximum height of Electrical Panel shall not exceed 2.40 meter including base frame. The base frame shall be able to withstand the static and dynamic loads of the Electrical Panels. The steel channels shall be painted with epoxy polyester paint. The main contractor shall ensure that the maximum height of the Electrical Panel at the site of installation shall not exceed 2.6 meter including foundation if any.

3.2.7 Electrical panel shall have provision for top/bottom in-coming and bottom/top out-going to suit site conditions of cable entries.

3.2.8 Non-magnetic gland plates of not less than 5 mm thick of suitable size shall be provided at the top and bottom of the LV main switchboards for the termination of incoming and outgoing power cables of size 120 sq. mm or more or bus ways and 3 mm thick for cables of size less than 120 sq. mm. Where armoured multi-core cables terminate inside the switchboard enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard.

3.2.9 Glanding plates, glanding brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated. The cables shall not put any stress on to the glanding plate and shall be secured adequately.

3.2.10 All relays and indicating instruments shall be at least 300 mm and not higher than 1.8 m from base frame. The clearance in front, back and side of all assemblies of switchgear and control gear shall beas per latest IE rule. .

3.2.11 Various units comprising a complete Electrical Panels shall be grouped in a multi-tier arrangement including a cabling and wiring chamber of ample dimensions to accommodate terminal blocks, cable boxes and gland plates.

3.2.12 The equipment shall be arranged within each compartment such that all normal maintenance can be carried out through hinged access doors or removable covers, and where possible from the front.

3.2.13 Adequate maintenance access shall be provided to equipment within the Electrical Panels. Demountable panels shall be provided at the back of the Electrical Panels that can be handled by a single person. Every demountable panel shall be provided with a pair of handles for easy removal and fixing.

3.2.14 Front access door shall be fixed with concealed hinges and interlocked with the switch mechanism. The door panel can be opened only if the switchgear is in the "OFF position" or the switchgear should switch off if the panel door is opened.

3.2.15 Ventilating louvers along with filter, where required, shall ensuringcompliance of IP 54. It shall be provided in such a way that it is easily accessible for cleaning or self cleaning filters shall be proved.

3.2.16 Anti-condensation heaters shall be provided at the rate of 60 W for each vertical of the Electrical Panels, incase the volume is greater than 1 cubic meter of one vertical then 2x60 W heater shall be provided. The heaters shall be of an enclosed tubular pattern, each separately fused/ MCBs and switch. Each heater shall be controlled by means of a step adjustable humidistat.

3.2.17 Adequate arrangements for air circulation shall be made within each compartment of the Electrical Panels, if required. The Contractor shall ensure that the internal temperature of the Electrical Panels will be well within the operating ranges as specified by IEC 61439-1of all electric components including switchgear, control gear, bus bars, relays, wiring and timers inside the Electrical Panels.

3.2.18 All the incoming / outgoing terminations shall be extended via copper connections into a separate termination chamber adjacent to the switchboard. When busbars are used between switchboards, the internal busbars of the switchboard shall beoftinned copper bars sizes of copper shall be as per tested design. No linking of busbar or incoming/outgoing terminals with switchgears/functional units shall be permitted with cable except in case of MCCBs./MCBs below or equal to 100 Amps rating.

3.2.19 The switchgear assembly/sub-assemblies or panels shall be termite and rodent proof.

3.2.20 The switchboard shall have sufficient space to house all electrical equipment allowing spare Space capacity of 10% for the future expansion if specifically asked in BOQ

3.2.21 Spare feeder shall be provided as per BOQ. Any Panel which comprises an assembly of similar modules shall be constructed such that further similar modules can be added at either end.

3.2.22 All similar items of the Electrical Panels and their component shall be interchangeable. Spare parts shall be manufactured to originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings accompanying the instruction manuals.

3.2.23 The Electrical Panel shall operate without excessive vibration and with a minimum of noise as per best of engineering practice and shall also operate without excessive temperature rise at the rated load conditions.

3.2.24 The style and finish of the workmanship shall be consistent throughout the Works. Unless otherwise specified, Engineer shall decide the final colours for all paintwork and other finishes to be applied to the Electrical Panels.

3.3 ELECTRICAL PANEL EARTHING AND SAFETY ARRANGEMENT

3.3.1 All non-current carrying metallic components shall be permanently connected to earth.

3.3.2 Material used for the earthing busbar shall be same as the main busbar.

3.3.3 The tin-plated copper earthing busbar inside the panel shall have cross-sectional area as per calculation given in Annex B.

3.3.4 A continuous earthing busbar shall be provided along the whole length of each Electrical Panels and shall be provided with terminals for connection to the metal housing of incoming busways, cable trunking and cladding or armouring of all incoming and outgoing cables and to the substation earth.

3.3.5 Switchboards shall be provided with two earthing terminals, one at each end, for the connection of external earth conductor for earthing. The earthing bars shall be fixed at rear interior bottom portion throughout the length of the switchboard, bonding all gland plates, and other component parts of the switchboard to a main earth point adjacent to the intake position in accordance with BS 951 and BS 7430.

3.3.6 All terminals, connections, relays and other components which may remain live when access doors are open shall be screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

3.3.7 Where several outgoing circuits occupy a common cabling chamber, all copper work, cable lugs, terminations and terminal blocks shall be fully segregated by compartmentation to enable work on any one circuit to be carried out with other circuits remain live.

3.3.8 Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts Control cables shall be segregated from primary conductors.

3.3.9 The protective earthing configuration shall be TN-S unless otherwise specified.

4. EQUIPMENT INSTALLED INSIDE ELECTRICAL PANELS

Electrical panels consist of Low Voltage Switchgear, control wiring and all other parts which are defined below.

4.1 BUSBAR

4.1.1 Busbars shall be of rectangular section hard drawn high conductivity tinned copper bare type conform to BS 1432/13601adequately rated for designed value and fault level of load as per BOQand supported by non-tracking moulded insulators spaced at suitable intervals. The complete assembly shall be capable of withstanding the maximum mechanical stresses to which it may be subjected to under fault conditions.

4.1.2 Sizing of the busbar shall comply with IEC 60890 for temperature rise assessment by extrapolation and in case of copper busbar temperature rise as per Copper Development association latest formula, may also be used.

4.1.3 Bus bar rating shall be same through out the length of panel and shall be as per BOQ type tested design and recommendation of IEC 61439. The bus bar shall be designed for easy extension in future at either end.

4.1.4 Busbars and busbar connections shall be constructed in accordance with the requirements of IEC 61439-1. The short-time withstand current rating shall be as mentioned in BOQ for 1 second at 415 V.

4.1.5 Connection in Bus bars shall be made as approved and proven design oforiginal manufacturer.

4.1.6 The maximum temperature of the bus bars and the bus connections shall be as per IEC 61439 standard.

4.1.7 The main busbars shall be so positioned and arranged that all busbar risers and droppers can be brought onto the main busbars without undue bending. Busbars shall be and supported with appropriate clearances in air to the requirement of providing full insulation.

4.1.8 Busbar chambers of similar rating shall be capable of coupled together using busbar coupling links, in accordance with the manufacturer's recommendation. Coupling links shall be approved by the Engineer before use.

4.1.9 Interconnecting conductors between busbar chambers and switchgear shall be as per rating of switchgear and type tested design.

4.1.10 Switchgear shall be joined to busbar chambers by means of properly designed busbar chamber connection flanges or conduit couplers and male bushes. Connection flanges shall be manufactured from galvanized sheet steel or CRCA and finished grey.

4.1.11 Busbars shall be coloured for phase identification at location of bus inspection points with the approval of site Engineer. The material for phase identification shall be non-fading colour of proven design to be decided by the Engineer and use of adhesive label shall not be acceptable.

4.1.12 The front cover and end plates of busbar chamber shall be removable and normally held in position by non-ferrous metal screws.

4.2 POLARITY

4.2.1 The polarity of all apparatus shall be arranged as follows when viewed facing the front of the Electrical Panels:

a) For two pole apparatus, phase pole and neutral pole when reading from top to bottom or left to right; and

b) For three or four pole apparatus, red, yellow and blue phases and neutral when reading from top to bottom or left to right.

4.2.2 All cables shall be so connected within the Electrical Panels such that the correct sequences are preserved throughout.

4.3 CONTROL SUPPLY

4.3.1 Separate control bus of suitable rating made of copper shall be provided through out the panel length, and the control bus should be accessible from the front/back of the panel. Control voltage taping for different feeder shall be done with proper clamp.

4.3.2 The control circuit shall be separated from other auxiliary circuits, i.e. indicating circuit, heater and lighting circuits, with dedicated circuit protective devices.

4.3.3 240V control supply will be available from the station UPS with standby utility or as decided by engineer at site. DP MCB protection shall be provided at incoming.

4.3.4 240V Volt sensing relay with volt free contacts shall be provided for sensing the control supply for local and remote indication to BMS/SCADA.

4.4 INSTRUMENTATION

4.4.1 Electrical meters shall conform to IS 13779 / IEC 62052-11 62053-22 suitable for single phase /three phase supply system in all respects. Accuracy of metersshall be of class as specified in BOQ.

4.4.2 All meters shall be digital type and multifunction meters should be with RS 485 connectivity to suit BMS System wherever mentioned in BOQ. Suitable memory and software for logging the information along with real time metering information must be available. The meters must have required level of protection and sufficient number of auxiliary contacts.

4.4.3 Meters shall be suitable for continuous operation as per IEC 898.

4.4.4 Meter shall be suitable for 3 phase, 4 wire systems, balanced as well as unbalanced load. All instruments and associated apparatus shall be capable of carrying their full-load current without undue heating. They shall not be damaged by the passage of fault currents up to the rating of the associated switchgear through the primaries of their associated instrument transformers. The instrument meter shall be earthed by a conductor of not less than 2.5mm^2 cross-sectional area.

4.4.5 Energy meters shall be two / three element, switch board mounting type suitable for unbalanced loads. In case of two incoming feeders, a summation C.T. shall be provided with the meter.

4.4.6 The display for meters i.e. ammeter, voltmeters or multifunction meter shall be auto-ranging type.

4.4.7 Selector switches shall be inbuilt in Voltmeter such that voltmeters can read voltages between phase and phase and between phase and neutral.

4.4.8 Ammeters shall normally be suitable for 5A secondary of current transformers

4.4.9 Voltmeter circuits shall be provided with protection through MCB as required.

4.4.10 Separate current transformers for a feeder shall be provided for protection device and for instrumentation.

4.4.11 **Current Transformers (CTs) and Voltage Transformers (VTs)**

4.4.12 CTs and VTs shall comply with IEC 61869/BSEN 61869 and CTs shall be of the epoxy resin encapsulated ring type. The ratings specified on the Drawings are indicative only and it shall be contractor/manufacturer's responsibility to ensure that the ratings offered are adequate for the relays/meters provided considering lead resistance, etc.

4.4.13 Current transformers shall comply with approved standard and shall be compatible with and provide the necessary accuracy, over current factors, characteristics, performance and VA rating for the satisfactory operation of the relevant protection devices, instruments and meters.

4.4.14 All CTs shall have a short-time current rating as specified in IEC 60044-1.

4.4.15 CTs for protection shall be compatible with the protection relays to ensure that the CTs will not be saturated up to the maximum prospective fault current.

4.4.16 CTs designed for unit protection schemes shall be able to withstand a stability of not less than the maximum through-fault of the units.

4.4.17 In balanced circuits, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

4.4.18 CTs for use in conjunction with protection relays shall be of class 5P accuracy or better. CTs for use in conjunction with measuring instruments shall be of Class 1 accuracy. The product of rated accuracy limit factor and rated output of the protection CTs shall not be less than 20 times the total rated burden of the trip circuit including the relay, connection leads and O/C release where applicable.

4.4.19 All CTs shall have output ratings adequate to cater for the burden connected to them. The Contractor shall demonstrate to the satisfaction of the Employer representative. By calculation or by test, that each group of the CTs, when installed and having the secondary burden connected, is capable of operating the relays and other measuring instruments in accordance with the manufacturer's published characteristics and the requirements of the system, with a reasonable margin of safety.

4.4.20 Measuring CTs shall be connected to test terminal block. The test blocks shall be provided with easily removable links and designed to facilitate connection of testing instruments on load without open-circuiting the CTs.

4.4.21 The secondary circuit of each set of CTs shall be earthed at one point only through a disconnectable copper link at a readily accessible position for testing.

4.4.22 Multi-ratio CTs (where used) shall have a label clearly indicating the connections required for the alternative ratios. These connections shall be shown on panel wiring diagrams.

4.4.23 Identification labels shall be fitted, mentioning type, ratio, rating, output and serial numbers.

4.4.24 VTs shall be provided with adequately rated primary and secondary fuses.

4.4.25 Instruments shall be similar in appearance throughout the whole of the Electrical Panels. All instruments, meters shall be of flush pattern, dust and moisture proof, suitable for the environment in which they are installed.

4.4.26 All instruments and meters shall be completely segregated in instrument compartments. Compartments containing these devices shall not contain any terminals or equipment operating at higher voltages with the approval of site Engineer.

4.4.27 The housing shall be of steel or phenolic mould. Design and manufacture of meters shall ensure prevention of fogging of instrument glass. Selector switches shall be provided for ammeters and voltmeters used in three-phase system. This selector shall be of built-in type with meters.

4.5 RELAYS

4.5.1 The relays are having in-built function with protective gears such as ACB, MCCB and MCB and MPCB etc. In case any relay is required for additional protection as stated in BOQ or otherwise, the same shall be provided to ensure full protection to the system.

4.6 EMERGENCY PUSH BUTTON (EPB)

4.6.1 Emergency lock and key type push buttons shall be installed wherever required or specified in BOQ to de-energize the Electrical Panels in the event of an emergency. The EPB shall be button type with flat surface protection guard ring and pressed-in design with key reset so that accidental triggering and vandalism shall be avoided as far as possible. Transparent hinged cover shall be provided in front. Unless otherwise specified on the Drawings, the EPB shall be mounted at 1300$\pm$100 mm above finish floor level. The button design and the installation details shall be submitted for approval.

4.7 INTERLOCK AND PADLOCKING FACILITIES

4.7.1 Mechanical key interlocks shall be provided wherever applicable or as specified in BOQ and shall be so designed as to avoid mal-operation at the point of manual application. The scheme shall be such that attempts to remove a captive key shall not result in tripping or opening of the device.

4.7.2 The tripping of the ACB(s) shall be via local hard wiring control and in Signal(s) shall also be generated from circuit breaker(s) upstream of the corresponding Electrical Panels and the switchboard interconnected section ACB.

4.7.3 Electrical interlocks on withdrawable equipment shall be so arranged that if the equipments are withdrawn, the complete operation of the withdrawn equipment shall be independent of the remote interlocking contacts. In addition, interlocks shall not be defeated leading to damages or unsafe operations of Electrical Panels due to the withdrawing of equipment.

4.7.4 Locking facilities shall be provided where appropriate for switches and isolators in order that they may be locked in the open position. Switchgear cubicle access doors shall be equipped with integral type locks, preferably incorporated in the handles of the equipment.

4.7.5 Where locking facilities are of the integral barrel type, the key for each lock shall be unique to the associated lock unless otherwise specified.

4.7.6 Two keys shall be provided for every lock supplied. The keys shall be fitted with rings with identification labels, and cabinets with glazed front- opening doors shall be provided. The cabinets shall be adequate in size and equipped with hooks to house all keys when not in use, and shall be mounted in positions to be decided.

4.8 INTERNAL AND CONTROL WIRING

4.8.1 All equipment shall have adequate provision for the entry and termination of all associated power and auxiliary cables.

4.8.2 Cable entry shall in all cases, except where otherwise specifically approved, and be at the base of the equipment. All cabling and wiring within the Electrical Panels shall be neatly run and fitted in or upon such cable trays, trunkings and conduits as may be appropriate to the layout and equipment. Cable trays, trunkings, conduits and cleats shall be non - metallic and shall be of the low smoke halogen free material.Metallic cleats is acceptable with the approval of the site Engineer.

4.8.3 LSZH and Fire Survival Cables shall be as specified in cable specification Section (BS 6724-multicore cable and BS 7211 for single core cable). All internal and control wiring shall be Low Smoke Zero Halogen (LSZH) copper conductor wires rated at 450/750 V complying with BS 7211 for this Specification. All control wiring within the Electrical Panels shall be with single core minimum 2.5 mm^2 for CT and balance as per approved manufacturer design. Insulation shall have a glossy finish, be resistant to oil and be incapable of supporting combustion. Fire Survival wires shall be provided as per BOQ.

4.8.4 Wiring from the fixed part of the switchboard to the movable part such as hinged door shall be enclosed by flexible tubing made of Low smoke Zero Halogen material. Exposed live terminals shall be suitably shrouded or covered.

4.8.5 Wiring passing out to fully accessible positions shall be run in non-metallic low smoke halogen free flexible tubes or conduits.

4.8.6 All internal wiring shall be neatly run and securely fixed in non-metallic cleats in such a manner that, wherever practicable, wiring can be checked against diagrams without removal of the cleats.

4.8.7 Access opening shall be fitted with a suitable long lifegrommet where inter-panel wiring passes through panel side sheets etc.

4.8.8 Bus-wires shall be fully insulated. Bus-wires terminals shall be fully accessible from the point of entry to each enclosure. MCB and links shall be provided to enable all control circuits within the Electrical Panels to be isolated from the bus-wires.

4.8.9 All control circuits shall be protected by a MCB.

4.8.10 There shall be no joint in conductors between terminal points.

4.8.11 Terminations for terminals shall be of the crimped-on ring type. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

4.8.12 No more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

4.8.13 Wiring for all known future equipment shall be provided and all wires shall be terminated.

4.8.14 All wires between the terminals of two equipment shall be given a unique number according to an approved system. A wire number shall not change solely by virtue of passing through, say, a marshalling terminal block.

4.8.15 In the interests of uniformity, the wire-numbering system shall be approved by the Engineer.

4.8.16 Identification markers shall be fitted to all wires and multicore cable tails within enclosures in accordance with the diagram for apparatus concerned. Cable and core makers shall be of insulation material, colored according to the wire numbering system with a glossy finish, be resistant to oil and be incapable of supporting combustion. Numbers shall not be duplicated unless the corresponding wires are directly in series or parallel

4.8.17 Different insulation colours shall be provided to distinguish the various circuits. All wiring shall conform to the colour and ferrule codes to be approved by Engineer.

4.9 TERMINAL BLOCKS

4.9.1 Both incoming and outgoing cable shall have top or bottom entry depending on site requirement.

4.9.2 Each terminal block compartment shall have not less than 20 % or 4 spare terminals whichever is greater.

4.9.3 Terminal blocks for low voltage wiring shall be moulded from high-grade non-hygroscopic melamine, comprise bank of rail-mounted blocks with all live parts fully shrouded, screw- clamp, spring loaded insertion, solder-lug or stud type terminals as appropriate to the design and duty of the cables to be terminated. Pinch-type screws, where the screw is in direct contact with the conductor, shall not be used.

4.9.4 Each terminal shall be provided with claw-type washers, crimp lugs or other approved means for connection of the wires. Plain and spring washers, nuts and lockouts shall be electro-tinned.

4.9.5 Terminals shall be assembled in banks and each terminal shall be complete with marking tags to fit into moulded tag slots.

4.9.6 Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities and an integral disconnecting device to facilitate testing.

4.9.7 Terminations shall be grouped according to function and no more than two wires Connected to one terminal. Labels shall be provided adjacent to the terminal block to identify the function and voltage of each group.

4.9.8 All terminals to which 240 V or 415 V AC circuits are connected, where they are in individual terminal blocks, shall be provided with a transparent insulated cover which in addition to any other form of identification and shall have a label engraved suitably indicating the voltage.

4.9.9 Terminals for the control supply which may be still alive when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact.

4.9.10 All terminals shall bear a permanent identification number or letter.

4.10 MARSHALING UNIT

4.10.1 In main distribution Electrical Panels separate marshalling chamber shall be provided for BMS interfaces terminals or wherever required as per BMS requirement.

4.10.2 Single location interface for different LV components of main distribution panel (DB100, DB200) or other Electrical panel where ever necessary or as per BOQ shall be provided through marshalling chamber for BMS interface.

4.10.3 All interface terminals and ports for BMS shall be wired up to the marshalling chamber. Necessary marking and ferruling shall be provided for individual termination.

4.10.4 Control command interface and other terminals having potential should have due separation from VFC interface terminals. Control and signal cable wiring from different relays, sensors, transducer, controller and contactor releases shall be through separate wiring bunch to avoid fault current or external magnetic/ electric interface.

4.10.5 Necessary multi dropping and single point interface provision shall be done through suitable short links. Communicable devices using standard protocol communication shall be looped as per BMS requirement.

4.10.6 Marshalling chamber should have provided with necessary mounting arrangement or space provision for BMS remote I/O module/ PLC equipment along with its associated interface equipment and power supply unit or as per BOQ.

4.10.7 Connecting cable with connector between ACB communication unit and junction box shall be provided.

4.10.8 24V DC source unit or as required (Incoming supply shall be taped form the control supply available in the panel) for communication of ACB/MCCB with SCADA/BMS system.

4.10.9 Panel manufactures shall provide the required termination and interface detail for BMS work. In case of requirement of supervision and guidance during BMS commissioning, same shall be inclusive to the panel manufacture's scope of work. It is the responsible of panel manufactures to provide necessary interface detail such as data point register address during BMS commissioning or supervise as appropriate during installation and testing of BMS system.

4.10.10 Marshalling box shall comply with EMC (electromagnetic Compliance) and protected from any electrical or magnetic interface. Required protection against any BMS or panel component has to be inclusive to respective contractor's scope of work.

4.10.11 Any specific interface requirement not specified here with shall be wired upto the marshaling chamber interface terminal. BMS/SCADA interface point should only confine to marshalling box.

4.11 BMS INTERFACE

4.11.1 Electrical contractor shall cross reference the requirement of BMS remote control and monitoring interface as required for electrical equipments and shall provide the necessary volt free contact and remote control interface for BMS.

4.11.2 Serial interface as applicable for ACB/MCCB and digital meters or MFMs shall be strictly on standard protocol communication (preferable with MODBUS-RTU, RS485, 2 wire communication). Necessary interface detail and drawing shall be provided to BMS contractor during commissioning.

4.11.3 All terminals and BMS interface terminal and ports shall be wired to a separate chamber with adequate number of ITBs and with proper marking as per interface document.

4.11.4 No such change in contact or pseudo signal shall be provided for critical alarms control interface.

4.11.5 BMS and PLC interface for control command shall be pulse type close contacts for single command output / double command output or a variable voltage/current (i.e. 0V- 10V or 4mA - 20 mA) for analog output command.

4.11.6 There shall be one interface for control open and one for control close operations. The Contractor shall provide appropriate equipment to sense and latch the remote control signal for performing the open/close control function. The BMS digital output (DO) &analog output (AO) signal shall be as stipulated.

4.11.7 Contacts shall be rated to adequately make and break and carry continuously not less than 5A at 250VAC or 2A at 11O VDC.Volt-free contacts for sequence of event (SOE) and alarms shall firmly close and seat in position once activated. The contacts shall not bounce or vibrate due to internal or external causes

4.11.8 Required data point as per BMS requirement shall be configured in respective controller or equipment by panel manufactures as required with necessary hardware and software for above said serial link communication.

4.12 INDICATING LAMPS

4.12.1 Indicating lamps shall be multiple LED type. All indicating lamps shall be suitably rated so that the indication is clearly visible from the side and front at a distance of not less than 3 m in a room.

4.12.2 The colours of indicating lamps for red, yellow, blue phases, ACB on, off and trip shall be red, yellow, blue, red, green and amber respectively.

4.13 LOW VOLTAGE SWITCHGEAR

4.13.1 AIR CIRCUIT BREAKERS

4.13.1.1 ACB should be mechanically robust of compact design, air break horizontal and withdrawable type, confirming to IS/IEC 60947-2 and EN 60947-2.

4.13.1.2 Air Circuit Breaker is provided in transformer incomer, outgoing feeder, Interconnector Bus-Section and essential/semi-essential circuit breaker as defined in BOQ.

4.13.1.3 Manual charging as well as by 240 V AC motor with charged spring closing mechanism complete with anti-pumping relay, discharge resistor, auxiliary switch, etc.

4.13.1.4 240 V A.C shunt-trip coil shall be operable, within operational voltage range of 70% to 110% of rated voltage as per Clause 7.2.1.3 of IEC 60947-1.

4.13.1.5 The operating mechanism shall be trip-free.

4.13.1.6 Maximum number of circuit breaker auxiliary switches, spare auxiliary switches to be equally divided between normally open and normally closed. At least 4 spare pairs of N.O. and N.C. volt free contacts shall be provided.

4.13.1.7 Indicating lamps for on, off, tripped on fault and trip supply healthy with all necessary push buttons, panel wiring, bus wiring, terminals, fuses, etc.

4.13.1.8 Power and control cable terminals with undrilled gland plates for outgoing power cables and multi-core cables.

4.13.1.9 Electrical connection between the breaker and switchboard shall be of plug and socket type with automatic screening shutters. An interlock to prevent withdrawal when the breaker is closed.

4.13.1.10 Number of Poles shall be as per BOQ.

4.13.1.11 Local/auto control selecter switch shall be lockable in all positions. The automatic control shall be defeated when the selector switch is put at local or OFF position as per drawing and BOQ

4.13.1.12 Remote indication and alarm facilities shall be provided for Circuit-breaker open, Circuit-breaker closed, Circuit Breaker is ready to close, Circuit-breaker tripped on fault, and Switch position of local/remote control selector switch.

4.13.1.13 **Control switch for air circuit breakers shall be as follows:**

4.13.1.13.1 Air Circuit breakers shall be fitted with operative switches of the pistol grip type. The handles of control switches for air circuit breakers shall turn clockwise for closing and anti - clockwise for tripping.

4.13.1.13.2 The control switch shall be clearly labelled as CIRCUIT BREAKER OPEN - NEUTRAL - CLOSE, with spring return to the neutral position. Mechanical interlock shall be fitted to prevent repetitive closing without moving first to the trip position, and shall be capable of padlocking in the neutral or trip position.

4.13.1.14 **Set of terminals wired to provide for connection to the following:**

4.13.1.14.1 Automatic changeover and interlocking as shown on the drawing

4.13.1.14.2 Operation of emergency push button as per requirement or as per BOQ.

4.13.1.14.3 Signal cables wired to terminal block for remote monitoring to SCADA.

4.13.1.15 **Electrical Characteristics:**

4.13.1.15.1 Rated Insulation Voltage: 1000 V

4.13.1.15.2 Rated Frequency: 50 Hz

4.13.1.15.3 Rated ambient temperature: As per Clause 6.1.1 and 6.1.3 of IEC 60947

4.13.1.15.4 Utilization category: B or as per drawing or BOQ.

4.13.1.15.5 Rated uninterrupted current: as shown on Drawings, however the contractor must provide breaker after taking into account of the installation conditions and derating for ambient temperature, based on selected make during preparation of working drawings.

4.13.1.15.6 Current Ratings shall be as follows:

4.13.1.15.6.1 Rated short-time withstand current (I_{cw}): 70/65/50 kA for 1 second (minimum)

4.13.1.15.6.2 Rated ultimate short circuit breakigcapacity(I_{cu}): 70/65/50 kA based on actual fault level or as per BOQ.

4.13.1.15.6.3 Rated service short-circuit breaking capacity (I_{cs}): 100% of Icu, and

4.13.1.15.6.4 Rated short-circuit making capacity: shall be atleast 2.1 times of ultimate short circuit breakig capacity at 0.25 power factor or as per BOQ.

4.13.1.16 **Protection**

4.13.1.16.1 ACB shall have microprocessor based protection releases for type of faults with selective over current (long time, short time & instantaneous) & earth fault protection, measurement of electrical parameters and with communication capability with SCADA/BMS system. Any other additional protection as mentioned in BOQ. ACB shall have an LED/LCD display to show true RMS current in all the three phases and highest current among these phases. The release shall be equipped with self diagnostic feature with indication. The release shall have zone selective interlocking and be capable for communication through Modbus over Serial (RS 485 port) as per the requirement of design or as defined in BOQ. The overload and short circuit characteristics should be front adjustable and password protected.

4.13.1.16.2 The release should have an internal fault indication for faster fault diagnosis/self diagnostic feature is required.

4.13.1.16.3 The release should have fault indications by which discrimination of fault is possible.

4.13.1.16.4 Control relays and wiring for automatic changeover interlocking and other breaker operation as shown on the Drawings.

4.13.1.16.5 Fire resistant transparent covers shall be provided over ACB's to achieve IP-54 protection and door interlock so thatACB access door shall not open if ACB is ON otherwise it will automatically OFF if Door is opened.

4.13.1.16.6 Electrical interlock for the two incoming circuit breakers and interconnector bus - section circuit breaker to prevent paralleling of different power supply sources at any one time as shown on the Drawings

4.13.1.16.7 Following shall be provided for ACB connected to the transformer incomer:

a) Four Protection Current Transformers (three in panel, one in loose to be mounted in transformer neutral), a Restricted Earth Fault Relay and a Standby Earth Fault relay as specified for the interface with high voltage switchgear.
b) Two ways inter-tripping relay shall be provided with the associated HV feeder circuit breaker by interfacing with the Power Supply Contactor.
c) Voltage sensing relay and associated relays for automatic changeover and interlocking operation as detailed on the Drawings.

4.13.1.16.8 Interlocks and Test Operation Facilities

All ACBs shall be provided with interlocks to ensure that:

a) The ACB cannot be plugged in or isolated while it is closed,

b) The ACB cannot be closed until it is fully plugged in or completely isolated

c) The ACB cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving portions

d) With manual charged and motor charged spring mechanisms the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected,

e) Facilities shall be provided for testing the ACB operation when in the isolated and withdrawn positions by the normal means as in service, and

f) Where control circuits are provided and interlock circuits are broken via plugs on withdrawal of the ACB, a minimum of one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn position.

g) The neutral shall be rated for 100%

4.13.1.16.9 Safety Shutters

4.13.1.16.9.1 A set of shutters with padlocking facilities shall be provided to cover each three phase group of stationary isolating contacts. The shutters shall be independent and operated automatically by a positive drive from the ACB withdrawal mechanism

4.13.1.16.9.2 In order to prevent unauthorized operation, the withdrawable air circuit breakers shall be provided with padlock facilities to secure them in their connected, test and isolated positions.

4.13.2 **MOULDED CASE CIRCUIT BREAKERS**

4.13.2.1 MCCBs shall comply with and be type-tested to IS/IEC 60947-2 or EN 60947-2. Each MCCB shall be of fixed or withdrawable type, as specified in the BOQ and have all the mechanical and live parts completely enclosed in an insulated moulded case. Withdrawable pattern circuit breakers shall be designed that their electrical equipment can be safely disconnected from or connected to the main circuit whilst the circuits are live. All incomer MCCBs shall be four pole.

4.13.2.2 MCCB shall be suitable for isolation as per Annexure 7.1.2 of IEC 60947-2

4.13.3 MCCBs shall meet the following requirements:

a) Number of poles: double-pole, triple-pole or four poles as specified on theDrawings or Design or BOQ
b) Rated operational voltage: 240 / 415 V AC, as per drawing or BOQ
c) Rated insulation voltage: 660 V AC, higher voltage acceptable
d) Rated uninterrupted current (In): as shown on the Drawings or BOQ, but after taking into account the installation conditions and temperature deration.
e) Rated frequency: 50 Hz,
f) Rated short-circuit making capacity (Icm): shall be at least 2.1 times of ultimate short circuit breaking capacity at 0.25 power factor,
g) Rated ultimate short-circuit breaking capacity (Icu): 65/50/35 kA (min),
h) Rated:service short-circuit breaking capacity (Ics): 65/50/35 kA Further, Ics must be equal to 100% Icu for the selected breaker,
i) Utilization category: A or B as appropriate,
j) Degree of protection: IP 3X to IEC 60529 or EN 60529, and
k) Rated ambient temperature: As per IEC 60947-2
l) Impulse Withstand Voltage - 8KV
m) 0 - t - CO - t - Co type of Duty i.e.Ics=lcu.

4.13.3.1 MCCB’s to be provided in LV Main Switchboard shall be stored energy type motorized and Suitable for Remote Closing by BMS.

4.13.3.2 All MCCB’s should have front adjustablemicroprocessor based releases with adjustment in the range of 40 - 100% for nominal overloads and adjustable setting for short circuit faults. MCCB’s for network/feeder Protection shall have releases with earth Fault Protection features, wherever and as indicated in Bill of quantities or drawings.

4.13.3.3 In case of 4 pole MCCB, neutral shall be defined and capable of offering protection upto full rating with possibility of adjustment at site in the neutral setting.

4.13.3.4 Mechanical endurance shall be as specified in latest IEC standard.

4.13.3.5 MCCB’s shall have an electrical endurance operation cyclesas per latest IEC standard 60947.

4.13.3.6 All MCCB’s shall be arranged for padlocking in OFF positions with lock provided. A shunt trip coil shall be provided to facilitate automatic tripping and local manual tripping. The manual trip device shall be fitted with the means of padlocking. The shunt trip coil shall be suitable for operation within a voltage range of 70% to 110% of the rated AC power supply voltage.

4.13.3.7 Electronic trip units shall comply with the requirements as specified in Appendix F (EMC /EMI Compatibility) of IEC 60947-2 or EN 60947-2.

4.13.3.8 The trip unit shall be easily replaceable in the same MCCB without changing the MCCB.

4.13.3.9 The time delay on overload tripping shall be inversely proportional to the over current up to a threshold value of approximately six to seven times the rated current at rated working temperature.

4.13.3.10 Handle position shall give positive indication of ’ON’ ‘OFF’ or ’TRIPPED’, thus qualifying to disconnection as per IEC 60947-3 indicating true position of all the contacts.

4.13.3.11 The operating mechanism of MCCB’s shall be Independent of the operating speed of the over centre toggle and the MCCB shall be of current limiting type and comprise of Quick make and Quick break switching. Contacts shall be non-welding type. The operating mechanism should be trip-free and provided with mechanical “ON", OFF" and "TRIPPED indicator. The MCCB shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance.

4.13.3.12 Remote closing and tripping coil should be of continuous duty cycle.

4.13.3.13 MCCB's shall have common field fittable auxiliaries for the entire range and above 250 A the accessories like copper spreadersand phase barriers should be the integral part of the MCCB's.

4.13.4 **MINIATURE CIRCUIT BREAKERS (MCB)**

4.13.4.1 MCBs shall comply with and be type-tested to IEC 60898 or EN 60898.

4.13.4.2 MCBs shall meet the following requirements:

a) Number of poles: single-pole, double-pole, triple-pole or four-pole as specified in the BOQ or Drawings

b) Protection against external influences: Enclosed-type,

c) Method of connection: Bolted type or clip-on type,

d) Rated operational voltage and frequency 240 / 415 V AC and 50 Hz.

e) Rated current: 6 A, 10 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, as shown on theDrawings. Above 50A, MCCB as specified above must be used.

f) Range of instantaneous tripping current: MCB's shall be current limiting TypeClass 3 with range of instantaneous tripping current B, C or D type as appropriate oras specified,

g) Rated short-circuit breaking capacity: not less than 10 kA (M3) unless otherwise specified in BOQ

h) I^2t characteristic: suitable for load and circuit being protected,

i) Degree of protection: IP-20 for MCB's

j) Reference ambient temperature: as per IEC 60898.

k) MCB's shall have minimum power loss (Watts) per pole as per the IEC andshould be proven by published value by manufacturer.

4.13.4.3 The load handling contacts shall be silver/tungsten or proven materialand the contacts and operating mechanism shall be designed so as to give a wiping action both at make and break. Thebreaker operating mechanism shall be of trip-free type. The breaker operating dolly shall be clearly indicated for the "ON" and "OFF" positions. It should be of Quick make and Quick break type.

4.13.4.4 Circuit protection against overload and short-circuit conditions shall be provided by meansof thermal-magnetic device. Double-pole, triple-pole, and four pole MCBs shall be integralunits and interlocked internally so that an over current through any pole shall trip all thepoles of the MCB simultaneously. An assembly of two or three or four single-pole unitsmechanically strapped together is not acceptable.

4.13.4.5 Housing shall be heat resistant and having high impact strength. All DP, TP and FPcircuit breaker shall have a common trip bar and should be mechanically coupled through a pin. It shall have an electrical endurance of the order of 10000 operation cycle for currentrating of up to 50A.

4.13.5 **RESIDUAL CURRENT CIRCUIT BREAKER**

4.13.5.1 RCCBs shall be double pole or four-pole current-operated, housed in a totally enclosedmoulded case, manufactured and tested in compliance with IEC 61008 or EN 61008.

4.13.5.2 RCCBs shall meet the following requirements:

a) Number of poles: double-pole or four-pole as specified on the Drawings,

b) Rated current (In): as shown on the Drawings,

c) Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on drawings or as per approval of the Engineer.

d) Rated voltage: 240/415 V AC,

e) Rated frequency: 50 Hz,

f) Rated short-circuit capacity: not less than 1.5 kA unless otherwise specified in BOQ

g) Operating characteristics in case of residual currents with DC components: as specified,

h) Method of mounting: distribution board type,

i) Method of connection: connection shall be made with propre size of thimbles and number ferruling for circuit identification,

j) I^2t characteristic: suitable for equipment and circuit being protected

k) Degree of protection: IP 3X to IEC 60529 or EN 60529, and

l) Reference ambient temperature: As per IEC.

4.13.5.3 The tripping mechanism shall be of trip-free so that the unit cannot be held closed againstan earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable.

4.13.5.4 Provision shall be made for testing the automatic earth - leakage tripping by an integral testdevice. A device shall be fitted for prevention against reclosing after the device has trippedon earth leakage.

4.13.6 **RCBO (RESIDUAL CURRENT CIRCUIT BREAKER WITH OVER-CURRENT) PROTECTION**

4.13.6.1 RCBOs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61009 -1, IS 12640(part 2) 2008 and ISI marked.

4.13.6.2 RCBOs shall meet the following requirements:

a) Number of poles: double-pole or four-pole as specified on the Drawings,

b) Rated current (In): as shown on the Drawings,

c) Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on drawings or as per approval of the Engineer.

d) Rated voltage: 230/415 V AC,

e) Rated frequency: 50 Hz,

f) Rated short-circuit capacity: 10kA

g) Operating characteristics in case of residual currents with DC components: as specified,

h) Method of mounting: distribution board type,

i) Method of connection: connection shall be made with propre size of thimbles and number ferruling for circuit identification,

j) I^2t characteristic: suitable for equipment and circuit being protected

k) Degree of protection: IP 2X, and

l) Reference ambient temperature: As per IS 12640-1

4.13.6.3 The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable.

4.13.6.4 Provision shall be made for testing the automatic earth - leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage

4.13.6.5 A mechanical flag indicator on RCBO for faster identification of fault trip condition i.e. earth leakage or over-current for faster fault diagnosis and preventive measures.

4.14 DESCRIMINATION

4.14.1 Selection of ACB, MCCB and MCB shall be of same make. Total discrimination up to the design fault level must be available between the various elements of switchgear (ACB, MCCB, MCB etc) selected. Supplier must provide test certificates from acceptable, accredited and reputed laboratories or submit published discrimination charts/tables to prove the same. In view of Standardization and Uniformity, mixing of two series of switchgear (even from the same manufacturer) for either MCCB or ACB will not be permitted.

4.14.2 In case higher frame sizes rating of switchgear(than those specified In the BOQ) is required to be provided to achieve the above requirement, due to selection of a particular make, the same shall be provided at no extra cost if other makes are able to achieve the same with the specified frame size.

4.15 REMOTE MONITORING

The following critical status and alarms for each Electrical Panels shall be sent to BMS for remote monitoring via volt-free contacts or serial interface over standard protocol communication as approved but not limited to:

a) Individual ACB/MCCB open/close status,

b) Common alarm for ACBs/MCCBs trip on fault/lock out,

c) Common alarm for any local/remote or local/auto selector switch in local mode

d) Control supply failure,

e) ACB ready to close indication.

f) Emergency push button (EPB) operated, and

g) Busbarvoltage ,current , frequency and energy parameter

h) Electrical Panels under voltage alarm and cause of tripping.

4.16 MOTOR STARTER

4.16.1 Every motor starter shall be designed to perform the following functions efficiently andsafety:

a) To start the motor without damage to the drive or driven equipment whilstregulating the starting current to the satisfaction of the requirements of this Specification and ensuring that at all stages of starting, the motor will developsufficient torque to accelerate the load.

b) To stop the motor.

c) To prevent damage to the motor due to overload, disconnection of one phase etc..

d) To prevent damage to reduced and danger to personnel due to resumption of the electricity supply following a failure.

e) To prevent the damage to the motor due to stalling or internal electrical ormechanical faults by quickly disconnecting the supply.

f) To prevent damage to the motor or the starter itself due to improper, unskilled orhesitant operation or failure to complete a starting sequence once it is connected.

g) To enable the motor and starter to be completely isolated from the main supply andfrom all control supplies for inspection and repairs by means of fixedtype unitfor each starter circuit.

4.16.2 Each motor starter assembly shall comprise MCCB/MPCB, contactors, protection relays,electronic circuitry, control switches, lamps and instruments and accessories as specified hereinafter. It shall include control devices for automatic control systems. The whole unitshall be enclosed in the cubicle, from which no access can be gained to adjoining cubicles.

4.16.3 The specified starter types are based on estimated motor ratings. The final selection ofstarter shall be based on the installed motor rating. Starters and associated over-loaddevices shall be selected in accordance with the run-up time of the associated motor drivenload, the maximum thermal capacity of the motor and frequency of starting, and the dutycycle. All starters shall have suitable protection for phase-to-phase, phase-to-neutral andphase-to-earth faults, over-loads, and single phasing, with additional protection measures as specified. Overload relays releases as specified shall have inverse time delaycharacteristics compatible with the motor drive to which they are applied for all protectivedevices the short-circuit capacity (Isc) shall be capable of withstanding a fault current of thepanel, as a minimum. The specifications of incoming and other circuit breakers (ACB/MCCB etc.) shall be as per clause 4.13, as relevant.

4.16.4 All starters shall be in accordance with section 7.2 of IEC 60947-4-1 or EN 60947-4-1, andshall be adequately rated for conditions in which it shall operate.

4.16.5 All starters shall be type tested by a competent and internationally recognized testingauthority for type 2 co-ordinations in accordance with IEC 60947-4-1 or EN 60947-4-1.

4.16.6 All contactors shall be electro-magnetic type with utilization category AC - 3 to IEC 60947-1.

4.16.7 All starter shall be of electrically held on pattern and shall not release until the over voltage falls below 70% of nominal.

4.16.8 Control circuits shall generally be operated on main supply derived from the LMCP, suitably protected by MCB type 2, as specified in clause 4.13. The control circuit shall be of self-holdingand latching design.

4.16.9 Where the control voltage is not 240V it shall be derived from transformers to BS 3535/BS 61558. Transformers shall be rated at the total control circuitload plus a minimum of 10% spare capacity. Transformer primary windings shall beprotected by MCB's in the line connection(s) and a removable neutral link shall be providedwhere the neutral is required. The supply shall be taken from downstream of the mainincoming Circuit Breaker. One end of the transformer secondary shall be connected directlyto the main earth bar. This connection shall be upstream of the control circuit neutral link.The supply from the other end-of the winding shall be protected by MCB.

4.16.10 The type of starters for other mechanical equipment such as plumbing, drainage, fire services pump and other motor circuits shall be as specified in this clause subject to rating of the motors selected during working drawing production as per clause 4.16.3. The starters shall also comply with the requirements laid down in the Code of Practice of electricity(Wiring) Regulations. Voltage for motors shall be 415V 3-phase or 240V 1-phase, asrequired. Motors rated 0.37kW and larger shall have a rated voltage of 415V, 3 phase,50Hz. Motors rated smaller than 0.37 kW shall be operated at 240V 1-phase. Direct-onlinemotor starters shall be used for motors up to and including 3.75 kW at 415 volts, 3phase. All motors over this limit shall be equipped with reduced voltage starters of the star-delta or soft starter type as indicated in BOQ.

Motor size (M) Load	Maximum starting current in multiple of full load current (phase of motors)
M≤ 0.37 kW	6 (single phase motor)
0.37 kW< M< 3.75 kW	6 (three phase motor)
3.75 kW ≤ M	6-7 (three phase motor)

(Tolerance in the above currents shall be of the order of ±20%)

4.16.11 The direct-on-line starters shall be provide based on condition given in Clause 4.16.10 and shall include, but not be limited to, the following:

a) MPCB as specified,

b) Triple pole air break contactor,

c) MPCB wherever specified or required shall be provided with inbuilt Thermal/Magnetic and single-phasing protection. MCCB, wherever specified/ required shallbe of Electronic Trip Unit type with single phasing preventer unit.

d) All Current transformers with suitable ratio, output and accuracy for motor protection,

e) Local/off/remote control selector switch lockable in each position,

f) Set of start and stop push button,

g) Set of indicating lamps for motor running, off and tripped on fault,

h) Set of digital input (dry contacts) interface wired to terminals for wiring connection to station building services controllers,

i) One set of terminals wired to the following:

    a. Emergency stop push button, effective in all positions of the local/remoteswitch if any.

    b. Remote start/stop of the motor, effective only in the remote position of the selector switch.

    c. Hour run meter,

    d. Lamp test button,

    e. Any other items required to affect satisfactory motor starting and control asspecified in this Specification, and

    f. double pole contractor and motor protection unit for single phase DOL type starter.

j) Interposing relays/contactor for remote close and remote open wheneverrequired.

k) Leakage Protection for DOL starters shall be provided with 25 / 40 A, 4 Pole RCCB with sensitivity of 100/300 mA as specified.

4.16.12 Based on criteria given in Clause 4.16.10or wherever specified on the Drawings, star-deltastarters shall be provided to limit the maximum starting current within 2.5 times therated motor full load current. The star-delta starters shall be equipped as per direct-on-linestarters specified above, with the following additional provisions:

a) Star-delta starters shall be of the automatic type and shall comply with BS EN60947-4-1. Triple pole air break star and delta contactors shall be electricallyinterlocked so that they cannot close or be closed at the same time. In all types ofstar-delta starters the correct phase relationship between the star and deltaconnections to minimize disturbance on changeover shall be maintained.

b) rated and adjustable solid state timer for automatic star-delta transition, and

c) Automatic changeover timers shall be adjustable from 1 second to 30 seconds.Timers shall incorporate a fixed delay of between 20 ms between the star contactor opening and the delta contactor closing.

d) MPCB /MCCB as specified in drawings /Schedules shall be used. MCCB shall beas specified in clause 4.13with the difference that the Electronic trip Units shall besuitable for Motor Protection against Over Load (Adjustable) and Short Circuit. Forrequirement of Earth fault/Earth Leakage protection, Clause 4.16.15 referred to.

Soft Starters

(a) All soft Starters shall be complying with class A for conducted and radiated emissions, described in the Standard EN/IEC 60947-4-2. Class B can be obtained with additional accessories and covers only soft starters with a rated current not exceeding 170 A.

(b) The Soft-starter shall comply with UL 508 and CSA "Industrial Control Equipment".

(c) All soft starters shall be equipped with motor current measuring means to ensure engine protection The soft starter should have a separate power control.

(d) The terminals of the board control shall be of plug type.

(e) The soft starter shall be able to operate at design ambient temperatures from -10 to + 40 °C without derating, and between 40 and 60 ° C with suitable derating factor shall be considered.

The maximum relative humidity will be 95% without condensation or dripping water according to standards IEC60947-4-2.

The storage temperature can be between -25 °C to + 70°C

Soft Starter Cooling should be manage automatically.

Voltage variation	-15% to +10 %
Frequency Variation	+/-5%

(f) Starter shall be protected against Thermal overload, reverse phase network, loss of phase, external faults, over current, short circuit faults etc.

(g) Access of setting should be protected by locked by code or other functions.

(h) Starter shall be handle the by-pass of soft starter, manage the closure of the by-Pass at end of acceleration time and open that by-Pass at end of stop sequence.

(i) Starter shall be monitoring following information on screen

Motor Current

Torque

Active Power

Current Status (acceleration, decelaration, etc.)

Operating time.

The last fault occured

4.16.13 **Reversing Starters**

Forward and reverse contactors will be mechanically and electrically interlocked. Reversingstarters will be in accordance with BS EN 60947 and be suitable for AC 4 utilization category.

4.16.14 **Incoming Supplies**

The isolation devices for assemblies with duplicated supplies shall be interlocked(electrically and mechanically) to prevent simultaneous closure.

4.16.15 **Earth Leakage/Earth Fault Protection**

For Earth Leakage /earth fault Protection for Circuits with Star-delta starters (whereverrequired, based on calculations done during working drawings Production Stage). Add- onModules to MCCB (based on current rating of MCCB) shall be provided with continuous adjustment from 30 mA to 10 A range with adjustable time delay.

4.16.16 **Status/Alarm**

a) Indicating lamps shall be provided on each phase of the main incoming supply.

b) All assemblies incorporating automatic control systems shall be equipped with suitable status/ alarm annunciation facilities. If these are not available directly from the automatic control system then a separate status/alarm annunciator shall be provided. Status/alarm enunciators shall provide indications for all starting devices of 'ON', 'OFF'and 'TRIPPED' conditions.

c) The status/alarm annunciator equipment shall be mounted in the same cubicle as theautomatic controls. Volt-free contacts shall be provided for each condition in eachstarter cubicle, which shall be wired internally to the status/alarm annunciator, viaterminals at each end.

d) The schematic diagrams as indicated in the Working Drawings shall be shown and theoperating status of all equipment shall also be indicated. Status indicating lights shall exhibit run/stop or open/close and fault conditions. The Contractor shall provide testbuttons for the indicating lights. The layout, color, symbols and arrangement of themimic diagram shall be submitted to the Engineer for review prior to manufacture.

e) Suitable interfaces shall be built into each channel to relay signals to remote locations,by means of volt-free contacts.

f) Hours-run meters shall be fitted as specified and not be resettable.

4.16.17 **Control Circuits**

a) In each individual starter, the control circuit shall be provided with MCB, a neutral link,a means of disconnection and, where specified, a disconnection override switch.

b) Neutral links shall comprise a solid copper link mounted in a white coloured fuse base and carrier, which shall not be interchangeable with control or power fuse carriers.

c) The control circuit supply shall be connected via an auxiliary contact on the starterisolator.

d) Where automatic changeover systems are specified for duty/standby operation, thecontrol circuit for the changeover controls shall be independent of both starters.

e) Start delay timers shall be incorporated for sequential operation of starters wherespecified. The failure of one timer or starter to operate shall not prevent operation of the remaining starters.

4.16.18 **Interlocking**

a) The control circuit of a dependent starter shall be wired via auxiliarymotorcootactor in the lead starter. In the case of reduced voltage starter, the contacts shall be on the full voltage contactor.

b) Should the lead starter be shut down either intentionally or by a fault condition, thedependent starter shall drop out immediately.

c) A time delay shall be incorporated in the interlock circuit to delay the operation of thedependent starter where specified. Such time delays shall be in addition to the interlock circuits.

4.16.19 **Auxiliary contacts**

Two normally open and two normally closed auxiliary contacts shall be provided for eachstarter as spares unless otherwise specified. These contacts shall be in addition to contactsused for the control of the starter.

4.16.20 **MPCB (MOTOR PROTECTION CIRCUIT BREAKER)**

Motor circuit breakers shall comply with the general recommendations of standard IEC 60947-1,-2 and -4-1.

1. The devices will be in utilization category A, conforming to IEC 60947-2 and AC3 conformingto IEC 60947-4-1.

2. Rated operational voltage of 690V AC (50/60 Hz)

3. Rated insulation voltage of 690V AC (50/60 Hz)

4. Isolation conforming to standard IEC 60947-2,

5. Rated impulse withstand voltage (Uimp) of 6 kV.

4.16.20.1 **MPCB shall meet following requirement:-**

4.16.20.1.1 Mounting:

The motor circuit breakers will be designed to be mounted vertically or horizontally without derating Power supply will be from the top or from the bottom.

4.16.20.1.2 Contacts:

In order to ensure maximum safety, the contacts will be isolated from other functions such as theoperating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers**.**

4.16.20.1.3 Operating mechanism

The operating mechanism of the motor circuit breakers must have snap action opening and closing withfree tripping of the control devices. All the poles will close, open, and trip simultaneously.

4.16.20.1.4 Button:

The motor circuit breakers will be actuated by a rotary operator clearly indicating the position ON (I), OFF (O), trip

4.16.20.1.5 Isolation:

In order to ensure isolation with clearly visible breaking conforming to standard IEC 60947-2 paragraph 7.2.7:

1. The mechanism will be designated so that the different types of operator will only be in position (O) if the main contacts are physically separated,

2. In position (0) the operating devices will indicate the isolated position.

3. Isolation is enhanced by the double break of the main circuit.

4.16.20.1.6 Padlocking

Motor circuit breakers will accept a padlocking device in the "isolated" position.

4.16.20.1.7 Trip

The motor circuit breakers will be equipped with a "PUSH TO TRIP" device on the front enabling thecorrect operation of the mechanism and poles opening to be checked.

4.16.20.1.8 Limitation, Durability

1. The motor circuit breakers will be current limiting for a mains voltage of 400 V, the maximum let-through energy (I^2t) on short circuit being extremely low.

2. The motor circuit breakers will have a high electrical and mechanism durability of at least 5 times thatrequired by the standard.

4.16.20.1.9 Protection functions

General recommendations:

a) The motor circuit breakers will be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection.

b) In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) will be factoryset to an average value of 12 Ir.

c) All the elements of the motor circuit breakers will be designated to enable operation at an ambienttemperature as per IEC without derating.

d) The thermal trips will be adjustable on the the front by a rotary selector.

e) The adjustment of the protection will be simultaneous for all poles.

4.16.21 **SWITCH FUSE UNITS & DISCONNECTS/ISOLATORS (WHERE APPLICABLE)**

4.16.21.1 Switch fuse units shall have quick-make, quick-break silver plated preferably double break contacts with operating mechanism suitable for rotary operation in the case of cubicle mounting. All switches shall be rated according to the equipment schedule or drawings and shall withstand the system prospective fault current let through. Cam operated rotary switches with adequate terminal adaptors up to 25A are acceptable but for all higher rating switch fuse units shall be heavy-duty type.

4.16.21.2 Fuses shall be HRC cartridge type conforming to IS: 13703 - 1993 with a breaking capacity corresponding to system fault level. Fuses shall be link type with visible indication. Screw type fuses are not acceptable for any ratings.

4.16.21.3 All disconnects shall consist of switch units quick-make, quick-break type with silver plated contacts. The switches shall preferably have double breaks. The switchesshall preferably have sheet steel enclosure, which in turn is mounted on suitable angle iron frame work. In wet locations enclosures shall be IP56 rated . Disconnects shall have a minimum breaking capacity of 5KA at 415 Volts.

4.16.21.4 Switch contacts shall be designed with arc repelling features to extinguish the arc quickly to provide long contact life.

4.16.22 **ISOLATORS**

4.16.22.1 Isolators shall be fixed on wall, on self-supported galvanized angle iron frame work as required and mounted as near to the motor as possible. Where several motors are installed, isolators if required shall be provided at a central location on a common frame work with prior approval at site . The Isolator shall be provided in IP 65 enclosures from the Isolator manufacturer only.

4.16.22.2 Painting, earthing and labels shall be provided as generally indicating for MV Switchgear and as shown on drawings.

4.17 CONTACTORS

4.17.1 Contactors shall comply with IS/IEC 60947-4-1 or EN 60947-4-1.

4.17.2 Contactors shall be electro-magnetically controlled, double air-break type. Contactors shall be four-pole, triple-pole, double-pole or single-pole as shown on the Drawings.

4.17.3 The mechanical endurance of the contactors shall not be less than 3 million no. load operating cycles.

4.17.4 Contactors shall be silver-faced.

4.17.5 The contactor should be modular in design with minimum inventory requirements and built -in mechanically interlocked wherever required. They should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors. The contactors from 4KW to 400kW shall be associated with the same 10 auxiliary contact block range or as per BOQ.

4.17.6 The control contactors for power factor correction equipment shall be of quick break and have a high arc resistance during switching operation. Contactors shall be of utilization category AC-6b for this application and specifically designed for switching directly connected capacitor banks.

4.17.7 The contactors for other applications shall have an un-interrupted rated duty and utilization category of at least AC3 at 415V and 50 Hz. The contacts should be of fast opening and fast closing type.

4.17.8 The making and breaking capacity values of the contactors should be as follows (as per IEC 60947-4)

a) For AC3 duty:

- Making capacity equal to or more than 10 I_e
- Braking Capacity equal to or more than 8 I_e,

b) For AC4 duty:

- Making capacity equal to or more than 12 I_e,
- Braking Capacity equal to or more than 10 I_e,

4.17.9 The contactors should be capable of frequent switching and should operate without derating at 60°C for AC3 applications. They should be climate proof. The coil of the contactor should have class H insulation to support frequent switching. Class F insulation is also acceptable with the consent of the site Engineer.

4.17.10 The rated voltage of the contactor and the rated insulation voltage shall be 690V. The rated Impulse voltage of the contactor should be at least 8 KV.

4.17.11 Wherever DC control is required, the contactor should have wide range (0.7 to 1.25 U_c) DC coil with built in interference suppression as required.

4.17.12 The control and power terminals should be at separate layers preferably with colour coding (black for power and white for control). All contactors power connection shall be finger safe (IP 2X)

4.17.13 They should be capable of being integrated into automated system (PLCs) without any interposing components in the minimum operating conditions.

4.17.14 Contactors used with surge suppressor.

4.18 AUXILIARY SWITCHES AND CONTACTS

4.18.1 Auxiliary switches provided for indication, protection, metering, control, interlocking supervisory purposes shall be readily accessible at the front of the Electrical Panels. Adequate secondary contacts shall be included to enable the auxiliary switch to be wired to the fixed portion of the equipment.

4.18.2 For each control compartment, spare auxiliary contacts with a minimum of two NO and two NC contacts shall be provided and wired to suitably identify spare terminals.

4.18.3 Auxiliary contacts for all applications shall be rated at 240 V AC or 110 V DC with contact rating of at least 6 A AC or DC and operating life of atleast one million on on-load operations at 0.4 power factor inductive load.

4.19 POWER FACTOR CORRECTION EQUIPMENT

4.19.1 Power factor correction equipment and its installation shall comply with IEC 60831/IS 13340. Each power factor correction equipment shall consist of capacitors, switchgears, cables, cable gland,micro-processor based intelligent power factor control relays, CTs and contactors etc.

4.19.2 Capacitor banks shall consist capacitors of variable capacity i.e. 5 kVAR, 10 kVAR, 15 kVAR, 25 kVAR or fixed type as per BOQ.Capacitor bank with total capacity as shown on the drawings or BOQ shall be provided and connected to the designated switchgear in the LV main switchboard to improve the overall power factor to not less than 0.98 lagging. The system shall ensure that a leading PF does not occur.

4.19.3 The Contractor shall ensure that the power factor correction equipment shall not cause harmonic resonance in the LV electrical network

4.19.4 The capacitor bank shall be of floor standing type built up from static primary capacitor units. The capacitor shall be mounted on the lower and de-tuned inductor on the upper part of the panel so that the temperature of capacitor environment is lower than the average temperature in the panel. In case, ventilating fan is required to maintain the desired temperature in the capacitor panel, the same shall switch on and off depending upon the set temperature and only when at least one capacitor is in service. The thermostate temperature shall be provided with step adjustment features if considered necessary as per design.

4.19.5 Each three phase capacitor unit shall be MPP self healing type with total losses not greater than 0.5 W/kvar. The primary capacitor unit shall comply with the requirement of IEC 60871-1 or BS 1650.

4.19.6 The capacitor unitshall be usable for indoor application with permissible overloads as below:

- Voltage overloads shall be 10% for continuous operation and 15% for 30 minutes in a 24 hours cycle
- Current overloads shall be 15 % for continuous operations and 50% for six hours in a 24 hours cycle.
- Over load of 35% continuously and 45%for six hours in a 24 hours cycle.

4.19.7 All capacitors involved shall be disconnected instantaneously, and reconnected step by step at intervals after the supply is restored.

4.19.8 Each capacitor bank shall be fitted with an automatic discharge assembly which shall discharge the entire capacitor bank from the peak alternating voltage to a voltage level not exceeding 50 V measured at the capacitor bank terminals one minute after disconnection from the supply.

4.19.9 The automatic power factor control relay (APFCR) shall be a microprocessor based static unit with output relays equal to the no. of capacitor steps. Minimum no. of relays shall be six/eight (6/8) or as specified in BOQ. The switching ON and OFF of the capacitor unit shall be done in a sequence so that even wear takes place on the contactors and relays over one week of operation.

4.19.10 The APFC relay shall be intelligent to ensure balancing of duty cycle of the capacitors. The APFC relay shall be communicable type with RS 485 connectivity.

4.19.11 APFC relays shall provide all necessary function of relay, controls, protection, annunciation and condition monitoring.A no-volt and single phasing protection shall be provided.

4.19.12 Local/off/auto selector switch and visual indication of energized capacitor with red lamps, etc shall be provided.

4.19.13 Type tests for the equipment shall include operating voltage, temperature cycling and repeated switching as per IEC 60831-2

4.19.14 Overcurrent shall be 1.8 x $I_{n.}$

4.19.15 Peak inrush current withstand capacity shall be 250 x I_n

4.20 DETUNED FILTER

4.20.1 Detuned harmonic filter reactors shall be used as per BOQ along with power capacitors to mitigate harmonics amplification and to avoid electrical resonance in LV electrical networks.

4.20.2 The reactors hall be made of high grade copper windings, having a three phase, iron core construction suitable for indoor use. The reactor are air cooled and the layout shall be in accordance with IEC 60289 / IS 5553.

4.20.3 The permitted tolerance of inductance is ± 3% of rated inductance value.

4.20.4 Reactor tuning factor shall be 7 % (189 Hz) and the current rating of the reactor shall include the effects of harmonics and other possible over-currents

4.20.5 The limit of linearity of inductance of the filter reactor is: $1.8*I_n$ with $L=0.95*L_N$.

4.20.6 All reactors shall be fitted with a temperature sensitive micro-switch in the centre coil (normally open) for connection to trip circuits in case of high operating temperatures.

4.21 AUTOMATIC LOAD TRANSFER SWITCHES

4.21.1 Automatic load transfer switches shall be composed of paired ACBs or MCCBs. ACBs and MCCBs used in Automatic Load Transfer switches shall be used as specifiedin this specification.

4.21.2 Paired ACBs or MCCBs (as specified above) shall be provided with motorized mechanisms for "ON/OFF" operation.

4.21.3 Each automatic load transfer switch shall be equipped with, but not be limited to, thefollowing:

a) Illuminated indicator for "Normal Supply On" and "Standby Supply On" to be providedat the front cover of the compartment housing the changeover switches.

b) Transfer mechanism to facilitate automatic/ manual changeover from the normalsource to the standby source.

c) Automatic/manual change-over selector switch shall be provided. It shall be possible to manuallyoperate the circuit breakers in the event of absence of control voltage.

d) ALTS should have electrical interlocking along with mechanical interlocking through base plate to ensure that two MCCBs shall not be ON simultaneously.

e) Interlocking facility to insure that normal breaker tripped on fault will not cause standby breaker to close or vice versa, unless the breaker are reset manually.

f) A test switches to simulate mains power failure and indicate the changeover sequence to allow on load testing.

g) Auxiliary relay and contacts to facilate main power source failure for routine testing of the automatic change-over operation.

h) 2 nos. each NO and NC volt free dry contacts shall be provided for each change-over circuit breaker unit.

i) The change-over function shall work without auxiliary power supply with fail safe operation.

j) All indications for all operations viz. ON, OFF, TRIP.

4.21.4 **The changeover system between the normal and standby sources shall be as follows:**

a) 3 phase sensing circuits with adjustable time delay facility in the range of 0 to 15 seconds shall be provided to monitor the voltage condition of the normal and standby source.

b) Failure of one or more phases of normal main supply or are reduction of voltage to a value of 90% to 70% (adjustable) of nominal value shall initiate the timing device. If the failure persist at the expiry of this present time delay, the changeover section will be effected provided that the voltage of the standby source reaches 90% of the nominal value.

c) Upon restoration of the normal power supply, which has been determined stable after a time delay, the changeover switch shall automatically be restored to the normal supply. It shall also be able to switch the load back to the normal supply under manual control.

4.22 DISTRIBUTION BOARDS

4.22.1 Distribution boards for miniature circuit breakers shall be of sheet steel construction with aminimum thickness of 1.6 mm, suitably braced to form a rigid structure. Exterior cornersand edges shall be rounded to give a smooth overall appearance. Hinged swing doors shallbe fitted with gaskets and shall be easily removable to simplify installation. DBs shall beprovided with suitable size of surge protection.DBs shall be fixed with bottom at 1200 mm from finished floors. DBs shall be fixed properly, fitted square with the frame and with holes correctly positioned. DBs shall be fastened to the walls with suitable grouted studs of not less than 12-mm diameter.

4.22.2 IP ratings for distribution boards shall be IP 54(used for Lights & small power).

4.22.3 All boards shall be meggered phase to phase and to neutral using 1000/500V megger with all switches in closed position. The megger value should not be lessthan 2.5 M Ohm between phases and 1.5 M Ohm between phase and neutral.Testing of minimum 10 kA short circuit current otherwise specified in BOQ required.

4.22.4 Each distribution board shall be arranged for top and bottom cable entry and shall beprovided with ample cable termination plates and chambers to enable cables to be neatlyglanded with tails grouped and terminated on to appropriate internal terminations.

4.22.5 Distribution boards shall be wall mounted and shall, where specified, incorporate doublepole or triple pole all insulated switches as appropriate, which shall be front of paneloperated with an "ON/OFF" indicator and capable of being padlocked in the "OFF" position.Distribution boards shall incorporate combinations of single pole, double pole, triple poleand four pole miniature circuit-breakers (MCBs/MCCBs) as specified in drawings.

4.22.6 Each bank of MCB’s shall be clearly identified with its appropriate phase colourscode, andthe mounting framework for the banks of MCB’s shall be easily removable to simplifyinstallation. Adequate phase barriers and shields shall be fitted to ensure that afterinstallation and wiring, all bare terminals and wires are covered to prevent accidentalcontact with live conductors during the normal procedure of resetting MCB’s.

4.22.7 Each distribution board shall be supplied complete with as built drawing/chart, preferably mounted within the front door. This chart shall be permanently and legiblyfilled in as circuits are completed, including the circuit description, the MCB rating and theidentification of upstream source of the distribution board.

4.22.8 Each distribution board shall be clearly labeled indicating its service and all 3-phasedistribution boards shall be fitted with standard labels as per relevant IS.

4.22.9 In the top and bottom, of each distribution board a 32 mm clear hole in addition to otherrequirements shall be provided. These spare holes shall be fitted with 32 mm stopping plugs and locknuts.

4.22.10 Spare MCB's shall be provided on the basis of one per four ways or part thereof for every distribution board ensuring that spares are provided in numbers and rating proportional to the numbers and ratings in the installation or as per BOQ.

4.22.11 Distribution boards shall comply with best industry practice.

4.22.12 All busbars shall be of hard drawn tinned copper having ratings as specified complying to relevant clauses givenunder clause 4.1 as relevant, and shall be electro-tinned. Neutral busbars shall be of thesame cross-sectional area as the phase busbars and shall have adequate number ofterminals for all outgoing circuits including spare ways.

4.22.13 The configuration of the busbars, busbar supports and busbar mounting arrangement) shall be rated at 415 V. It shall be certified to a short time withstanding current which is not less than 10 kA for 1 sec at voltage of 415 V as per design.

4.22.14 Multi-terminal connectors shall be provided within the distribution board for connection ofprotective conductors of all outgoing circuits including spare ways.

4.22.15 Size of the DB shall be optimized precisely by proper utilization of points on MCB. Proper utilization of points reduces the space acquired by DB as well. If the numbers of points are few on MCB then it shall be avoided by adjusting the same on other MCB having sufficient free points. MCB rating shall be as per the number of points to be included. Circuit for areas other than critical rooms e.g. SER, TER,SCR etc. shall be clubbed according to the rating of MCB. While designing DBs, efforts shall be made in such a way that each circuit shall have not more than 800 Watts connected load or more than 10 points, which ever is less. However, In case of LED Points where load per point may be less, number of points may be suitably increased.

5. FINISHES

5.1 Sheet Steel materials used in the construction of these units should have undergone a rigorous rust proofing process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process. The steel work shall then receive two dip-coats of oxide filler/primer before final painting. Castings shall be scrupulously cleaned and fettled before receiving a similar oxide primer coat. The manufacturer is required to have 7 tank treatment facility for this.

5.2 All exposed metal surfaces, both internal and external, shall be thoroughly cleaned of all dust, oil, grease, scale, rust or any other contaminants and shall be epoxy powder coated immediately at the manufacturer's factory. In case of any doubt, the painting procedure, paint samples and process shall be approved prior to commencement of painting.

5.3 The epoxy powder coating shall be not less than 50 micron thick and with colour in accordance with BS 381C or BS 4800 as approved by Engineer.

5.4 Every care shall be taken to protect the surface of the panel from damages during transporation and installation. In case, there is any damage, the same shall be made good by the method as approved by the site engineer which may also include change of the panel.

6. NAMEPLATES AND LABELS

6.1 NAMEPLATES

6.1.1 Each Electrical Panels shall have permanently attached to it in a conspicuous position labels upon which shall be engraved or stamped with the manufacturer's name, type and serial number, date of manufacture, designation of each Electrical Panels, details of the loading and duty at which the item of the Electrical Panels has been designed to operate. Such labels shall be of non-hygroscopic material.

6.2 LABELS

1. Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control equipment mounted externally and internally.

2. The designation on these labels shall be clear and shall, where applicable, incorporate the device number along with concise descriptive wording in English.

3. Externally fitted panel labels shall be of perspex or other approved transparent plastic with letters and numbers rear engraved and filled with black.

4. Internally fitted panel labels shall be finished in white with engraved letters and numbers filled with black, laminated material such as Traffolyte or rear engraved and filled plastic may be used. Embossed materials and techniques will not be accepted or any latest technogoly which provides same result as mentioned above shall be applicable.

5. Labels shall be provided in conformity with the above requirements or by other approved means wherever necessary to designate panels or panel sections. To describe or identify circuits or circuit components, to provide warnings or reminders ofdangerous or potentially dangerous circumstances and wherever called for elsewherein this Specification.

6. Safety labels "Danger 415 V in both English and Hindi shall be provided on both thefront and rear of the Electrical Panels. The safety labels shall have graphic symbols exactly as per IS standards. The design of all such signs shall be submitted forapproval. Similar labels shall be provided for other panels at different voltages.

7. Labels shall not be less than 45 mm high. Lettering shall be of not less than 10 mm high. All labels shall be securely fixed to the panels by bolts and nuts.

8. Details of proposed inscription, including the English and Hindi wordings, and samples of the labels shall be submitted for approval before any labels are manufactured.

9. Circuit labels, one on the front of the panel and one on the rear of the panel suitably engraved.

7. FOUNDATION (IF REQUIRED) AND INSTALLATION

7.1 The location of each foundation shall be correctly set out in accordance with the approved foundation layout drawing. Base channels shall be grouted, leveled in cement concrete pad for switchgear and other cubicle panels, etc. with reference to a bench mark in the building. Pedestal type panels and superstructures shall be erected by grouting foundation bolts into the foundation in cured holes left in foundation blocks. For concreting on existing floors, a proper bonding surface shall be made by chipping the floor. The final finish to the surface of the floor shall be given after all equipment has been installed. If floor is broken for installation of equipment, it shall be restored to original finish after completion of installation.

7.2 The concreting shall be done in accordance with the provision of Indian Standard Code of Practice for Plain and Reinforced Concrete, IS 456-2000. Concreting IS: 383-1970 Specification for coarse and fine aggregates from natural sources for concrete IS: 269-1989 Specification for 33 grade ordinary portland cement IS: 516-1959 Method of test for strength of concrete

7.3 Suitable grooves or niches shall be provided in the foundation block at the time of casting to enable embodiment of earth strips without calling for chipping of the blocks. Subsequently conduits of appropriate size shall be embedded in the foundation blocks for cabling, in the first instance, wherever required.

7.4 All foundations shall be cast in the presence of the Employer's representatives. All foundation and grouted bolts shall be cured for a minimum period of 48 hrs.

7.5 Foundations shall be prepared as per manufacturers drawing, shall be leveled, checked for accuracy and the switchboards installed. Busbar connections shall be checked with a feeler gauge after installation. Tightness of accessible bolted bus joints shall be checked using calibrated torque wrench. Sealing of cable and boxes to prevent moisture entry shall be checked. Switchboard earth bars shall be connected to the earth grid.

7.6 Fabrication drawings of all panels shall be approved by the Employer's representative before fabrication

7.6.1 The Electrical Panels shall be installed in the locations as approved by the Engineer. Electrical Panels shall be secured, plumbed and levelled and in true alignment with related adjoining work,

7.6.2 The rigid galvanized U-channels to ensure effective fixing of the Electrical Panels on the uneven floor shall be provided.

7.6.3 Anchor bolts and anchorage items shall be provided where required and field checked to ensure proper alignment and location. Templates, layout drawings, and supervision on Site shall be provided to ensure correct placing of anchorage items in concrete.

7.6.4 Supporting members, fastenings, framing hangers, bracing, brackets, straps, bolts, angles, shall be installed as required to set and rigidly connect the work.

7.6.5 Temporary bracing,gauge, or other devices shall be provided as required to accomplish erection and to provide safety and stability until the ELECTRICAL PANELSis in its final and approved position.

7.6.6 Erection tolerance requirements shall be controlled so as not to impair the strength, safety, serviceability, or appearance as Approved.

7.6.7 After installations are complete, all places where the shop applied coating is abraided, all bare steel, including bolts, nuts, washers, and welds shall be thoroughly cleaned. Each item shall be painted with the same paint as used for shop coating in the corresponding location.

8. OTHER PROVISIONS

8.1 The Electrical Panels shall be provided with all necessary cable lugs etc., fixed in positions onmounting plates and straps, to suit the types and directions of entry of the cables as shown on the Drawings or as specified.

8.2 Cable conductors for all circuits within the Electrical Panels shall be arranged in a tidy manner and mechanically secured at regular intervals such that any movement occurring to the conductors, either under normal operation conditions (e.g. thermal expansion, vibration, etc.) or due to short circuit in any one of the circuits, shall not cause any damage or short circuit to any healthy bare live parts in the Electrical Panels.

8.3 Each Electrical Panels shall be supplied complete with all operating handles jigs, etc. required for the normal charging, closing, opening, racking in and out operations of all circuit breakers of the Electrical Panels and shall be properly fixed in a neat manner on a board with brass hooks inside the switch room/plant room where the Electrical Panels is installed.

8.4 Each Electrical Panels shall be provided with two rubber mats of ribbed surface, complying to BS 921 or equivalent Indian standards, laid in front of and at the rear of the switch board. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the switchboard and minimum width of not less than 1000 mm or the width of the space between the fronts or back of the switchboard to the adjacent wall.

8.5 Hydraulic operated handling truck suitable for handling all sizes of air circuit breakers for the Electrical Panels shall be provided as indicated in the BOQ.

9. SPECIAL CONDITION:

9.1 The Switchboard shall be complete with all components andaccessories, which are necessary or usual for their efficient performance and satisfactory maintenance under the various operating and atmospheric conditions. Such parts shall be deemed to be included within the scope of supply whether specifically included or not in the specifications or in the tender schedules. The contractor shall not be eligible for any extra charges for such accessories etc.

10. RELIABILITY, MAINTENANCE, SPARES AND LIFE

10.1 The electrical panel shall be designed for reliable and safe working. It shall be designed for a maintenance free secure service life of switchboards, sub-assemblies and components for at least 30 years.

10.2 The manufacturer shall submit the list of spares which are required to be replaced as a must change item along with interval.

11. MATERIAL AND MANUFACTURING:

11.1 Allsimilar items of the Electrical Panels and their component interchangeable. Spare parts shall be manufactured originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings accompanying the instruction manuals.

11.2 All parts which are susceptible to wear or contaminated by dust shall enclosed in dust-proof housings.

11.3 The style and finish of the workmanship shall be consistent throughout the Works. Unless otherwise specified, Engineer shall decide the final colours for all paintwork and other finishes to be applied to the Electrical Panels.

12. TESTING

12.1 The firm shall submit valid type test not more than 5 years old of the equipment conducted at accredited/authorised/reputed/nominated by DMRC laboratory. The type test shall be as per the governing specification.

12.2 DMRC will carry out Routine and factory acceptance tests as prescribed in the specification with following additional test

12.3 In case of Distribution Boards type test is not essential,however test of short circuit capacity must be submitted.

12.4 The manufacturer shall not change the Bill of Material used in the manufacturing of samples used for Type testing. In case the bill of material is changed then Engineer-in-charge may ask for the repetition of those type test which he considers relevant.

13. TRAINING

The contractor shall provide the following details

- ✓ Every marshalling box and PLC compartment of the Electrical Panels shall be provided with a wiring diagram suitably treated to prevent deterioration from dirt or age. The diagrams shall be drawn as if viewed from the point of access to the enclosure, and shall be securely fastened to the inside of the access door of that compartment.
- ✓ Bound booklet consisting of the details of the equipment
- ✓ Operating manual
- ✓ Warranty/DLP
- ✓ Purchase specification of maintenance spares
- ✓ List of staff trained
- ✓ Details of service centre

14. INDICATIVE LIST OF ITEMS TO BE INCLUDED IN FAT PLAN FOR ELECTIRCAL PANELS

(This list is an indicative List for the inspectors to be conducted during FAT of Power Panels. However, the detailed FAT plan needs to be developed for the specific Panel based on approved GADs and Contract Specifications and as per the tests defined in Clause – 11 of IEC 61439 -1 (Routine Verification)/as per the relevant Standards as applicable.)

S. No	Description	Type of Check	Remarks
	GENERAL		
A	All items/components (switchgears, cables, wires, meters, relays etc.) used are as per the Approved Makes, Vendors and ratings.	Visual Check & Certification before Call letter	Obtain confirmation from Panel Manufacturer for each Panel duly verified by the Main Contractor.
B	Obtain the Factory Test reports of Incoming/Raw Material	Verify	
C	Obtain the Internal Test reports/Manufacturer Test Report of Internal Quality Tests done on Panel offered for Inspection as per ISO 9001.	Review	
D	Confirmation from Panel Manufacturer that Penel has been manufactured strictly as per approved GADs.	For record	
E	List of tools required for Inspection and copy of their Calibration Certificates from	Check for Validity	

	independent Labs/Authorities.		
Note:	All the above are to be made part of this FAT report		
	Panel must be of Modular construction as per PS. The Inspection team shall carry the approved GAD, approved Bill of materials, Contract Specification, relevant standards, copy of Approvals and approved FAT Plan from the office before proceeding for the FAT inspection to the factory promises.		
Physical/Dimensional Checks(as per approved GADs).			
1	Check the Length, Breadth and Height of the complete Panel.	Measurement	
2	Check dimensions of each Sections and Cubicles.	Measurement	
3	Check Number and dimensions of Space for future additions as per Specifications & Bod.	Measurement	
4	Check dimensions of the Doors/back Panels, etc. (Note: Back Panel sections should not be too bulky to handle by one individual. May be taken care during GAD and checked during FAT).	Measurement	
5	Check height/dimensions of all front Mounting Accessories (such as indicators. Measuring instruments, knobs, etc.)	Measurement	
5.1	EPB (Emergency Push Button) at 1300 mm where applicable.	Measuremnt	
5.2	All Relays & indicating instruments between 300 to 1800 mm	Measurement	
5.3	Max. Operating Height should not be more than 1800 mm	Measurement	
5.4	Blank Space between the Floor of Switch board and bottom unit (Min. 200 mm or as per PS)	Measurement	
6	Check size/height of Base Frame (may be min. 100 mm. or as per PS).	Measurement	
6.1	The make of the manufacturer of bought out items is clearly displayed on the items where possible.		
6.2	Check that all materials used in the manufacturing of the electrical panel are fire refardant, low smoke & zero halogen.		
7	Verify Material and Thickness of Load bearing and Non-Load Bearing Member of Panel Enclosure:	Certificate/Measruement	
7.1	Panel Structure		
7.2	Bus bar Section		

7.3	Cable Alley		
7.4	Switchgear/feeder sections		
7.5	Doors		
7.6	Gland Plate		
8	Check Quality of Sheet Metal Painting and Color used. It should be as per the Specification/Approved drawings.	Visual/Measurement	
9	Check for the Quality of Sheet Metal Workmanship. There shall not be any sharp edges, burrs, dents, etc. on the panel.	Visual	
10	Check Number and Quality of the Door Hinges. Ensure that doors is strongly supported and should not have any unwanted deflection/shakiness. When door is closed, it is latched at adequate places with adequate crushing of gasket on metal frame.	Visual	
11	Check Quality of the Door handles, Locks etc.	Visual	
12	Check interlocking of Doors, Switchgears, incomers, outgoings and couplers as per the design logic and drawing	Verify and Visual Check	
13	Check and compare the sealing arrangements all around the panel to ensure intended ingress Protection is achieved and compare with the Type test reports.	Verify and Visual Check	
13.1	Simple Paper insertion test for IP54. Insert a paper in the gasket and metal frame, close the door and pull the paper. It should nto pull out.		
13.2	Check Quality of Gaskets/sealing rubber, etc. for the Doors. The arrangement shall be such that it is replecable during maintenance.		
13.3	Check Quality of Gaskets/sealing rubber, etc., around the cut-outs for Measuring & indicating instruments, Switchgears, Relays etc.		
13.4	Proper sealing of knock-outs/cut-outs/gaps for control cabling bus bar, etc., between different feeders/sections within the Panels.		
14	Check the Lifting arrangements (Hooks etc.) are provided.	Visual	
14.1	Adequate Number of Lifting points/Hooks		
14.2	Adequate Strength of Lifting Points/Hooks		
15	Check proper identification markings, numbering labeling, tags have been provided.	Visual	
15.1	For the Penel		
15.2	For each incoming and Outgoing Feeders		

15.3	For Measuring and indicating instruments		
15.4	Danger Plates/Signages		
16	Check for rust, any sign of initiation of corrosion, oxidation, etc., on the support members/nut bolts/bus bars/terminal points, etc. Initiation is an indication of use of defective material.	Visual	
CABLE ALLEYS			
17	Check for Cable Entry Arrangement (top entry/Bottom entry) as per GADs.	Visual	
18	Check for Maintenance/Working space in Cable Alleys, etc.	Visual/Measurement	
19	Check for adequate Space for accommodating Cable Loops, etc.	Visual/Measurement	
20	Provision for securing/clamping cables in Cable alley for proper dressing of cables.	Visual	
21	Check for Knock outs for Glanding of different smaller sizes of Cables in Marshalling box (to be used for BMS cables).	Visual	
22	Thickness ofGlanding Plates should be minimum 5.0 mm & strong enough to take the simultaneous load/forces of cables glanded on to it. The Cables shall be well supported and not exert any force on the glanding plate	Measurement	
23	Proper dressing/harnessing of internal control cables and wiring within the Panel.	Visual	
24	Provision of identification tags/ferrules on the internal control cables and wiring within the Panel.	Visual	
EARTHING ARRANGEMENT			
25	Check that Material of Earth Bus provided in Panel is as per PS.	Visual	
26	Check the Size of continuous Earth Bus provided in the Panel as per IEC.	Measurement	
27	Check if the Earth Bus is properly supported and connected to the outside terminals.	Visual	
28	Check that proper earthing has been provided through out the Panel and all non-current carrying parts are properly earthed.	Visual	
29	All the Gland plates have been earthed properly	Visual	
30	All Doors and openable sections must be earthed through flexible wires/jumpers (dual if required as per Specs)	Visual	
31	Cases of all instruments and apparatus shall be earthed by a conductor of suitable size	Visual	

	(but not less than 2.5 sq. mm)		
32	Check that the Frame of Switchgear is earthed, when racked in to the Cubicie.	Visual	
BUS BAR SECTION			
33	Check Bus bar dimensions as per Approved GAD (Only rectangular Busbar is permitted)	Measurement	
34	Neutral bus shall be of full size	Measurement	
35	Material of the busbar shall be as per approved specification	Visual/Certificate	
36	Quality (Conductivity) of the Material of the busbar (Copper/Almunium) shall be as per approved specification	Certificate/Measurement	
37	Check the quality of conducting material used for Bus bar and the Quality of Tinning on the Copper Bus bar.	Certificate/Measurement/Visual	
37.1	Factory tinned Bus bars to be used. Obtain the Factory Test certificate and attach the report.		
37.2	Tinning of Bus Bar edges after cutting/sizing also to be checked.		
38	Check that the Bending of Bus Bars should be on Rollers of adequate diameter to avoid undue bending stresses	Confirmation & Cross-Check	
39	Check the fixing/mounting arrangements of Main bus bar to ensure that there are no undue stresses due to misalignment of fixing arrangements. (Focus on the location where Panel is divided in to different sections to ensure that the Bus Bar sections match properly).	Visual	
39.1	Check the proven design of bus bar connections of OEM & its compliance in the manufactured product		
40	Bus bar must be color coded for Phase identification	Visual	
	Note: In case, sleeve is to be provided over the Bus bar for color coding as per PS, then the material of the sleeve must be as per the relevant clauses of PS.		
41	Check the distance between Bus bar supports and compare with Type tested assemblies/Approved GADs.	Measurement	
42	Bus Bar Supports should be of approved material.	Confirmation	

43	Measure minimum Electrical clearences between the bus bars for different Phases, Neutral and Earth. (Main Bus as well as Tap off Bus bars) (Minimum clearance will be between Live parts and Earth)	Measurement	
44	Check the interconnecting / Tap - off links between Main Bus and bus sections for proper tightness etc. (connection with the double split cast brass clamp is permitted)	Measurement	
45	Interconnection between Bus Bar and Switchgear - must be high conductivity Copper Bar and must be insulated and Colour coded	Visual	
46	Proper compartmentation at locations where connecting Links enter the Switchgear section, bus bar sections and Cable Alley must be ensured. (Form - 4 b, Type - 5 to be ensured, for Underground section) For elevated, separate compartments for incoming and Outgoing cable terminations, to be ensured.	Visual	
47	Proper Shrouding of Bus bar joints / tap off points to be ensured. Material to be as per PS of the Contract.	Visual	
48	Proper clearances and seggregation must be maintained between Terminals / Tap - offs of different feeders from Main Bus Bars.	Measurement	
INTERNAL WIRING, TERMINAL BLOCK			
49	Check if the Wiring for all power and Control circuit is being provided as per Approved GAD / Specifications.	Verify Material Test Certificate	
	Note:- Internal Wiring in LT panels to be LSZH / FS as per Specs for Underground stations. For elevated stations, internal wiring may be ensured as per PS.		
50	Termination arrangements		
50.1	Terminal blocks should be of Non - Hygroscopic of Melamine	Verify Material	
50.2	At terminal points - Plain and Spring Washers with electro - tinning to be used	Visual	
50.3	Check the tightness of wiring termination	Visual	
50.4	Terminal should have test probe facility	Visual	
50.5	All Live parts of Terminal blocks must be fully shrouded	Visual	
50.6	Spare Capacity of Terminals	Visual	

50.7	Cable terminations should be with lugs of adequate size and with proper crimping	Visual	
50.8	No more than two wire to be connected to the Terminal	Visual	
50.9	Terminals should have identification Labels.	Visual	
50.1	All cables should have identification ferrules	Visual	
50.11	Check if the adequate size of the cables / wires is being used for the control wiring	Measurement	
50.11	All the internal wiring shall be properly dressed and randomly check the tracebility of the wires from the wiring diagram	Visual	
50.12	Check Provision of Protection for Control wiring as approved	Visual	
MARSHALLING BOX for BMS (if applicable)			
51.1	Marshalling Box / Separate chamber for the BMS connection is provided as per the Approved GAD	Visual	
51.2	Check the BMS points have been provided as per the approved I/O schedule	Visual	
51.3	Provision of Softlinks points for the control shall be checked	Visual	
51.4	All the terminals for the BMS shall be properly secured and identification mark along with the voltage level shall be provided	Visual	
51.5	Randomly check voltage level at the BMS points for any leakage voltage etc (at Potential free contacts)	Measurement	
51.6	No power wiring / cable should pass through marshelling box	Visual	
SWITICHGEARS, PROTECTIONS, INDICATIONS, ANNUNICATIONS AND MEASURING INSTRUMENTS			
52	Detailed Check list for these items of the Panel may be prepared based on the GADs / Contract Specifications	Factory Test Certificates and Test during FAT	
53	Test Certificates / Calibration Certificates for Measuring instruments to be ensured	Factory Test Certificates	
54	Check Surge Arresters (if applicable) have been provided	Visual & Manufacturer's Test Reports	
55	Separate CTs for Measurement and Protection of relevant Class and Burden as per PS to be ensured	Visual & Manufacturer's Test Reports	

56	Check Control Logics, Interlocks and Protections Schemes in detail as per the approved plan / arrangement.	Visual, Simulation, Primary & Secondary Injection etc	
57	Check the working of ALTS & Controls provided for safe operation.	Visual, Simulation, Primary & Secondary Injection etc	
	MISCELLANEOUS		
58	Check the lights, sockets, anti condensation heaters and air circulation means provided in the Panels as per GADs.	Visual	
59	All the Control and power wiring must per properly segregated.	Visual	
60	Padlocks and interlock provision and Functions to be checked for the safety for each.	Visual	
61	Check for extendability of the Panels (including Bus Bars) on either side.	Visual	
62	Check provision of entry for Fire Trace Tube and internally with in the various cubicles and adequate sealing arrangements.		
63	Ensure that there are No Joints in the cables used		
64	The tests defined in Clause - 11 of IEC 61439 - 1 (Routine Verification)/as per the relevant Standards as applicable are also to be performed for which separate Test sheet may be prepared.		
65	The make of the manufacturers of bought out items is clearly displayed on the items where posible.		
66	Check that all materials used in the manufacturing of the electrical panel are fire refardant, low smoke & zero halogen.		
APFC PANEL			
67	Ensure that material/equipment of only one make is used in the entire Electrical Panel assembly.		
68	Check the make, rating and specification of capacitors used.		
69	Check the functioning of APFEC relay as defined in the operating manual of the relay.		

70	Check the installation of capacitor & inductor as per the form & specification.		
71	Check the working of cooling fans only when temperature goes above set value and atleast one capacitor in service.		
72	Check the sizing of the filter used to ascertain the cleaning frequency for continuous working of cooling fan.		

15. DATA SHEET -

S. No.	Description	Unit	Values		
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9					
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11					
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30					

Length marking: *Length shall be marked with number at one meter intervals on the sheath.**Bidder to furnish the data

E02. LV POWER AND CONTROL CABLES

E02.1 General

E02.1.1 This Section specifies the manufacture and installation of Power and Control Cables.

E02.2 Standards

E02.2.1 Relevant Codes and Standards

E02.2.1.1 The power / control cables shall comply with the latest versions of the relevant requirements of the British Standards, International Electromechanical Commission (IEC) standards, European and other International Standards specified in this section of Specifications or approved equivalent International standards.

The following standards for cables and cable testing shall apply where appropriate:

Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire	LSZH	BS 6724
Electric cables. Thermosetting insulated and thermoplastic sheathed cables for voltages up to and including 450/750 V for electric power and lighting and having low emission of smoke and corrosive gases when affected by fire	LSZH (Non-armoured)	BS 7211
Specification for 600 / 1000V fire resistant armoured cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire	FS cables	BS 7846
Specification for insulating and sheathing materials for cables. General introduction.		BS 7655-1-3
Specification for conductors in insulated cables and cords	IEC 60228	BS EN 60228

Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions		BS 6387
Tests for electric cables under fire conditions		**BS 6387:2013**
Method of determination of amount of Halogen acid gas evolved during combustion	IEC 60754 – Part 1 and 2	BS – EN - 60754 Part 1 and 2
Determination of flammability by oxygen index	ISO 4589-2	ASTM – D2863
Method for determination of temperature index	ISO 4589-3	ASTM – D2863
Measurement of smoke density of electric cables burning	IEC 61034	
Methods of test for insulation and sheaths of electric cables	IEC 60811	**BS 50396/ BS EN 60811**
Calculation of continuous current rating of cables	IEC 60287	
Specification for performance of mechanical and compression joints in electric cable and wire connecting		BS EN 61238
Mechanical cable glands		BS 6121
Requirements for electrical installations IEE wiring regulations. Sixteenth edition		BS 7671
Measurement of smoke density of electric cables burning under defined conditions	BS 7622 Parts 1, 2	BS EN 50268 - 2
Test on gases evolved during combustion of materials from cables. Determination of the halogen acid gas content	IEC 60754	BS EN 60754-1:2014

(Note: In case of contradiction between various standards mentioned, the latest and most stringent standard will apply)

E02.3 Technical and Installation Requirements

E02.3.1 Quality Control

E02.3.1.1 Cables shall be manufactured from fire resistant/retardant, low smoke and halogen free materials, and utilised at locations as specified herein.

E02.3.1.2 All the cable requirements listed herein shall be met without compromising the mechanical and electrical properties of the cables both during and after installation.

E02.3.1.3 The Employer's Representative / Engineer shall have such access to the premises of the Contractor / Manufacturer as is reasonable to enable him to determine the quality of the material and the workmanship and may reject any part of the cable which may appear defective either in material or workmanship.

E02.3.1.4 For Underground areas such as tunnels and stations, the cables shall be XLPEinsulated (except for cables as per BS7211 (table 3), which shall be with EL-5 / GP-6 insulation for applications listed in Table A1, Annexure A to BS7211) with LSZH properties as described in clause *E02*.3.2. Further, these cables should have reduced flame propogation properties to BS EN50268/61034.

E02.3.1.5 Cables used in external or open areas shall be ultra violet radiation stabilised.

E02.3.1.6 Employer's Representative / Engineer may direct contractor / manufacturer to conduct tests listed in clause E02.3.9 and E02.2.1.1. This shall not preclude any further tests, which may be required to determine the quality of the cable. If so desired by the Employer's Representative / Engineer, the tests shall be conducted at a recognised testing laboratory.

E02.3.1.7 Unless otherwise specified, all power and auxiliary / control cables shall be rated at 600 / 1000 V for armoured and non-armoured cables and 450/750 V for non-armoured wires.

E02.3.2 Construction Requirement for cables required for Underground Station

E02.3.2.1 Power and Auxiliary Cables for use in the Underground areas of DMRC Metro shall be of the type and manufactured to the standards as given below.

(a) Cables conforming to BS 7846: "Specification for 600 / 1000V fire resistant armoured cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire"

Fire resistant / fire survival power cables shall be provided for the emergency lighting circuits, UPS supply circuits, battery and charger circuits, fire services installations, smoke extraction system, staircase pressurization system, fireman lifts, disable lifts, and those circuits required to maintain circuit integrity under fire conditions. Cables for loads classified as the "Emergency" loads shall be Fire Survival type and shall conform to NFPA requirements.

(b) Cables conforming to BS 6724: "Specification for 600 / 1000V armoured electric cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire "

(C) Cables conforming to BS 7211. "Specification for Thermosetting insulated cables (Non-armoured) for electrical power and lighting with low emission of smoke and corrosive cases when effected by fire ". In case of FS wires, it must also comply with CWZ category of BS6387.

Other than the cables specified in Clause E02.3.2.1 (a), cables for Essential and Non-essential circuits shall be of the type specified in Clause E02.3.2.1 (b) and (c).

Some of the major constructional features of these cables are described below. Further requirements additional to the standards mentioned are also described and the same must be complied with. In case of any contradiction between these the most stringent conditions will apply.

Conductors

a)The conductors shall be of stranded, high conductivity annealed copper wire complying with all the requirements of IEC 60228 and **BSEN 60228**.

b) Cables for fixed installations shall have conductors with stranding to Table II Class 2 of IEC 60228 or BS EN 60228, and flexible cables shall have stranded conductors to Table II Class 5 of IEC 60228 or BS EN 60228.

c) Conductors shall be smooth, uniform in quality, free from scale, spills, splits and any other defects. There shall be no joints in individual strands except those made in the base rod or wire before final drawing.

E02.3.2.2 Insulation

All cables shall be insulated with extruded Cross-linked Polyethylene (XLPE) / complying with the requirements of BS 7655-1.3 (Type GP8). However, whereever the cables as per BS7211 are required, type of insulation shall be used for installation in surface mounted or embedded conduits or similar closed systems. The insulation properties and construction shall comply with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause *E02*.3.2.1 of this Specifications. The multicore XLPE insulated cables shall be rated for continuous operation at a maximum conductor temperature of 90 ºC and for a maximum short circuit temperature of 250 ºC.

E02.3.2.3 Cable and Wire Colours

a) All single-phase wires and cables shall be colour coded, i.e. Red, Blue and Yellow colours.

b) Black denotes the neutral conductor and other colours denote the phase conductors.

c) The earth conductor shall be coloured green.

E02.3.2.4 Fillers and Binders

a) Low Smoke and Zero Halogen Fillers and synthetic binders, compliant with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications, shall be applied to ensure that the cable is compact and reasonably circular, If necessary

E02.3.2.5 Bedding

b) The bedding shall consist of an extruded layer of low smoke halogen free bedding compound compliant with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications.

E02.3.2.6 Armour

a) Armouring shall be of galvanised steel wire compliant with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications. The direction of lay of the armour shall be left hand, and the wire shall be sized in accordance with the manufacturer's recommendations.

b) Where single core cables are armoured and are in use on ac circuits, the armouring shall consist of non-magnetic material.

E02.3.2.7 Over-sheath

a)The over-sheath of the cable shall be an extruded layer of anti-corrosion, reduced flame propagation, low smoke halogen free compound complying with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications and the fire performance requirements in clause E02.3.3 of this M&W Specification.

b) The colour of the over-sheath shall be black as required.

c) Outer sheath should be of such material to make the cable rodent and termite proof.

E02.3.2.8 Properties of Cable Sheathing

a)Physical properties of the cable sheathing materials shall comply with the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications and have the following requirements when tested in accordance with **BS EN 60811**.

Property	**Requirement**
Minimum tear resistance	8 Nmm-1

E02.3.2.9 a) Cables to be used should be moisture – resistant and to be tested through gravimetric water penetration test.

b) Cables used in moist area should be corrosion resistant.

E02.3.3 Fire Performance Requirements

E02.3.3.1 **Flammability**

a) The bedding and over-sheath of the cable shall have a minimum oxygen index of 30 when tested in accordance with ISO 4589 – 2 / ASTM – D2863

b) The temperature index of the bedding and over-sheath of the cable shall not be less than 280 °C when tested in accordance with EN ISO 4589-3 / ASTM – D2863.

E02.3.4 Flame Propagation/Integrity under fire conditions

E02.3.4.1 **Fire Resistant or Fire Survival Cable**

Fire Resistant / Survival cables shall comply with the requirements of BS 7846 .

E02.3.4.2 **XLPE Insulated LSZH cables as per Clause E02.3.2.1 (b) and (c)**

a) These cables shall comply with the requirements of BS EN **60332**/BS EN 50268/**61034** / IEC 60332: Part 1 for tests on a single cable under fire conditions when tested in accordance with that standard.

b) The cables shall comply with the requirements of BS EN **60332**/**61034** /IEC 60332: Part 3 Category 'A' for tests on bunched cables under fire conditions when tested in accordance with that standard.

E02.3.5 Corrosive and Acid Gas Emission

E02.3.5.1 The level of hydrochloric acid gas (HCl) emission of the insulation, fillers, binder tapes, bedding, and over-sheath of the cable shall not be greater than 0.5% when tested in accordance with IEC 60754 / BS EN 60754 Part 1 , whichever is latest.

E02.3.6 Smoke Emission

E02.3.6.1 The value of smoke generated (Ao) shall meet the requirements of the relevant clauses of BS 6724 / BS 7211 / BS 7846 for different types of cables mentioned in Clause E02.3.2.1 of this Specifications, when a sample of the complete cable is tested in accordance with IEC 61034 / BS 7622 /**BS 61034** (3 m Cube Test).

E02.3.7 Toxic Gas Emission – Not used

E02.3.8 Cable Current Carrying Capacity and Design Parameters

E02.3.8.1 The maximum continuous current carrying capacity and the factors for determining such ratings and temperatures, for XLPE insulated cables shall be based on IEC 60287 and on the conditions available at Site.

E02.3.8.2 The maximum continuous rating of the cable shall be based on the following conditions:

a) Cables laid direct in ground or buried pipes

Ground or duct temperature -50 °C

Depth of laying to top of cable – as actual

b) Cables in air in railway tunnels:

Ambient air temperature - 50 °C

c) Cables in air above ground:

Ambient air temperature (shade) - 50 °C

d) Maximum continuous conductor temperature:

XLPE insulated cables (up to 1000 V) -90 °C

e) Rated duration for maximum short circuit current: - 3 sec

f) Max temperature under Short circuit conditions:-250 °C

E02.3.9 Testing of Cables and Accessories

All the materials employed in the manufacture of the cable shall be subjected to tests specified in relevant standards before manufacture of the cable.

The manufacturer must have type test certificates from the third party accredited laboratories certifying compliance to all the type tests mentioned in the relevant clauses of BS 6724 / BS 7211 / BS 7846 and relevant tests mentioned in Clause E02.2.1.1. In case of non – availability of these test certificates, the manufacturer must get these cables type tested at third party accredited laboratory prior to production of cables. The sample selection for the all type tests shall be as per Annexure P.2 of BS 6724 & BS 7846 respectively. The type test report shall consists of all the tests confirming to table-2 of BS 6724 & BS 7846 respectively.

After completion of manufacture and prior to dispatch the cables shall be subjected to routine & acceptance tests as specified in relevant standards.

Any additional test during work execution required by the employer shall be at employer's cost.

E02.3.10 Cable Construction Identification

E02.3.10.1 The individual cores of the cable shall be clearly identifiable in terms of phase sequence.

E02.3.10.2 The over-sheath of the cable shall be embossed with the following legend:

Voltage Designation	Cable Marking
240/415 Volts	'Electric Cable 600/1000 V' or 'Electric Cable 450/750 V'

E02.3.10.3 A means of identifying the manufacturer, year of manufacture, conductor size and insulation type shall be provided throughout the length of the cable. If the identification is by means of embossing, it shall not affect the spacing of the legend specified above. If the proposed power and control cables are approved by any product certification agency like BASEC, LPCB etc., the agency trade mark/name shall be present on the embossing of cables.

E02.3.10.4 All FS cables shall have continuous red strip throughout the cable length for the ease of identification.

E02.3.11 Cable Drums

E02.3.11.1 Immediately after the manufacturer's tests both ends of every length of cable shall be sealed by enclosing them with Approved caps, tight fitting and adequately secured to prevent ingress of moisture.

E02.3.11.2 The ends of the factory lengths of cable shall be marked "A" and "Z", "A" being the end at which the sequence of core numbers is clockwise and "Z" the end at which the sequence is anti-clockwise.

E02.3.11.3 The end which is left projecting from the drum shall be consistently "A" or "Z", and shall be protected against damage in such a manner that the enclosure cannot be easily removed during handling while in transit

E02.3.11.4 Cable drums shall be stored on well-drained hard surfaces to prevent cable drums sinking and to simplify drum movements.

Cable drums shall be stored on battens placed directly under the flanges. Storage shall be in such a manner to leave sufficient space for air circulation. Every three months of storage the drums shall be rotated 90^{o} in the direction of the arrow.

During storage the ends of the cable shall remain properly sealed to prevent ingress of moisture.

Adequate shelter from rain and sun shall be provided. Adequate drainage shall be provided to prevent the cable drums standing in water.

Cable drums shall not be dropped during transit, and cranes should be employed during unloading. Cable drums should be rolled only in the direction of the arrow.

If passing one cable to another drum, the cable drum sizes must be the same.

During removal of the cable from the drum the minimum bending angle of 1 in 15 shall not be exceeded.

Pulling force when using stockings shall not exceed 9D in Newton (N) where D is the outer diameter of the cable.

Drum Lengths

Cables shall be supplied in drum lengths as follows:

- Medium voltage power cables up to and including 6 sq. mm - 1000 m.
- Medium voltage power cables from 10 sq. mm up to

and including 400 sq. mm - 500 m

- Control cables - 1000 m

A tolerance of + 5% shall be permissible for each drum.

5% of the order quantity can be supplied in non-standard lengths of not less than 100 metres.

E02.3.11.5 **Packing and Marking**

Packing

Cables shall be dispatched in wooden / metallic drums of suitable barrel diameter, securely battened, with the take off end fully protected against mechanically damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum.

Marking

On flange of the drum, necessary information such as manufacturer's name, type, size, number of cores, voltage grade of cable, length of cable in metres, drum No, cable code, finish, gross and net weights etc. shall be printed. An arrow shall be printed on the drum indicating the direction of rotation of the drum.

E02.3.11.6 All cable drums shall be arranged to take a 100 mm diameter round spindle and shall be lagged with strong closely fitting battens so as to prevent damage to the cable. Each drum shall bear a distinguishing number, either printed or neatly chiselled on the outside of one flange.

A suitable spindle shall be provided with each consignment for loading and unloading where the gross weight of the drum and cable exceeds 10 tonnes.

E02.3.11.7 The words "Running End A" or "Running End Z" as appropriate shall be marked on the flange.

E02.3.11.8 All cables and accessories shall be carefully packed for transport and storage on Site in such a manner that they are protected against all climatic conditions, particular attention being paid to the possibility of deterioration during transport to the site by sea or over-land and to the conditions prevailing on the Site.

E02.3.11.9 Wooden cable drums shall be suitably constructed to avoid any problem due to shrinkage. The drums shall be designed for use in conjunction with any special cable-laying equipment complete with spindles and cable drum braking gear.

E02.3.12 Cable Installation

E02.3.12.1 This clause covers the requirements for the use and installation of all cables on or in conduits, trays, trunking and accessories.

E02.3.12.2 All cables shall be provided with identification labels at each end and at each position where cables change direction. In the instances where cables are multiple runs, labels shall be provided at 10 m intervals indicating run number also. Identification discs for cables installed within buildings or tunnels shall be supplied

and attached with galvanised wire to each cable at intervals not greater than 12 metres and at all cable terminations.

E02.3.12.3 Cables shall be installed in accordance with this M&W Specification and BS 7671 and shall be run between their source and termination points on or in cable ladder/trays, ducts, cable brackets, trunking and conduits.

E02.3.12.4 Cables running horizontally at high level shall in general be supported by cable ladder and/or perforated cable trays or trunking. Where cables are installed in vertical ducts or on vertical cable ladder/tray, they shall be cleated at intervals not exceeding 1,200 mm

E02.3.12.5 Where cables pass through fire-rated walls and floors, all openings shall be sealed with fire-resistant material of a fire rating equivalent to that of the fire rating of the wall or floor approved by Jaipur Fire Services.

E02.3.12.6 Where cables are to be laid at ground level these may be laid in concrete duct banks (with or without conduits) or laid in GI / HDPE / RCC pipes available directly in ground as per the approval of Employer's Representative. The cables shall be segregated according to their duty.

E02.3.12.7 Cables shall be installed with a minimum of 300-mm clearance from any equipment or pipe work including lagging associated with other services. Where this condition is unavoidable or difficult to maintain, the Employer's Representative shall be informed prior to the installation being commenced.

E02.3.12.8 The power cables shall, for interference purposes be separated from the signal & communication cables in the tunnel, stations & under platform voids. Control and other cables shall be routed separately from traction or power cables. Cables shall be installed so that any one cable can be removed without disturbance to cables from other circuits in the same route.

E02.3.12.9 Materials manufactured for use as conduits, raceways, ducts and their surface finish materials, when installed in stations and train-ways shall be capable of being subjected to temperatures up to 930^{o} F (500^{o} C.) for an hour, and shall conform to the National Electrical Code (NFPA 70). They shall also conform to the codes of the National Electrical Manufacturers Association (NEMA), the American National Standards Institute (ANSI), and Underwriters Laboratories, Inc.

Materials manufactured for use as conduits, raceways, ducts and their surface, finish materials when used for emergency power circuits shall be strong and durable.

E02.3.12.10 All cable routes near tracks are to be parallel or perpendicular to the running lines.

E02.3.12.11 In general two cable routes shall be constructed, one each for Up and Down lines, with minimum changes of directions. Bends shall not be less than the manufacturer's recommended minimum bending radius for the cables to be installed.

E02.3.12.12 Cables passing under road and railways shall be mechanically protected (i.e. HDPE / Galvanized iron sleeves / pipes) and have a minimum cover of 1000 mm.

Proper care must be taken for jointing of metallic pipes, so that they do not give way due to weight above and damage the cables.

E02.3.12.13 Track crossings are to be at right angles and at least 2 m clear of any rail switches or crossing areas of leads.

E02.3.12.14 All cable entries into cable pit shall have rounded edges to prevent damage to cables during installation or during service or as a result of the weight of the cables themselves bearing against the edges.

E02.3.12.15 Unarmoured cables, which are direct buried, shall be mechanically protected throughout their length such as laid in metallic pipes or by other equivalent methods.

E02.3.12.16 Cable route markers shall be installed for underground cables where cables change direction and on straight runs of cable at intervals of no more than 50 m. Markers shall be of pre-cast concrete type and be marked "electrical cable" and have a projection of 200 mm above the finished ground level.

E02.3.12.17 Cables shall be installed without tee joints.

E02.3.12.18 Cable armour shall be earthed at one end or both ends of the cable as required by the installation and system. Cleats shall be of the moulded reinforced nylon type of low smoke and halogen free materials.

E02.3.12.19 Where cables are laid in concrete troughs, the trough opening shall be sealed with concrete slabs.

E02.3.12.20 Bends in cables shall have an internal radius of not less than six times the overall cable diameter, or as specified by the cable manufacturer.

E02.3.12.21 Where cables are laid in open ground they shall be bedded in 75 mm of sieved sand, covered with a similar material, and protected by concrete slabs or interlocking tiles, and the trench shall then be back filled. Medium voltage and signalling cables shall have a minimum cover of 750 mm.

E02.3.13 Not Used.

E02.3.14 Installation of Insulated Power Cables

E02.3.14.1 The installation and handling of cables shall be undertaken at all times by adequate and suitably trained staff, equipped with all the necessary plant, equipment, tools and lighting.

E02.3.14.2 Every precaution shall be taken to ensure that the cables and accessories are not installed in a manner or under conditions likely to cause electrolytic or other corrosive action or damage to the cables, or be detrimental to the performance of the cable during operation.

E02.3.14.3 The cable system shall be fully protected from mechanical damage and be accessible at all points for inspection.

E02.3.14.4 All cables installed shall conform to the relevant International standard for acceptable bending radius.

E02.3.14.5 In case, it is unavoidable, to cut any cables during installation, all cut ends shall be properly sealed.

E02.3.14.6 All transitions where cables pass from one graded area to another shall have an approved means of sealing the aperture against fire transference.

E02.3.14.7 The maximum pulling force on any cable shall not exceed the design force of the cable.

E02.3.14.8 All bolts, studs and nuts supplied shall comply with the relevant requirements.

E02.3.14.9 All exposed metalwork surfaces shall be properly painted, finished and galvanised as per relevant specifications.

E02.3.15 Installation of Cable Supports for Insulated Power Cables.

E02.3.15.1 The design of all support and fixing items shall ensure freedom from rough edges, burrs and sharp corners. No materials shall be used which will promote electrolytic or other corrosive action in contact either between the various parts, or with the cable sheaths or the building surfaces and other materials with which they may make contact. All cable supports shall be hot dipped galvanised.

E02.3.15.2 Hot dipped galvanised cable supports that are subject to excessive humidity shall be protected with an approved coating.

E02.3.15.3 The cable supports required for the installation of single-core cables forming three phase circuits shall permit the cables to be laid in close trefoil formation in case of three-phase circuit without neutral conductor or quadrature formation in case of three-phase circuit with neutral conductor. Non-magnetic metal cleats shall be used for this purpose. Low smoke halogen free packing material shall be applied between the cables and the cleats to avoid damaging the cable sheath by the installation of the cleats.

E02.3.15.4 Where single core cables in trefoil or quadrature formation are secured in cleats, intermediate binders of approved material and construction shall also be fitted around the formation to prevent the cables separating under fault conditions. The binders shall be secured around the cables by means of a bolted connection with low smoke halogen free packing material applied between the cable and the binder.

E02.3.15.5 Unless otherwise indicated on the Drawings, all non-armoured cables, where required to be run on walls, ceilings or other building structures, shall be secured or enclosed in conduit or trunking. Armoured cables shall generally be supported by cable ladders, cable trays or cable brackets.

E02.3.15.6 Every cable, whether in or out of sight, shall be neatly run vertically, horizontally or parallel to adjacent walls, beams or other structural members.

E02.3.15.7 Spacing of clips, saddles and cleats shall be such as to prevent sagging of the cables at all times during their installed life.

E02.3.15.8 All steel trays, supporting steel work, brackets, clamps, hangers, cleats, saddles and other fixings necessary for the support of the cables shall be approved by the

Engineer, and be of adequate strength for the cables they are supporting. All supporting steelwork and brackets shall be fitted with adjustable mechanisms.

E02.3.15.9 Where a number of cables are terminated to any particular item of plant or machinery, special care shall be taken to ensure that the cables finally approach the plant or machinery from a common direction and are individually terminated in an orderly and symmetrical fashion.

E02.3.15.10 At joints and terminations, all cables shall be adequately supported and secured by cable cleats at a distance of not more than 300mm from the glands or joints.

E02.3.15.11 LV power cables terminated onto the LV cable box of the Distribution transformer shall not impose load on the LV cable box to cause sagging, distortion, etc.

E02.3.16 Termination

E02.3.16.1 The terminating kits shall be suitable for termination of the cables on an indoor switchgear or equipment. These shall be of proven design and shall be type-tested as per relevant Indian or International Standards. Type test certificates shall be submitted. The cable and wire terminations shall avoid any possibility of loose joint and wire snapping. Cable conductor termination shall be by means of a heavy-duty solder less cable lug. The lug shall be of high conductivity copper, electro-tinned and applied to the conductor by means of a hydraulic crimping tool. All such crimping should meet the requirements of BS 4579/**BS61238**.

E02.3.16.2 The cable sheath shall be clasped by means of a gland of compression type based on BS 6121 or equivalent Indian standard with a compression washer, which will hold the cable sheath securely. A cable shroud shall be fitted to cover the body of the compression gland.

E02.3.16.3 All wires shall be terminated with an Approved type of connector.

E02.3.17 Cable Glands and Accessories

E02.3.17.1 Non-Armoured Cables

a) All cable glands and accessories shall be to BS 6121 or equivalent Indian standard.

b) The cable glands shall have a watertight seal when fitted to a cable.

c) Each cable gland shall be supplied with a brass gland locknut and a flame retardant low smoke halogen free outer gland shroud. The shroud shall totally enclose the gland body and form an effective seal against the cable sheathing.

E02.3.17.2 **Armoured Cables**

a) All cable glands and accessories shall be approved to BS 6121 or equivalent Indian standard.

b) The cable glands shall have a watertight seal when fitted to a cable.

c) Cables shall be terminated in a gland fitted with an armour clamp and an earth tag. The gland body shall be provided with an internal conical seal to receive the armour clamping cone, and a clamp nut, which shall secure the armour-clamping

cone, and conical armour seal. The spigot of the gland body shall be threaded to suit standard conduit accessories. A flame retardant low smoke halogen free shroud shall be fitted to cover the gland body.

E02.3.17.3 **Cable Ties**

a) Cable ties shall be made from corrosion resistant, flame retardant and ultra violet stabilised materials. At locations where cables are installed above tracks or in areas subjected to significant and constant vibration, cable ties shall be of metal construction type and coated with a corrosion resistant, low smoke halogen free and flame retardant insulation material.

E02.3.18 Cable Joints

E02.3.18.1 The straight through jointing kits shall be suitable not only for conditions of high humidity encountered in Metro sub-way, but also for underground buried installation with uncontrolled back-fill and possibility of flooding by water. These shall be of proven design and shall be type-tested as per relevant Indian or International standards. Type test certificates shall be submitted.

The jointing kits shall match the cable specifications. Joints shall not be permitted in the fire survival cables in case the joint does not meet the fire survival conditions.

E02.3.18.2 Every connection at a cable joint shall be mechanically and electrically sound, be protected against mechanical damage and any vibration, shall not impose mechanical stress on the fixings of the connection and shall not cause any mechanical damage to the cable conductor.

E02.3.18.3 The appropriate tools specified by the joint manufacturer shall be used when jointing cables.

E02.3.18.4 The outer casing/outer sheath of the cable joint shall be fabricated from a low smoke halogen free material.

E02.3.18.5 No cable joints shall be allowed without the prior Approval of the Employers Representative / Engineer. All joints, accessories and cable joint locations shall be submitted to the Engineer for Approval prior to any jointing of cables. All cable jointing shall be performed by a qualified jointer and preferably by the manufacturer of the jointing kits.

E02.3.19 Cable Identification

E02.3.19.1 All cables shall be provided with identification markers, at each end of the cable, at entry and exit point of cable trays, ducts and trenches and in other such positions as are necessary to identify and trace the route of the cable. Identification discs for cables installed within buildings or tunnels shall be supplied and attached with galvanised wire to each cable at intervals not greater than 12 metres and at all cable terminations.

E02.3.19.2 Cable identification shall be assembled from elliptical profiled low smoke halogen free markers, carrier strip and cable ties.

E02.3.19.3 Every single core cable and every core of a multi-core cable shall be provided with identification at its terminations in the form of sleeves or ferrules of appropriate colours or as specified for signalling cables.

E02.3.20 **Screened Signal and Control Cables**

E02.3.20.1 **General**

a) The control cables shall meet the requirement specified in this Section.

b) Cables for protection and control functions associated with the Power Supply System and Fire Alarm System, and used on line-side routes, shall be armoured and shall be low-smoke, non-halogenated type where used on underground sections or in enclosed public areas. All critical control cables shall be duplicated and run separately in the underground section. SCADA related wiring shall be terminated in supervisory termination cabinets.

c) The control cable shall be heavy-duty type, 600V / 1000 V grade FRLS (complying with the standards BS 6724 and BS 7846, as specified above for Power and Auxiliary cables and fire performance requirements specified in Clause E02.3.3 of this M&W Specification.), nil halogen with stranded copper conductor of suitable size. The outer sheath shall also be mixed with chemicals for protection against rodent and termite attack. Wherever specified, fire resistant type cable shall be provided.

d) All cables for fire alarm system shall of fire survival type. For fire detection, contractor may also use mineral insulated cable complying with CWZ category of BS6387.

e) In addition Screening to be applied on each pair as per BS EN 50288.

E02.3.20.2 **Conductors**

a) The conductors shall be of stranded, high conductivity annealed copper wires complying with BS 6360/**BS 60228**.

b) Flexible cables and cables for fixed installations shall have stranded conductors.

c) Conductors shall be smooth, uniform in quality, free from scale, spills, splits and any other defects. There shall be no joints in individual strands.

d) All signal /control copper armoured cables shall be rated at 600 / 1000 V whilst non-armoured cables shall be rated at 450 / 750 V and have a minimum cross sectional area of 2.5 mm^2.

E02.3.20.3 **Screening**

a) Screening shall be achieved by the use of laminated tape, consisting of an aluminium foil bonded to a polyester film for the strength, applied to the cable with an overlap so that full 100 % coverage of the conductors is afforded.

b) The cable shall be individually screened pair cables to provide improved cross talk immunity characteristic if required.

c) A drain wire or continuity conductor, laid under and in contact with the aluminium foil shall be provided. The tinned annealed copper conductor may be of solid or strand construction, using the approved manufacturing technique.

d) The maximum resistance of the drain wire or continuity conductor provided shall meet with the requirements of **BS EN 50288-7**.

E02.3.21 **Storage: -**

a) Contractor shall take proper care to avoid deterioration of drums or their becoming a hazard to the general public.
b) Contractor shall ensure that safe handling of drums as per BS 8512.
c) Battens, where applied, should not be removed from drums until the cable is about to be installed.
d) Contractor shall ensure that incineration of scrap cable should only be under taken by licensed contractor.

E03. CABLE CONTAINMENT SYSTEM

E03.1 General

E03.1.1 This Section specifies the manufacture and installation of cable tray, cable trunking, cable ladder, ducts and conduits.

E03.2 Standards

E03.2.1 **Relevant Codes and Standards**

E03.2.1.1 BS 476: Part 6: Fire tests on building materials and structures. Method of test for fire propagation for products only for conduits

E03.2.1.2 IEC 61537 : Requirements and tests for cable tray systems and cable ladder systems intended for the support and accommodation of cables and possibly other electrical equipment in electrical and/or communication systems installations. Where necessary, cable tray systems and cable ladder systems may be used for the segregation of cables.

E03.2.1.2 BS 476: Part 7: Fire tests on building materials and structures. Method of test to determine the classification of products based on surface spread of flame only conduitsE03.2.1.3 BS 729/IS 4759: Specification for hot dip galvanized coatings on iron and steel articles.

E03.2.1.4

E03.2.1.5 BS 970: Part 3/**10277/ 10278**: Specification for wrought steels for mechanical and allied engineering purposes. Bright bars for general engineering purposes.

E03.2.1.6 BS 1449: Part 1: Steel plate. Sheet and strip. Carbon and carbon-manganese plate, sheet and strip.orIS: 10748: Specification of Hot Rolling SWteel Strips for welded tubes and pipes

E03.2.1.7 BS 7371-12: Coatings on metal fasteners. Requirements for imperial fasteners or equivalent IS

E03.2.1.8

E03.2.1.9

E03.2.1.10 **BS 61386: Part 1: Conduit systems for cable management. Generalrequirements**

E03.2.1.11 BS 4678: Cable trunking.

E03.2.1.12 BS 4678: Part 1: Cable trunking. Steel surface trunking.

BS 50085: Part 1 and 2: Cable trunking systems and cable ducting systems for electrical installations

E03.2.1.13 BS 7671: Requirements for electrical installations. IEE Wiring Regulations.Sixteenth edition.

E03.3 Technical and Installation Requirements

E03.3.1 General

E03.3.1.1 Material for use in cable containment system including their surface finish materials shall be capable of being subjected to temperatures up to 500 degree Celcius for an hour and shall not support combustion under the same temperature conditions.

E03.3.1.2 All cable containment ducts, particularly concrete cable ducts shall be sloped toward manhole or box from which water may be drained or pumped.

E03.3.1.2 All cable tray and Cable Ladder systems shall be in accordance of IEC 61537 or NEMA VE 1

E03.3.2 Installation of Cable Containment System, Supports and Hangers

E03.3.2.1 All steel components shall be hot-dip galvanized to BS 729/ IS 4759 after manufacture. Where an exposed galvanised surface has been cut or otherwise damaged it shall be repaired by application of a zinc rich epoxy primer.

E03.3.2.2 The use of rag bolts, indented bolts, foundation bolts or similar fixings requiring grouting shall not be permitted.

E03.3.2.3 Where supports have to be carried on structural steelwork, they shall be attached to the steelwork by means of girder clips, beam clamps or other proprietary attachment devices not requiring drilling or welding of the steelwork.

E03.3.2.4 Where trays or ladders cross open spaces or in other locations where no structure is available on which to fix cable supports, suitable fabricated steel auxiliary supporting structures shall be provided subject to approval by Employers Representative.

E03.3.2.5 Where tray and ladder systems are supported by drop rods additional restraints shall be included to provide adequate lateral support. Restraints shall be installed at all bends and intersections and at intervals not exceeding 15m on straight runs. Support rods shall be at least 6 mm diameter. Trapeze or other hangers shall be clamped on the drop rods between two nuts.

E03.3.2.6 Support channels shall be the basic structural members of the system and shall be easily fixed to the floors, walls or ceilings as necessary and may be interconnected in a multitude of ways by using different brackets. All components shall be fitted together using bolts, spring washers and channel nuts.

E03.3.2.7 The channels shall be cold rolled from 2.6 mm mild steel with a hot dip galvanised finish, to BS 729 orIS 4759 . In environment with excessive humidity, the cable containment system shall be protected with an approved coating.

E03.3.2.8 Channel nuts shall be inserted into the channel as necessary along its length, and a 90° clockwise turn of the nut shall clip each nut firmly into position. Each channel nut shall have two parallel grooves on its outside face with teeth along its length.

E03.3.2.9 Channel nuts shall be manufactured from steel bar, to BS 970: Part 3/**BS 10277/10228** and shall be zinc plated to. BS 7371-12 or equivalent IS Channel nuts of M6, M10 and M12 screw threads shall be used as appropriate to meet specified requirement based on the working drawing approved by Employers Representative.

E03.3.2.10 The standard fixing bolts for use throughout the system shall be M10 or M12 high tensile, hexagon head set screws to BS 3692-8.8. The standard finish for these bolts shall be zinc plated to. . BS 7371-12 or equivalent IS

E03.3.2.11 For fixing cable tray to tray arms, tray brackets or cantilever arm, M6 by 16 mm bolt shall be used, unless otherwise specified.

E03.3.2.12 Brackets and fittings shall be attached to the channel using bolts, spring washers and channel nuts. Standard fittings shall be used for the attachment of cable tray to a framework.

E03.3.2.13 Acceptance tests for the safe carrying load for each bracket at typical locations shall be established by the Contractor during preparation of working drawings for the Employers representative's consent.

E03.3.3 Cable Trays and Ladders

E03.3.3.1 **General**

a) Cable trays shall be of a perforated factory-made type complete with factory made bends, tees and fixing accessories. The cable trays shall be made from mild steel sheet, complying with BS 1449: Part 1 / IS10748 and shall be hot-dipped galvanised after perforation. Cable trays shall have corrosion protection not less than Class 2 to,**BS 50085: Part 1 and 2.**

b) All cable trays and ladders installed in stations and tunnels shall be capable of being subjected to temperatures up to 500 °C for one hour and conform to National Electrical Code (NFPA 70).

c) The cable tray/ladder shall be of sufficient width to take the cables without crowding and shall allow for future additions to the proportion of 25-30 % of present requirements. Contractor shall prepare Working Drawings based on actual cable routing and above mentioned spare capacity and obtain consent of Employers Representative. Double stacking of cable shall not be allowed except where specifically agreed by the Employers Representative

d) Hot dipped galvanised cable trays and supports used within damp environment shall be protected with an approved coating. All the cable trays shall be of heavy duty with return flange type **All cable tray sizes 450mm and above shall be of heavy duty type with return flange. All cable tray below 450mm shall be with standard configuration.**

e) Widths of cable trays, thickness of steel, flanges of trays, and bends or tees, shall be nominally as follows:

Width of Tray (mm)	Thickness of Steel (mm)	Flanges of Tray (mm)
300 & below	1.5	35

300-450	1.6	35
450-900	2	35
1000	2	50

f) All trays / ladders that are cut for installation shall be made good by first treating the surfaces with a suitable rust-proofing agent, similar to that used in the original manufacture, and then shall have their ends painted with a zinc coating to ensure continuous protection.

g) Trays / ladders shall have suitable strength and rigidity to provide adequate support for all contained cabling.

h) Steel trays and ladders shall be supported so that the maximum deflection between supports is 1/360th of the span length.

i) Midspan joints shall be located as close as practical to one-quarter of the span distance away from a support position. Joints at mid-span or directly over supports shall be avoided. Supports shall be provided within 150 mm of all accessories.

j) Cable trays / ladders shall not present any sharp edges, burrs, or projections that could damage the insulation or sheathing of the cables.

k) Each run of cable tray/ladder shall be completed and cleared of debris before the installation of any cables.

l) Sufficient space shall be provided and maintained above the cable trays to permit adequate access for the installation and maintenance of the cables. Where a cable tray / ladder is suspended from the ceiling, wall or structure, it shall be supported by hot dipped galvanized steel supports or hangers of Approved design.

m) Cable ladders shall be used for supporting cables of bigger size. Cable trays shall be used for cables of smaller sizes, control cables and wires.

E03.3.3.2 **Cable Tray Installation**

a) Where two straight lengths of cable tray are joined together, an external coupler or joint plate shall be used to prevent any sag or bending at that point. The coupler or joint plate shall be joined to each length of the tray by means of not less than two non-corrosive round-headed screws fixed from the inside of the tray.

b) All bends and tee's shall be 90° bends or tee-offs with minimum 50 mm inside bend radius. Cable bends in cable trays shall be such that the bending radius of the largest cable to be clipped to the tray shall not exceed the bending radius limits as specified in BS 7671.

c) The cable trays shall be fixed in such a manner that it is rigid throughout its length with a minimum of 13mm clearance between the tray and the structure.

d) Cable trays shall be adequately supported. Fixing of cable trays shall be provided at regular interval not exceeding 1.2m and on both sides of and at a distance not exceeding 225 mm from, a bend or intersection especially where bends and tee joints are fitted to the trays.

e) Where cable trays pass across structure movement/expansion joints, the cable trays shall be physically separated by a gap of width equal to the joint it is crossing. To maintain electrical/earth continuity of the cable trays a 150mm^2 copper flexible earth continuity conductor shall be installed across the gap and secured to each end of the cable trays.

f) Where cables are required to pass through the tray, or over the lip of the cable tray, a low smoke halogen free grommet or packing section shall be installed to protect the cable sheath from sharp edges.

g) Where cables pass through wall openings the cable tray shall be installed in such a manner as to support the cables as they pass through the wall opening.

E03.3.3.3 **Cable Tray Earthing**

(a) Each joint shall have a 6 mm ^{2}tinned copper bond bolted to each adjacent tray to ensure electrical continuity. The cable tray systems shall be bonded to the earthing system by use of LSZH insulated stranded single core Copper cable.

E03.3.3.4 **Cable Ladders - Additional General Requirements**

a) Cable ladder shall be NEMA VE 1 class 8C/ IEC 61537 and sizes according to loading, number and diameter of cables.

b) The complete cable ladder system shall be designed so that drilling will not be necessary on site and cutting will be kept to a mini mum.

c) Cable ladders shall be manufactured from 2mm thick mild steel and hot-dip galvanized to BS 729 or IS 4759. The two side rails of the cable ladder shall be of minimum 40mm in height with returns at top flange to gain extra strength. The rung shall be spaced at approximately 250mm centres with sufficient width for various cable fixing methods including nylon tiles, saddles and perforated strips, cable clamps and cleats.

d) Factory standard right-angle bends, tee junctions, off-set reducers, straight reducers shall be used for horizontal bends, vertical bends, branching out and reduction of cable ladder width. Factory standard expansion splice plate shall also be provided to allow for expansion and contraction of the cable ladders.

e) All clamping nuts, bolts, washers etc. shall be hot-dipped galvanized to BS 729 or equivalent Indian standards.

f) Vertical runs of cable tray or ladder shall not be installed such that they straddle vertical expansion joints of the building structure.

g) Notwithstanding the above, complete cable ladder system shall be electrically continuous.

E03.3.3.5 Cable Ladders Installation The same requirements as specified cable tray installation, Clause E03.3.3.2, shall apply.

E03.3.3.6 Cable Ladder Earthing The same requirements as specified cable tray earthing, Clause E03.3.3.3, shall apply.

E03.3.4 Cable Trunking

E03.3.4.1 **General**

a) Trunking and fittings shall comply with BS 4678: Part 1/**BS 50085: Part 1 and 2** or equivalent Indian Standards. Factory fabricated bends and tees shall be used.

b) Trunking shall be top accessed. Inverted trunking is not acceptable.

c) All multi-compartment trunking systems shall maintain the stated segregation throughout, including all accessories. Sub-main cables shall be laid in a single layer.

d) Trunking shall be manufactured in mild-steel sheet and shall be hot-dip galvanized. Trunking shall have a removable cover throughout its length with centre-screw latch fixing, or quick-fixing device to the Employers Representatives approval, sizes up to 100mm by 100mm shall be 1.6mm thick and from 150mm by 75mm up to 150mm by 150 mm shall be 1.8mm thick. Spring clip type cover shall not be used. The trunking shall normally be supplied in 2400mm lengths. Lengths of trunking, bends tee sections and offsets shall be coupled together by means of fish plates and the trunking manufacturer's cadmium plated steel set screws, nuts and shake proof washers. At each joint in the trunking, continuity shall be maintained by means of copper links, not less than 25 x 3 mm to achieve an acceptable earth loop impedance level in compliance with BS 7671, fixed with brass nuts, bolts and serrated washers. Links shall be supplied by the trunking manufacturer at no extra cost to Employer. Removal of any lid no matter how it is fitted shall not affect the earth continuity of the trunking. LSZH copper cable link with cable lugs may be used, if the proper connection method is provided to avoid long term corrosion and electrolytic action. The LSZH cable shall have an equivalent cross sectional area to the copper links. Bonding link shall be fixed on external surfaces.

e) Manufacturer's standard fittings shall be used for all connections and changes of direction. All bends, tee pieces, stop ends, outlets, intersections and adapters shall be of the same manufacturer as the trunking. Trunking shall not be cut or bent to form bends, flanges or attachments. Gusset bends shall be used wherever necessary to provide sufficient bending radius for the cables. Site fabricated items shall not be accepted

f) Hot dipped galvanised trunking used in damp environment shall be protected by an Approved coating.

g) The minimum size shall be 50mm by 50mm.

h) All inside edges of trunking shall be smooth and provision shall be made to prevent abrasion at bends.

i) Cable retaining straps supplied by the trunking manufacturer shall be fitted at intervals not exceeding 1m. Where trunking passes through walls, floors and ceilings, proprietary fire barriers shall be installed in the trunking. The fire barrier shall have a rating not less than that of the original construction of the opening.

j) Trunking shall be adequately supported throughout its length. Trunking support and channel shall be quick-fixing type and shall be such as to space the trunking a minimum of 13mm from any part of the wall or bulkhead. The maximum spacing between fixings shall be as follows:

Trunking Size	Maximum Distance
up to 50 mm by 50 mm	900 mm
up to 75 mm by 75 mm	1200 mm
up to 150 mm by 150 mm	1500 mm
above 150 mm by 150 mm	1800 mm

k) A minimum of two fixings shall be provided between joints in the trunking except where the distance between is less than the maximum spacing.

l) Where trunking is suspended, the suspension shall be rigid. At the suspension point the trunking shall be reinforced by a plate or washer of minimum thickness 3mm or 10 SWG whose cross-sectional area shall not be less than half that of the trunking (cross-sectional area). Unless additional stiffening is provided, the spacing between suspension points shall not be greater than those shown above.

m) Where trunking is cut or drilled, the cut edges of the trunking shall be smoothed to prevent abrasion of the cables and shall be painted with anti-corrosion paint, to the same colour as the adjacent surfaces, such painting to be carried out as the work proceeds. In no circumstances will rough screw edges and nuts be allowed in the interior of the trunking. Round headed screws of a non-corrosive material shall be used when installing trunking. The round screw heads shall be on the interior of the trunking.

n) Flush or buried trunking and under floor metal ducts shall comply with BS 4678.

o) The space factor for cables installed in trunking shall not exceed 45%.

p) All lengths of vertical run trunking in excess of 3000mm, shall contain cable supports made of insulating, non-hygroscopic, non- ombustible material. The spacing between such supports shall not exceed 1800mm. An additional

support shall be provided at the top of all vertical runs exceeding 3000mm, to support the weight of the cable and distribute the cables within the trunking to prevent undue compression of the installation.

q) Where trunking crosses expansion joints, a trunking fitting shall be used which shall allow for expansion and maintain earth continuity.

r) Suitable cutout on underfloor trunking at ticket barriers shall be provided to suit Automatic Fare Collection System Contractor's requirement. The cutout shall not have a sharp edge or abrasive effect on cables. The location and route for the cutout and under floor trunking shall be according to Working Drawings.

s) Trunking installed externally shall be manufactured from galvanized sheet steel in accordance with BS 4678: Part 1/ **BS 50085: Part 1 and 2** or equivalent Indian Standards. . Trunking installed internally shall be of Class 2.

t) Partitions or dividers shall be of the same material and finish as the trunking. The method of fixing shall not cause any long-term corrosion or electrolytic action.

u) Connections to multiple boxes, switchgear and distribution boards shall be made with flanged units or bell mouths. Expansion joints in long continuous runs shall be provided as recommended by the manufacturer

E03.3.5 Ducts

E03.3.5.1 The term "ducts" in this clause shall mean any pipe, open or covered trench or cavity formed for the specific purpose of routing electrical and/or other services and shall be other than electrical conduits, trunking and cable trays.

E03.3.5.2 Ducts into which cables are to be drawn shall be such that the usable spare capacity is not less than 50%.

E03.3.5.3 Care shall be taken to make the bends of pipe or duct lines as easy as practicable. In no case shall the radius be less than 6 times the outer diameter of the duct circumference, or 6 times the minor dimension of the duct if rectangular.

E03.3.5.4 Before drawing or installing cables in the duct, the duct shall be clean, dry and free from obstructions and of adequate size for the cables to be installed, having particular regard for the separation from other services and to the provision of adequate drawing pits, covers and markings, and allowances for bending radii. Adequate provision shall be made for cables entering or leaving ducts. Draw wires shall be provided wherever appropriate.

E03.3.5.5 All cables run in open ducts or in ducts shared with other services, shall be adequately secured to the wall of the duct by type saddles or hangers.

E03.3.5.6 Adequate precautions shall be taken to ensure that there is no interference to the cables from the other services both mechanically and electrically.

E03.3.5.7 Trunking shall be used within a duct, only where specified.

E03.3.5.8 No materials other than completely water-proof materials shall be installed in any duct.

E03.3.5.9 The duct shall be sealed to prevent the entry of water or vermin.

E03.3.6 Not used

E03.3.7 Penetration in walls

E03.3.7.1 Where proprietary cable transits are required, they shall be installed strictly in accordance with the manufacturer's recommended procedures. Where cables pass through walls, floors, or fire partitions, sleeves shall be installed to facilitate installation and subsequent withdrawal of the cable.

E03.3.7.2 After installation of the cables, the hole(s) through which the cables pass shall be sealed with fire resisting material to achieve the fire rating as the structure through which they pass. Details of the proposed sealing method shall be submitted for approval prior to implementation. Cables passing through external walls shall additionally be sealed with appropriate additional weather protection to prevent the ingress of water.

E03.3.7.3 The fire resisting material shall intumesce to form a hard char that tightly sealspenetrations against flame spread, smoke and toxic fumes. The fire resisting material shall be tested according to ASTM E119, ASTM E814 and ASTM E84. Test certification and test report shall be submitted.

E03.3.7.4 The materials shall emit toxic gases on exposure to fire. The materials shall be easy to dismantle and replace in case of rearrangement and also withstand vibration due to rail operation and seismic tremor.

E03.3.8 Conduit and Accessories

1. **Detailed Description and Application in DMRC for Conduit and Accessories**

Supply and Installation of Rigid Steel Conduits, Associated Fittings and Accessories:

Conduit is a part of closed wiring system of circular or non- circular cross-section for conductors and/or cables in electrical installations allowing to draw them in and/or to replace them. However, in this document the word 'conduit' shall refer to circular cross- section only. Conduits shall be sufficiently closed- jointed so that the conductors can only be drawn in and not inserted laterally. The conduits shall be rigid Steel type.

Conduit Fittings referred to in this document is a device designed to join or terminate one or more portions of a conduit installation which shall be of metal (Galvanized Steel) only.

Conduit Accessories are the parts other than fittings used in fixing steel conduits.

The specifications contained herein are applicable to Elevated/ Underground/ At Grade stations, Depots, Staff Quarters and office Complex etc.

Governing Specifications

The conduits, associated fittings and accessories shall satisfy the requirements given below and shall also comply with standards mentioned particularly in the table below unless otherwise stipulated in the specifications. The latest version of standards shall be applicable.

Specification For Conduits For Electrical Installations: Part I General Requirements, Part II Rigid Steel Conduits	IS: 9537 : Part I, 1980 IS: 9537: Part II, 1981
Specification For Accessories For Rigid Steel Conduits For Electrical Wiring	IS: 3837 : 1976
Conduit Fittings for Electrical Installations: Part1 General Requirements Part 2: Metal Conduit Fittings	IS: 14768 Part-1, 2000 IS: 14768 Part-2, 2003
Specification for Flexible Steel conduits for electrical wiring	IS: 3480 : 1966
Code of practice for electrical wiring installations	IS: 732 : 1989
National Electrical Code, 2011	
National Building Code, 2005	
Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010	
Plugs And Socket-Outlets of Rated Voltage up to and Including 250 Volts And Rated Current up to and Including 16 Amperes — Specification	IS: 1293 : 2005
Switches for domestic and similar purposes	IS: 3854 : 1997
General Requirements for Enclosures for Accessories for Household and Similar Fixed Electrical Installations – Specification	IS: 14772:2000
Code of practice for electrical installation fire safety of	IS: 1646: 1997

buildings	
Recommendations on safety procedure and practices in Electrical works	IS: 5216 : 1982
Specification for Hot-dip Zinc coating on mild steel tube	IS: 4736 : 1986
Methods For Determination of Mass of Zinc Coating on Zinc Coated Iron and Steel Articles	IS: 6745 : 1972
Plugs, Socket-Outlets and Couplers for Industrial Purposes, Part 2: Dimensional Interchangeability Requirements for Pin and Contact-Tube Accessories	IS: 60309-2
Degrees of protection provided by Enclosures (IP Code)	IS: 60529
Recommended Practice for hot-dip galvanizing of Iron and Steel	IS: 2629
Zinc Ingot- Specifications	IS: 209
Hot Rolled Carbon Steel Sheet and Strip Specifications	IS: 1079
Standard Test Method for Surface Burning Characteristics of Building Materials	ASTM E84
Standard Test Methods for Fire Tests of Building Construction and Materials	ASTM E119
Standard Test Method for Fire Tests of Penetration Fire stop System	ASTM E814

Note: The latest edition of the standards shall be used. Wherever Indian Standards are not available, relevant latest British and/or IEC Standards shall be applicable.

1.1. Abbreviations

- IS- Indian Standard
- IEC- International Electrotechnical Commission
- ERW- Electric Resistance Welding
- GI- Galvanized Iron
- MS- Mild Steel
- NEC- National Electrical Code
- NBC- National Building Code
- ASTM- American Society for Testing and Materials

  Note: The term 'Approved' in this specification means that the approval of the Engineer-in- Charge shall be taken.

2. Requirement

2.1. Rigid Galvanized Steel Conduits (IS: 9537, Part I & II)

These shall be galvanized steel with minimum wall thickness of 1.6mm up to 32mm diameter and 2.0mm for sizes above 32mm diameter, electric resistance welded (ERW), electric threaded type, with both ends screwed having perfectly circular tubing. Conduits shall show no appreciable unevenness and shall be free from burrs, fins and the like which may cause damage to cable insulation. These rough internal edges shall be removed by means of a proper reamer. Conduits shall be precision welded and shall be fabricated from tested steel strips of required thickness by electric resistance welding. Welds shall be smooth and consistently of high quality to ensure crack proof bending. The conduit shall be galvanized according to IS 4736-1986. All conduits used in this work shall be marked according to IS: 9537 Part-2 and also with ISI certification mark. Other requirements for the conduits shall be as per IS: 9537, Part-1 and Part-2.

2.2. Flexible Conduits (IS: 3480)

The usage shall be restricted to only those areas where it is not possible to use Rigid Steel Conduits. All final connections especially to vibrating equipments shall be made through flexible conduits. Flexible steel conduits shall be as per latest edition of IS: 3480. Where flexible steel conduit is employed, the length shall not exceed 2.5 metres and shall be provided with an earth continuity conductor of copper size not less than 2.5mm^2.

2.3. Galvanized Steel Bends (IS: 14768)

Large right angle bends (as per IS: 14768 but more than 75mm radius) or non-right angle bends (as per IS: 14768) in conduits runs shall be made by means of conduits bending machines carefully so as not to cause any crack in the conduit. Small right angle bends in conduits runs can be made by standard conduit accessories (solid/inspection bends/elbows). Facilities such as draw-in boxes must be provided so that cables are not drawn round more than two right-angle bends or their equivalent. The radius of bends must not be less than the standard normal bend. Bends in multi runs of conduits shall be parallel to each other and neat in appearance, maintaining the same distance as between straight runs of conduits.

2.4. Standard Fittings & Accessories IS: 3837 & IS: 14768, Part-1 and Part-2.

Heavy Protection Class Galvanized (IS 4736 & IS 6745) standard conduit fittings and accessories like standard/extra-deep circular boxes, looping in boxes, junction boxes, solid / inspection elbows, solid/inspection tees, couplers, nipples, saddles, check nuts, earth clips, bushes etc. shall be of superior quality and of approved makes. The covers screwed with approved quality screws shall be used that can withstand hard use or wear. Samples of all conduits fittings and accessories shall be got approved by Engineer-in-Charge before use. Conduit fittings and Accessories shall be as per IS: 3837 and IS: 14768, Part-1 and Part-2.

Conduit boxes and covers shall have a minimum degree of protection as follows:

Description	Against Corrosion	Enclosure	Surface or Concealed
Outside buildings	Heavy Protection both inside and outside	IP 54	Surface
Plant rooms and service ducts, Switch Rooms, Store Rooms, Ceiling Voids	Heavy Protection both inside and outside	IP 41	Surface
Below Ground	Heavy Protection both inside and outside	IP 44	-
All other locations	Heavy Protection both inside and outside	IP 41	Concealed

The contractor shall submit for approval the 'Method Statement including Tests' to ensure above degree of ingress protection. In case no testing facility is available, the contractor shall comply with this clause by submitting design and installation features.

2.5. Fabricated Fittings & Accessories

Wherever required, outlet/ junction boxes of required sizes shall be fabricated from 1.6mm thick MS sheets except ceiling fan outlet boxes which shall be fabricated from minimum 3mm thick sheets. The outlet boxes shall be galvanized and of approved quality, finish and manufacture. Suitable means of fixing connectors etc., if required, shall be provided in the boxes. A screwed brass stud shall be provided in all boxes except circular junction boxes as earthing terminal.

a) Outlet Boxes for Light Fittings

These shall be minimum 75mm x 75mm x 50mm deep and provided with required number of threaded collars for conduit entry. For ceiling mounted fluorescent fittings, the boxes shall be provided 300mm off center for a 1200mm fitting and 150mm off center for a 600mm fitting so that the wiring is taken directly to the down rod. 3mm thick Perspex/hylam sheet cover of matching color shall be provided.

b) Outlet Boxes for Ceiling Fans

Outlet boxes for ceiling fans shall be fabricated from minimum 3mm thick MS sheet steel and galvanized. The boxes shall be hexagonal in shape of minimum 100 mm depth and 60mm sides. Each box shall be provided with a recessed fan hook in the form of one 'u' shaped 15 mm dia rod welded to the box and securely tied to the top reinforcement of the concrete slab for a length of minimum 150 mm on either side. 3mm thick Perspex/hylam sheet cover of matching colour shall be provided.

Nominal cross sectional area of conductor in sq.mm	*20 mm*		*25 mm*		*32 mm*		*38 mm*		*51 mm*		*64 mm*	
	S	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1.50	5	4	10	8	18	12	–	–	–	–	–	–
2.50	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	12	8
25	–	–	–	–	3	2	5	3	8	6	9	7
35	–	–	–	–	–	–	3	2	6	5	8	6
50	–	–	–	–	–	–	–	–	5	3	6	5
70	–	–	–	–	–	–	–	–	4	3	5	4

(2) The columns headed 'S' apply to runs of conduits which have distance not exceeding 4.25 m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed 'B' apply to runs of conduit, which deflect from the straight by an angle of more than 15 degrees.

(3) Conduit sizes are the nominal external diameters.

2.8. Modular Cover Plated Mounted Wiring Accessories

2.8.1. Switches

For underground stations, switches shall be single pole and rated not less than 20A, for use on AC systems, including fluorescent or inductive loads. All 6 A, 16 A and 20A switches shall be of the modular enclosed type flush mounted 250 volt AC of the best quality and standard approved by Engineer-in- Charge. The housing of switches shall be made from high impact resistant and flame retarding plastic material. The switch controlling the light point shall be connected on to the phase wire of the circuit. Lighting switches used on AC supplies shall be of "AC only" type and not de-rated when used with fluorescent or inductive loads. Lighting switches used on DC supplies shall be of "double-pole" quick make-and-break type, with pillar type terminals and earthing straps. Every switch controlling an appliance shall be labeled with the name of the appliance it controls and shall be fitted with an indicating lamp. The switch shall govern to 250 V grade as per IS 3854:1977 Amendment No. 6, Aug 2011 and IS 1293 respectively. Brands namely Crabtree, MK Electric, CPL-obsession, MDS, Schneider, SSK, ABB shall be used.

2.8.2. Molded Cover Plates

For underground stations, front plates of lighting and appliance switches shall be made of stainless steel with mat satin finish except for those in plant rooms which shall be stove enameled aluminium finish. Switches, receptacles and telephone system outlets in wall shall be provided with molded cover plates of shape, size and colour approved by the Engineer- in- Charge made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material, and secured to the box with counter sunk round head chromium plated brass screws. Where two or more switches are installed together, they shall be provided with one common switch cover plate as described above with notches to accommodate all switches either in one, two or three rows.

One and two gang switch cover plate, telephone outlet cover plate, 6 A and 16 A switched / unswitched plates, shall have the same shape and size. Three and four gang switch cover plates shall have the same shape and size. Six and eight gang switch cover plates shall have the same shape and size. Nine and twelve gang switch cover plates shall have the same shape and size. Wherever five switches, seven switches, ten switches and eleven switches are to be fixed the next higher sizes of gang switch cover plate to be used and openings shall be provided with blank-off covers at no extra cost.

2.8.3. Wall Socket Outlets

All 6/16 A wall sockets outlets unless otherwise mentioned on the drawings shall be switched, with round pins and fitted with automatic linear safety shutters to ensure safety from prying fingers. Unswitched 6/16 A wall socket outlets where called for in the drawings shall be of three pin type. . The socket outlets shall be made from high impact resistant, flame retarding and ultra violet stabilized engineering plastic material. For underground stations, the cover plates of socket outlets shall be AISI Type 304 stainless steel in public area and standard plaster for staff/ back of house areas. Socket outlets mounted externally or in damp areas shall be weatherproof and shall have a degree of protection of IP54. The switch and sockets shall be located in the same plate. The plates for 6A switched / unswitched plugs and telephone outlets shall be of the same size and shape. All the switched and unswitched outlets shall be of the best standard. Mounting boxes shall be galvanized steel. The switch controlling the socket outlet shall be on the phase wire of the circuit. An earth wire shall be provided along the cables feeding socket outlets for electrical appliances. The earth wire shall be connected to the earthing terminal screw inside the box. The earth terminal of the socket shall be connected to the earth terminal provided inside the box.

2.8.4. Industrial Socket Outlets

Industrial plugs, connectors, socket outlets and appliance inlets shall be provided to meet IS 60309-2. Heavy- duty three phase socket outlets shall be 32A, complying with IS 60309-2. For interior use such as plant room unit shall be rated to IP44. Externally or in wet environments such as Tunnel and Undercroft level the protection shall be IP66.

2.9. Conduit Installation (IS: 732 and Relevant clauses of NEC, 2011)

2.9.1. System

The whole conduit system shall be installed to comply fully with relevant provision in Indian Standard Specifications, National Electrical Code, 2011. Conduits shall be laid either recessed in walls and ceilings or on surface on walls and ceilings or partly recessed and partly on surface, as required. Same rate shall apply for recessed and surface conduiting in this contract. Steel wire of 1.6 mm^2 size to serve as a fish wire shall be left in all conduit runs to facilitate drawing of wires after completion of conduiting. No conduit shall be under mechanical stress. When crossing through expansion joints in building, the conduit sections across the joint shall be through approved quality metallic flexible conduits (as per IS 3480) of the same size as the rigid conduit. Allowance shall be made for running an earth wire of size not less than the largest conductor contained between each terminal fitted in the nearest conduit boxes on each side of the telescopic/ flexible conduit joint.

2.9.2. Layout

Conduits layout and routes shall be submitted for Engineer-in-Charge's approval prior to execution. Allowance for adjustments due to site conditions shall be provided with no extra cost.

Conduit routes shall be chosen for easy, straight runs with a minimum of bends and crossing. Generally they shall follow the structure of building, running at right angles or in parallels to floors and ceiling. Conduit shall be kept within 300mm of floors and ceiling when running parallel to them.

Outlets boxes for housing accessories shall be used as draw boxes. The total number of draw boxes shall be kept to a minimum and shall be provided so that conduits runs do not exceed 8m or have more than two right angle bends.

Conduits from different distribution boards shall not be connected to the same junction box. Each run of conduit shall be assembled complete with draw in wires.

2.9.3. Joints and Terminations

Conduit threads shall be thoroughly cleaned and the conduits tightly screwed. The conduit system shall be watertight after installation. The contractor shall submit for approval the 'Method Statement including Tests' to ensure the above requirement.

Conduits shall be connected using couplers or via boxes. With a coupler, the ends of the conduit shall be butted close together and the running coupler is screwed tightly on and tightened by a locknut.

Conduits terminating into boxes provided with spouts shall be threaded so that there are no exposed threads. For boxes with no spouts, the termination shall be made using a brass bush and a coupler. The conduit is pushed through the knockout or drilled entry and the bush is screwed tightly onto its end. The coupler is screwed to butt firmly against the exterior wall of the box.

Where conduits are not jointed or terminated in boxes, they shall be terminated in a screwed brass bush.

In all joints and terminations, conduits threads shall not be exposed. Where this cannot be avoided as in a running coupler, the exposed threads shall be treated as given in Section 4(b) of this specification.

2.9.4. Bends (IS: 14768-2)

Conduits shall be bend cold with an approved type of bending block or bending machine, without altering the dimensions of their sections. The approval for the bending block or bending machine proposed to be used at site shall be taken from the Engineer-in-Charge.

All conduits bends shall be such as to permit compliance to the requirements for bends in the IS regulations.

Bends shall be made with as large a radius as the position of the conduit within the building permits. Where the bend is more than 90 degree, circular or rectangular junction boxes shall to be used for connecting conduits.

2.9.5. Recessed Conduiting

Conduits recessed in concrete members shall be laid before casting, in the upper portion of slabs or otherwise as may be instructed, so as to embed the entire run of conduits and ceiling outlet boxes with a cover of minimum 12mm concrete. Conduits shall be adequately tied to the reinforcement with steel wire of not less than 1.5mm diameter to prevent displacement during casting at intervals of maximum 1 metre. No reinforcement bars shall be cut to fix the conduits. Suitable flexible joints shall be provided at all locations where conduits cross expansion joints in the building. Spacing between concealed conduits entering the draw-in boxes shall not be less than 25mm to allow concrete aggregate to pass and set between conduits.

Conduits recessed in brick work shall be laid in chases to be cut by electrical contractor in brick work before plastering. The chases shall be cut by a chase cutting electric machine. The chases shall be of sufficient width (minimum 10mm spacing between adjacent conduit) to accommodate the required number of conduits and of sufficient depth to permit full thickness of plaster (minimum 6mm) over conduits. The conduits shall be secured in the chase by means of heavy duty pressed steel clamps screwed to MS flat strip saddles at intervals of maximum 600 mm.The chases shall then be filled with cement and coarse sand mortar (1:3) and properly cured by watering. Galvanized chicken wire mesh of 0.6mm thick with 10 to 15mm aperture shall be provided for the full length and width of the chase in the plaster to prevent cracking.

Junction boxes intended for facilitating drawing of wires in conduiting system shall be located in accessible locations to permit redrawing of wires in future. Open ends of conduits laid in slabs and walls shall be suitably plugged before pouring concrete/plastering to prevent ingress of water / debris in to the conduits.

Entire recessed conduit work in concrete member and in brick work shall be carried out in close coordination with progress of civil works. Conduits in concrete member shall be laid before casting and conduits in brick work shall be laid before plastering. If it becomes necessary to embed conduits in already cast concrete members, suitable chase shall be cut in concrete for the purpose. For minimizing this cutting, conduits of lesser diameter than 25mm and outlet boxes of lesser depth than 50mm could be used by the contractor for such extensions only after obtaining specific approval from Engineer-in-Charge. For embedding conduits in finished and plastered brick work, the chase would have to be made in the finished brick work. After fixing conduit in chases, chases shall be made good in most workmanlike manner to match with the original finish.

Cutting chases in finished concrete or finished plastered brick work for recessing conduits and outlet boxes etc. shall be done by the Contractors without any extra cost.

In the concealed conduit system, all boxes for accessories & draw/junction boxes shall be installed such that outer rim is flush with the finished surface of the wall. Sockets near skirting level shall be fed from the floor above rather than the floor below, because in the latter case it would be difficult to avoid traps in the conduit

Where surface mounted distribution boards are used with a sunk conduit, a flush adaptable box shall be fitted in the wall behind the distribution board and to take the flush conduits directly into it. Holes can be drilled in the back of the distribution board and bushed. Spare holes should be provided for future conduits. Distribution boards must be bonded to the adaptable boxes and unused holes should be sealed.

2.9.6. Surface Conduiting

Wherever so desired, conduit shall be laid in surface over finished concrete and/or plastered brickwork. Suitable spacer saddles of approved make and finish shall be fixed to the finished structural surface along the conduit route at intervals not exceeding 600mm (except from fitting where 300mm). Fixing of standard bends or elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with a long radius which will permit easy drawing-in of conductors. Holes in concrete or brick work for fixing the saddles shall be made neatly by electric drills using masonry drill bits. Conduits shall be fixed on the saddles by means of good quality Galvanized steel clamps meant to withstand hard use and wear screwed to the saddles by counter sunk screws. Neat appearance and good workmanship of surface conduiting work is of particular importance. The entire conduit work shall be in absolute line and plumb. Conduits above false ceiling shall be fixed on suitable hangers supported from structural ceiling.

All surface conduits shall be run in a vertical or horizontal direction. Diagonal runs shall not be permitted.

2.9.7. Penetration in Walls

Where proprietary cable transits are required, they shall be installed strictly in accordance with the manufacturer’s recommended procedures. Where cables pass through walls, floors, or fire partitions, sleeves shall be installed to facilitate installation and subsequent withdrawal of the cable.

After installation of the cables, the hole(s) through which the cables pass shall be sealed with fire resisting material to achieve the fire rating as the structure through which they pass. Details of the proposed sealing method shall be submitted for approval prior to implementation. Cables passing through external walls shall additionally be sealed with appropriate additional weather protection to prevent the ingress of water.

The fire resisting material shall intumesce to form a hard char that tightly seals penetrations against flame spread, smoke and toxic fumes. The fire resisting material shall be tested according to ASTM E119, ASTM E814 and ASTM E84. Test certification and test report shall be submitted.

The materials shall not emit toxic gases on exposure to fire. The materials shall be easy to dismantle and replace in case of rearrangement and also withstand vibration due to rail operation and seismic tremor.

2.9.8. Fixing of Conduit Fittings and Accessories

For concealed conduiting work, the fittings and accessories shall be completely embedded in walls/ceilings leaving top surface flush with finished wall/ceiling surface in a workman like manner.

Loop earthing wire shall be connected to a screwed earth stead inside outlet boxes to make an effective contact with the metal body.

2.9.9. Painting and Colour Coding of Conduits

Surface conduits shall be provided with 20 mm wide and 100 mm long color coding strips as below.

USE	**COLOUR CODE**
Low Voltage	Grey
Telephone	Black
Earthing System	Green
Security Conduit	Blue
Fire Alarm Conduit	Red
Control System Lighting	Purple

Conduit identification shall be provided by means of conduit feeder schedule. The conduit schedule shall identify all feeder conduits to be installed, using symbols and annotations. Conduits that are to be enclose circuits installed by other contractors shall be clearly indicated. Installation specification shall require pull wire and permanent tagging of each conduit access.

Conduit feeder schedule shall include the following information:

a) Conduit identification- Conduit Size

b) Circuit identification- Conduit Type

c) Conduit from- Conductor Description

d) Conduit to- Conductor Quantity

e) Identification of multiple runs

f) Drawing reference

2.9.10. Protection of Conduit

To safeguard against filling up with mortar / plaster etc. all the outlet and switch boxes shall be provided with temporary covers and plugs, which shall be replaced by

sheet/plate covers as required. All screwed and socketed joints shall be made fully water tight with white lead paste.

2.9.11. Cleaning of Conduit Runs

The entire conduit system including outlets and boxes shall be thoroughly cleaned after completion of erection and before drawing in of cables. For cast in-situ conduits, it shall be checked for freedom from blockage and continuity as soon as the shuttering is removed. All conduit shall be swabbed through before wiring is commenced and cables hall not be drawn into any section of the system until all conduits and draw boxes for that particular section are fixed in position. The contractor shall submit for approval the 'Method Statement including Tests' to ensure the above requirements of cleaning of conduit runs.

2.9.12. Loop Earthing

Loop earthing shall be provided by means of insulated stranded copper conductor wires of sizes as per bill of quantities laid along with wiring inside conduits for all wiring outlets and sub mains. Earthing terminals shall be provided inside all switch boxes, outlet boxes and draw boxes etc.To satisfy requirements for earth fault loop impedance, the layout of conduit, trunking and ducting and routing of cables, contractor shall ensure that the maximum circuit lengths allowable are not exceeded.

3. Additional Requirements

a) All conduits shall be electrically and mechanically continuous and substantially water tight after installation. Electrical continuity and resistance of steel conduit systems intended to be encased in concrete shall be tested immediately prior to pouring.

b) Where an exposed galvanized surface has been cut or otherwise damaged, it shall be repaired by application of a zinc rich epoxy primer with a generous overlap on the existing sound metal coating. Exposed threads and connections shall be similarly treated. The epoxy primer shall be used strictly in accordance with the manufacturer's instructions.

c) The use of inspection elbows and tees shall be avoided, as there is insufficient room for drawing in cables and, in addition the installation presents a shoddy appearance. Round boxes in accordance with relevant Indian Standards may be used. For conduits up to 25 mm diameter, the small circular boxes should be used. Circular boxes are not suitable for conduits larger than 32 mm, and for these larger sizes rectangular boxes should be used to suit the size of cables to be installed.

d) All circular boxes shall be provided with long spouts, internally threaded, incorporating a shoulder for the proper butting of the conduit.

e) An indelible display shall identify the cables laid along with the conduits at each conduit junction/ termination etc. for identification during any future handling.

f) The contractor shall submit 'Method Statement' for Installation, Testing and Commissioning of the conduit system as per the requirements of this specification. The

'Method Statement' shall also cover the aspect of quality and safety during Installation, Testing and Commissioning of the system.

g) For underground stations, switches shall be single pole and rated not less than 20A, for use on AC systems, including fluorescent or inductive loads.
h) All boxes and conduit accessories shall be fully weatherproof when used in outdoor locations and tunnels. Weatherproof boxes and conduit accessories shall also be used in locations other than outdoors where specified.
i) Covers for external application shall have machined faces, and shall be provided with neoprene type gaskets. No box shall be fixed in such a position as to be inaccessible on the completion of the building structure or other services.

4. Safety

The conduit system shall follow the relevant clauses of Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2010, National Building Code, 2005 and National Electrical Code, 2011 for the safety precautions to be adopted. In addition to this, following conditions should be adhered to:

a) All conduits shall be kept clear of gas and water pipes. In particulars, conduits shall be at least 150mm away from gas pipe. Where proximity to these pipes is unavoidable, they shall be effectually segregated e.g. using rubber or other insulating material to prevent appreciable voltage difference at possible points of contact. Segregation from extra low voltage circuits and telecommunication circuits shall also apply unless these are wired to that same voltage requirement as lighting and power circuits.
b) Emergency power sockets for Fire Services Department shall be provided in headwall units, tail-wall units and other locations shown on the drawings. The socket outlet shall be 32A, three phase, 5 pin socket outlets, in red colour, to IP54.
c) The materials used in the conduit system shall be fire retardant, shall not emit toxic gases and smoke on exposure to fire. The materials shall be easy to dismantle and replace in case of rearrangement and also withstand vibration due to rail operation and seismic tremor.
d) No timber or inflammable material shall be used for any supports.
e) No sharp edges or portion shall be present which may cause injury during handling or installation.

5. Energy Efficiency- NA

6. Maintenance and Life

This is an installation not requiring any maintenance with a long life. The contractor shall take suitable measures during manufacturing and installation of the product to achieve long life.

7. Special Condition- NA

8. Inspection, Testing & Dispatch

8.1. Inspection & Testing

All tests to be conducted as per relevant IS. In case of any contradiction with the relevant IS and this specification, this specification shall prevail.

8.2. Packaging and Sealing

The contractor shall ensure to the satisfaction of the Engineer-in- Charge that the material is properly packaged with inspection seal before dispatch. The contractor shall ensure satisfactory dispatch of material so as not to damage the packing condition and inspection seal.

E04. WIRING ACCESSORIES AND MISCELLANEOUS ELECTRICAL EQUIPMENT

E04.1 General

E04.1.1 This Section specifies the manufacture and installation of electrical wiring accessories including lighting switches, sockets outlets and switches. Relevant codes and standards up to latest revision shall be applicable.

E04.1.2 The miscellaneous electrical equipment specified in this Section include outdoor bell push buttons and terminal blocks.

E04.1.3 Metal boxes for the enclosure of electrical wiring accessories in conduit system shall be 35 mm deep for lighting switches and 47 mm deep for power sockets and all other outlets, complying with BS 4662 or equivalent Indian Standards. Earth bonding between the metal boxes and the associated accessories shall be achieved by a LSZH sheathed copper wire of minimum size 2.5 mm^2.

E04.1.4 Coloured labels shall be provided on the front plates of the wiring accessories to indicate the phase of circuitries.

E04.2 Standards

E04.2.1 Relevant Codes and Standards

E04.2.1.1 BS 546: Two-pole and earthing-pin plugs, socket-outlets and socket-outlet adaptors.

E04.2.1.2 BS 1362: Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).

E04.2.1.3 BS 1363: Plugs, socket-outlets and adaptors.

E04.2.1.4 BS 3676/**BS 60669**: Switches for household and similar fixed electrical installations.

E04.2.1.5 BS 4343: Specification for industrial plugs, socket-outlets and couplers for AC and DC Supplies

BS 60309-2: Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories.

E04.2.1.6 BS 4662: Specification for boxes for the enclosure of electrical accessories.

E04.2.1.7 BS 5733: Specification for general requirements for electrical. accessories.

E04.2.1.8 BS 6220: Specification for junction boxes for use in electrical installations with rated voltages not exceeding 250 V

BS 60670: Boxes and enclosures for electrical accessories for household and similar fixed electrical installations. Particular requirements for connecting boxes and enclosures.

E04.2.1.9 BS 7671: Requirements for electrical installations. IEE Wiring Regulations.Seventeenth edition.

E04.2.1.10 IEC 60529/EN 60529: Specification for degrees of protection provided by enclosures (IP code).

E04.2.1.11 BS7211: 2012 - Electric cables. Thermosetting insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring, and having low emission of smoke and corrosive gases when affected by fire.

E04.3 Technical and Installation Requirements

E04.3.1 Quality Control

All similar items of equipment shall be interchangeable and shall be from the same manufacturer. All accessories shall comply where applicable with the general requirements specified in BS 5733 and BS 6220/**BS 60670**, or equivalent Indian standards.

E04.3.2 Lighting and Appliance Switches

E04.3.2.1 All switches for lighting and associated circuits shall comply with BS 3676 /**BS 60669**or other international standards and shall be slow break for use on AC supplies. Switches shall be single pole and rated not less than 20A, for use on AC systems, including fluorescent or inductive loads to the amended BS 3676/**BS 60669**or other international standards. The front plates of lighting and appliance switches shall be made of stainless steel with mat satin finish except for those in plantrooms which shall be stove enamelled aluminium finish.

E04.3.2.2 For staff/back of house areas: Individual wall switches.

E04.3.2.3 For public areas:2 -wire control latched contactorswitching with manualoverride facilities.

E04.3.2.4 For external lighting:2-wire control latched contactor switching interlocked with photo-electric/ time switch with manual override.

E04.3.2.5 Wall Switches;

a) Device body: plastic with rocker handle,

b) Switch plate: made of AISI Type 304 stainless steel,

c) Voltage rating: 300 volts, AC,

d) Current rating: 15 amperes.

E04.3.2.6 In damp or exterior locations switches shall be of non-tracking plastic, single pole, operated by external means. The switch enclosure shall be either weatherproof of galvanized metal or splash proof plastic construction to IP 54.

E04.3.2.7 Light switches forming part of a multi-gang arrangement shall be separated so that light switches connected to the same phase are located under the same switch plate. Separate switch plates shall be provided for switches connected to different phases. Adjacent switches, connected to different phases, shall be separated by a fixed partition in the wall box.

E04.3.2.8 Lighting switches used on AC supplies shall be of "AC only" type and not derated when used with fluorescent or inductive loads. Lighting switches used on DC supplies shall be of "double-pole" quick make-and-break type, with pillar type terminals and earthing straps.

E04.3.2.9 Switches shall be one way, two way or intermediate as required and where mounted together, they shall be fitted in a common multi - gang box and share a common front plate. For surface installation they shall be adjustable with front plates having a 6mm minimum overlap.

E04.3.2.10 Every switch controlling an appliance shall be labelled with the name of the appliance it controls and shall be fitted with a 0.5 W neon indicating lamp.

E04.3.3 Socket Outlets

E04.3.3.1 Socket outlets for 240V AC supplies shall be 6A and 16A universal pin, 3 pin simplex type shutter protected pin pattern complete with single pole switch and shall comply with IEC 60884-1, TIS 166-2535 or equivalent. 6/16A sockets shall be connected in the form of ring circuits.

E04.3.3.2 The cover plate of the socket outlets shall be AISI Type 304 stainless steel in public areas and standard plaster for staff / back of house areas. Socket outlets mounted externally or in damp areas shall be weatherproof and shall have a degree of protection of IP 54 to IEC 60529 or EN 60529.. Mounting boxes shall be galvanised steel incorporating an earthing terminal and shall accommodate conduit entry for flush mounting or surface mounting. Labels shall be provided on all the front plates to indicate their circuits.

E04.3.3.3 Outlets shall be recessed wherever possible. Mounting height of outlets shall be as indicated in the drawing and designs.

E04.3.3.4 Unless otherwise indicated, outlets shall be surface mounted in plant rooms and flush mounted in all other areas. Outlets shall include flush plates (and mounting blocks whereapplicable) of impact resistance, suitably reinforced.

E04.3.3.5 Heavy-duty three phase socket outlets shall be 32A, complying with BS 4343/**BS 60309-2**or other International Standards. Interlocked switch-fuses shall not be required.

E04.3.3.6 Emergency power sockets for Fire Services Department shall be provided in headwall units, tailwall units and other locations shown on the Drawings. The socket outlet shall be 32 A, three phase, 5 pin socket outlets, in red colour, to IP 54 in accordance with IEC 60529 or EN 60529.

E04.3.4 Industrial Socket Outlets

Industrial plugs, connectors, socket outlets and appliance inlets shall be provided to meet BS EN 60309-2 or other international standards. For interior use such as Plant room unit shall be rated to IP44. Externally or in wet environments such as Tunnel &Undercroft level the protection shall be IP 66.

E04.3.5 Outdoor Bell Push Buttons

E04.3.5.1 Outdoor bell push buttons shall be weatherproof, complying with BS 3676/**BS 60669**or equivalent Indian Standards and with a degree of protection not less than that defined by characteristic IP 54 in accordance with IEC 60529 or EN 60529.

E04.3.6 Not Used

E04.3.7 Terminal Blocks

E04.3.7.1 The rated voltage of terminal blocks shall be 415 V between terminals, 240V to earth.

E04.3.7.2 Terminal blocks shall comprise brass tubular connectors with screw connections contained within a moulded block suitable for working temperature up to 100°C.

E04.3.7.3 Terminal blocks shall be designed to clamp the conductor between metal surfaces with sufficient contact pressure but without causing damage to the conductor. With the largest recommended conductor in position and tightly clamped, there shall be at least two full thread pitches of the screw engaging in the connector.

E04.3.7.4 Disconnect type terminal blocks shall be used for terminals designated to receive signals for control and monitoring purpose and/or where frequent maintenance is required.

E04.3.7.5 Cage-clamp type terminal blocks shall be used where frequent vibration is expected.

E04.3.7.6 IP ratings for terminal block enclosures shall be as follows:

(a) Within Station, AncillaryBuildings and Depot : minimum IP 42,

(b) Outdoor areas Minimum IP 54.

E05. NOT USED

E06. NOT USED

E07. NOT USED

E08. LIGHTING

E08.1 General

E08.1.1 This Section specifies the manufacture and installation of luminaires for Underground Stations of Jaipur Metro. Relevant codes and standards up to latest revision shall be applicable.

E08.1.2 Each fitting shall be suitably equipped with its own fuse protection.

E08.1.3 All light fittings shall operate at power factor of not less than 0.95 lagging. High power factor correction capacitor unit shall be added wherever required. All lamp should be high efficiency lamp & each lamp should have separate ballast.

E08.1.4 Conduit terminations to all aluminium fittings shall be fitted with special accessories to prevent corrosive action between the steel and aluminium components.

E08.1.5 Electrical Distribution cables shall not be routed through bulkhead or other fittings where the cables would be liable to undue temperature rise but shall terminate in a fixed base connector in a conduit box mounted behind or adjacent to the fitting. All wiring within the light fitting shall be with Heat resisting, Low Smoke Zero Halogen wires for normal luminaries and with Low Smoke Zero Halogen, Fire Resistant / Survival wires for Emergency Luminaries. The Low Smoke Zero Halogen and Fire Survivability/Fir Propagation properties of the wires shall be as specified in M & W Specification E 02.

E08.1.6 The light fittings to be provided in vandal prone area should be vandal – resistant.

E08.1.7 The light fittings or its paint shall not emit toxic gases / corrosive gases in case of fire and shall be non- combustible and fire – resistant type.

E08.1.8 Unless specified otherwise, the minimum IP rating of various Luminaries used in various areas shall be as follows:

- Tunnels, Exterior areasIP 65
- Platforms, near Entry / exits, IP 54
- Other Areas and Plantrooms(Non-Sprinkler) IP 20

E08.1.9 Lighting report illustrating concept of lighting shall be supplied after award of work it may be used for preparation of working design/ Drawings in consultation with architects.

E08.2 Standards

E08.2.1 Relevant Codes and Standards

E08.2.1.1 All lighting fittings shall comply with BS 4533, ”Specification for general requirements and tests”/**BS 60598,”Luminaires. General requirements and tests”** and BS 5225, “Photometric data for luminaires”/**BS 13032 Part 3, “Measurement and presentation of photometric data file of lamps and luminaires.Presentation of data for emergency lighting of work places”.**

E08.2.1.2 All lighting fittings shall be supplied complete with lamps and control gear and shall be effectively earthed in accordance with BS 7671, “Requirements for Electrical Installations, IEE Wiring Regulations 16th Edition”. The general, safety and performance requirement of ballasts for discharge lamps shall comply with IEC

60923 or EN 60923 “Auxiliaries for lamps-ballasts for discharge lamps - performance requirements” and IEC 60922 or EN 60922 “General and safety requirements for ballasts for discharge lamp” /**IEC 61347 Part 1 and 2 or EN 61347 Part 1 and 2 “Lamp controlgear. General and safety requirements for ballasts for discharge lamp”**respectively.

E08.2.1.3 BS 646: Cartridge fuse-links (rated up to 5 amperes) for AC and DC service.

E08.2.1.4 BS 2818/**BS 60921/ 61347**: Ballasts for tubular fluorescent lamps.

E08.2.1.5 IEC 60742/EN 60742/BS 3535/**BS 61558**: Isolating transformers and safety isolating transformers.

E08.2.1.6 IEC 55015/EN 55015: Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.

E08.2.1.7 IEC 60081/EN 60081: Double-capped fluorescent lamps. Performance specifications.

E08.2.1.8 IEC 60529/EN 60529: Specification for degrees of protection provided by enclosures (IP code).

E08.2.1.9 IEC 60555/EN 60555: Disturbances in supply systems caused by household appliances and similar electrical equipment

IEC 61000-3-2/ 61000-3-3/EN 61000-3-2/ 61000-3-3: Electromagnetic compatibility (EMC). Limits.

E08.2.1.10 IEC 60928/EN 60928: Auxiliaries for lamps, AC supplied electronic ballasts for tubular fluorescent lamps. General and safety requirements.

E08.2.1.11 IEC 60929/EN 60929: Specification for AC supplied electronic ballasts for tubular fluorescent lamps. Performance requirements.

E08.2.1.12 IEC 60947-4-1/EN 60947-4-1: Specification for low - voltage switchgear and control-gear. Contactors and motor-starters.Electromechanical contactors and motor-starters.

E08.3 Technical and Installation Requirements

E08.3.1 General Requirements

E08.3.1.1 The lamps and control gear shall be suitable to operate in the ambient environmental conditions.

E08.3.1.2 All the luminaires shall generally be suitable for operation with voltage in the range of plus or minus 10 % at luminaires terminals, however, these shall be able to withstand short time, voltage fluctuation of ± 20% of the input voltage. The power factor correction capacitors to BS 4017 shall be provided. The capacitance shall be such that the power factor of the luminaires, measured at the incoming cable terminals during start or running does not fall below 0.95 lagging at the input terminals.

E08.3.1.3 All the components including the internal wiring of the luminaires, to be used in under ground location shall be manufactured of materials, which are of the Low Smoke and Zero Halogen (LSZH) type. All luminaries shall be manufactured to relevant sections of IEC 60598 or other approved international standards and type tests for all the Luminaries shall be provided.

E08.3.1.4 All luminaires supplied shall be photometrically tested to BS5225 Part 1/**BS 13032 Part 3**, or other approved international standards. Test certificate shall be provided. The photometric data for all luminaires shall be provided along with the design calculations during preparation of Working Drawings.

E08.3.1.5 All luminaires shall be provided with a lamp compatible with the control gear used. Luminaires shall not be suspended by their flexible cords. A separate means of suspension shall be provided. The suspension and mounting detail shall be provided during working drawing preparation based on the manufacturer selected.

E08.3.1.6 All flexible cords / wires shall be installed in the cable tray or conduit according to BS 7671 wiring regulations and as specified in the electrical installation specifications. All the flexible wires shall be anchored at both ends such that the cord is free from strain.

E08.3.1.7 Any plastics used in the luminaires shall be of non-flammable material meeting all NFPA requirements, preferably UV and light stable and shall be suitable for the application. These plastics must meet UL 64 standard on Flammability of Materials or approved equivalent.

E08.3.1.8 All sheet steel components shall be suitably pre-treated and painted using epoxy powders. The colour shall be according to architectural finishes requirement. Only compatible materials shall be used in contact with each other.

E08.3.1.9 Louvers or diffusers shall be restrained to prevent them from falling out of the body of the luminaires under normal conditions and when re-lamping. An insulated flexible copper conductor shall connect metal louvers to the body of the luminaires or the earth terminal. Luminaires must meet the relevant IEC regulation for earthing requirements of metallic parts.

E08.3.1.10 Luminaires fitted with high frequency or electronic control gear shall be disconnected before the circuit is tested for insulation resistance.

E08.3.1.11 Control Gears, if any and wiring assemblies shall be sprayed with an approved non – hardening lacquer coating to prevent the ingress of moisture.

E08.3.1.12 Cables interconnecting components shall be as specified in Clause E08.1.5 and shall be neatly secured within the fittings to prevent undue looseness and contact with ballasts.

E08.3.1.13 Where wiring passes through the edge of any metal section of the fitting, it shall be protected by an approved grommet. All connections of wires to terminals shall be

of approved types. All wiring shall be concealed from view with the luminaire installed.

E08.3.1.14 Light fixtures installed in the battery rooms shall have an enclosure approved for Class 1, Division 2 locations as per NFPA 70.

E08.3.2 Lighting control system

E08.3.2.1 The lighting control system shall be applicable to the public area lighting only.

E08.3.2.2 The lighting control system in SCR will select 25%, 50%, 75% or 100% of lighting ON. The Selector switches on each sub-circuit at the Distribution Boards nominate either Manual/Off/Auto function. In Manual or OFF mode, they bypass the remote control and each circuit can be switched ON/OFF to achieve the desired lighting pattern / lighting level required. In Auto mode, they are under remote control.

E08.3.2.3 The latching contactors, selector switches and accessories shall be housed in the distribution board where the sub-circuits originate. Supply source for the control circuit shall be derived from the same distribution board where the power for the lighting circuits is obtained.

E08.3.2.4 Contactors shall be of the air-break type fitted with arc shields and rolling self-leaning double-break silver faced contacts complying with IEC 60947-4-1 or EN 60947-4-1 and shall be contained in a dust-tight metal case. The units shall be supplied complete with 240 volts AC operating coils, neutral links and HBC (High Break Capacity) control fuses. Contactors shall be electrically held in when in the closed position and fitted with a latch-in facility for test purposes.

E08.3.3 Electro-Magnetic Compatibility

E08.3.3.1 All equipment shall confirm with the objective of the European Directives on EMC (89 /336/EEC) and where appropriate shall be fixed with the CE mark.

E08.3.3.2 The radio frequency interference (RFI) levels generated by the Electronics ballasts andcontrol gear shall also be in accordance with the requirements of standard EN 55015, or other international standards as stated in the schedules.

E08.3.3.3 It shall comply with the following:

- Electromagnetic Compatibility: Emission
- IEC 60555/**IEC 61000-3-2/ 61000-3-3**
- EN 55015

E08.3.4 Fluorescent Luminaires (Linear & Compact Fluorescent)

E08.3.4.1 Unless otherwise specified all fluorescent luminaires shall be supplied with HF, electronic ballasts.

E08.3.4.2 Aluminium reflectors and louvers shall be made from high purity aluminium (99.85% minimum) with low iridescence and the total reflection shall be around 87%. The anodic film shall have a minimum thickness of 2.5 microns.

E08.3.4.3 Diffusers shall be made from light stabilised polycarbonate/glass, injection moulded, glass or equal and approved) The diffusers shall not support combustion and shall be self-extinguishing. The control gear enclosure shall be designed such that the temperature is less than 70 °C

E08.3.4.4 An earthing conductor of not less than 2.5 mm² shall be provided from the base box to the light fitting.

E08.3.5 High Intensity Discharge (HID) Luminaires

E08.3.5.1 All HID luminaires shall be provided with semi parallel igniter with self-stopping mechanism.

E08.3.5.2 All high bay luminaires shall be provided with safety chains, in addition to the primary fixing, to prevent them from falling during cleaning or re-lamping.

E08.3.6 Installation of Interior Luminaires

E08.3.6.1 All screws, battens, roses, noggins, trims, packing, etc., necessary for the proper fixing of luminaires, shall be provided as part of the work, whether individually specified or not. Packing pieces of approved material shall be fitted where required to level the luminaires and to prevent distortion.

E08.3.6.2 Where painted surfaces are damaged, they shall be made good by painting. Such repairs shall be of the same standard as the original paintwork.

E08.3.6.3 Generally, fluorescent luminaires shall be securely fixed to the lighting boom, structural members of the ceilings or walls, or fixed by hangers, brackets or the like which are themselves securely fixed to the building members.

E08.3.6.4 The following provisions apply to fluorescent luminaires or any other luminaires of the same configuration;

Each Luminaire shall be supported by two fixings, one at each end.

PVC is not to be used within boxes or fittings attached to luminaires.

E08.3.6.5 Luminaires shall be installed to suit the ceiling system and as indicated on the working Drawings.

E08.3.6.6 Luminaires shall be suspended using pendants supported from swivel hangers. Install pendant length required to suspend luminaires at indicated height.

E08.3.6.7 Luminaires shall be recessed in such a way to permit removal from below. Luminaires shall be recessed using accessories and fire stopping materials to meet regulatory requirements for fire rating.

E08.3.6.8 Clips shall be installed to secure recessed grid supported luminaires in place. Wall mounted luminaires shall be installed at heights as indicated on Working Drawings. Accessories shall be installed to branch circuit outlets provided using flexible conduit.

E08.3.6.9 Wiring connection shall be made to branch circuit using building wire (LSZH or LSZH and Fire Survival Type), as specified in section E02 of M & W Specifications and suitable for temperature condition within Luminaries.

E08.3.6.10 Specified lamp shall be installed in each luminaires and all luminaires shall be effectively earthed.

E08.3.6.11 Luminaires shall be aimed and adjusted as indicated on Working Drawings.

E08.3.6.12 After Installation

- Remove dirt and debris from enclosures.
- Clean photometric control surfaces as recommended by manufacturer.
- Clean finishes and touch up damage.

E08.3.6.13 Lamps, which have failed during the period of installation, testing etc., must be replaced without any extra cost until the commissioned system is handed over. In addition, requirement of DLP shall be complied with.

E08.3.6.14 Objects protruding from walls, such as telephones or light fixtures, with their leading edges between .7m and 2m above the finished floor must not protrude more than .1m into walks, halls, corridors, passageways, or aisles. Protruding objects must not reduce the clear width of an accessible route or manoeuvring space. Walks, halls, corridors, passageways, aisles, etc. must have 2m minimum clear headroom.

E08.3.6.15 All fixtures particularly lighting fittings suspended from the ceiling soffits in the underground station public areas and tunnels, shall be designed, manufactured and installed to withstand an air flow having a drag of not less than 100 Pa (500 Pa in tunnels) normal to the projected area of the surfaces of the fixtures facing the airflow.

E08.3.7 Exterior Luminaires

E08.3.7.1 For remote control gear, cables interconnecting the igniter and control gear shall be heat-resisting cables rated at 90 °C minimum and shall be neatly secured to prevent undue looseness.

E08.3.7.2 Poles shall be tapered round of galvanised steel inside and out. Height shall be as indicated on Drawings. Loading capacity of poles shall be able to withstand steady wind of 180 km / hr minimum. Poles shall be protected from physical damage by a concrete base of 0.64 m diameter and extend not less than 0.75m above grade.

E08.3.7.3 Lighting poles shall be installed in concrete bases at locations as indicated on Working Drawings. Poles shall be installed in plumb. Shims or double nuts shall be installed to adjust plumb. Grouting shall be done around each base.

E08.3.7.4 Lamp and control gear shall be installed in each luminaire. Luminaires, metal accessories and metal poles must be bonded and grounded in accordance with these specifications.

E08.3.7.5 Clean photometric control surfaces as recommended by manufacturer. Clean finishes and touch up damage.

E08.3.7.6 Lamps, which have failed during the period of installation, testing etc., must be replaced without any extra cost until the commissioned system is handed over.

E08.3.7.7 Poles for external light fittings shall be constructed from mild steel tubes, hot dipped galvanised and may be reduced in diameter in one, two or three steps depending on the height of the poles. The erected poles shall be painted with at least two coats of primer and two finishing coats to a colour as Approved. Each pole together with the light fitting shall be able to withstand the wind loads. Pole root sections shall have suitable slots for cable entry. The poles shall be set in the ground to a depth of 1030mm or one fifth of the length above ground, whichever is the less. The top surface of concrete shall be slightly chamfered to provide adequate drainage.

E08.3.7.8 A service box incorporating a RCBO unit suitable for looping in and out of up to 25mm^2 two core armoured cable or equivalent shall be mounted inside each pole at an appropriate height above ground level and shall comprise terminal blocks for the phase and neutral conductor and a RCBO unit mounted on a galvanized steel back plate. Provision shall be made for supporting cable glands for armoured cable at the bottom of the service cut-out unit. Access shall be by a removable metal cover with brass hexagon head screws.

E08.3.7.9 Pole internal wiring shall be with Copper conductor, PVC insulated as per IS 694, of adequate size and rubber grommets shall be used where wires pass through metal.

E08.3.7.10 Control gear for discharge lighting shall be contained within a galvanized steel case mounted on or inside the pole. When mounted on the pole, the steel case shall be watertight, and positioned at a height higher than normal working level such that a ladder is needed for access.

E08.3.7.11 Pole mounted fittings and luminaries shall be of weatherproof construction with a degree of Ingress Protection not less than that defined by classification IP 65, in accordance with IEC 60529 or EN 60529 construction and completely adjustable for direction of illumination.

E08.3.8 Emergency Lighting

E08.3.8.1 The emergency lighting installation shall fully comply with NFPA 101 and NFPA 130, BS 5266 and emergency luminaires shall comply with BS 4533 Part 101 and Part 102.22/**BS 60598 Part 1 and Part 2**, CIBSE, for LED shall be follow the clause no. E08.3.14 and other international standards.

E08.3.8.2 All emergency lighting luminaires and exit signs shall be fed from a 415 / 240V UPS power supply. All indoor lights shall be LED type. The location of the same shall be according to architectural drawings.

E08.3.8.3 Emergency Luminaires;

a) The luminaires shall be clearly marked with a label visible to persons standing on the floor beneath them.

b) Emergency lighting luminaires shall, wherever possible, be fluorescent type/ **LED** for superior lamp life and lumen output. This includes linear lamps in conventional fluorescent luminaires and TCD lamps in down lights.

E08.3.8.4 Illuminated Emergency Exit Signs

a) Exit signs shall be manufactured to meet the appropriate requirements of BS4533/**BS 60598**, BS 2560 and BS 5266, or other international standards.

b) Each sign shall be internally illuminated by two lamps. The housing shall be designed to maintain an internal ambient temperature below that of the lowest temperature rating of any piece of equipment installed therein.

E08.3.8.5 Installation;

a) Install surface mounted emergency lights and exit signs plumb and adjust to align with building lines and with each other. Secure to prevent movement.

b) Install suspended exit signs and emergency lights using pendant supported from swivel hangers. Install pendant length required to suspend sign at indicated height. Install accessories furnished with each emergency light and exit sign.

c) Connect emergency lights and exit sign to branch circuit outlets. Make wiring connections to branch circuit using fire survival building wire in flexible conduits. Install specified lamps in each emergency light and exit sign.

E08.3.9 Parameters for Lamps

E08.3.9.1 The following general lamp parameters shall be applicable unless otherwise specified in specific design data;

a)	Linear Fluorescent Lamp	16.1.1
16.1.2	Type	T5, High output, 2900 lumen output nominal for 1200 mm, 28W
16.1.3	Colour Rendering Index Ra	85
16.1.4	Colour Temperature:	6500/4000 K
16.1.5	Tube diameter:	16 mm
16.1.6	Life:	In excess of 20,000 hours
16.1.7	Compliance	IEC 600081
b)	Metal Halide	16.1.8

16.1.9	Colour Rendering Index Ra	80 for 70 W and 150 W Lamps, 65 for 250 W and 400 W or above
16.1.10	Colour Temperature:	4000 K
16.1.11	Life	10500 hrs
c)	High Pressure Sodium	16.1.12
16.1.13	Colour Rendering Index Ra	23
16.1.14	Colour Temperature:	2000 K
16.1.15	Life	10500 hrs
d)	Compact Fluorescent	16.1.16
16.1.17	Cap	G23 or G24
16.1.18	Starting	Instant
16.1.19	Colour Rendering Index Ra	80
16.1.20	Colour Temperature:	4000 K
16.1.21	Life	20000 hrs

E08.3.10 Parameters for Control Gear

E08.3.9.1 Ballasts for fluorescent, metal halide, and high-pressure sodium: Power Factor shall be according to manufacturers recommendation and type of luminary. Input voltage shall be 240V, 50Hz. Voltage tolerance: ± 10% of rated voltage.

E08.3.9.2 Fuse holder and fuse for metal halide, high-pressure sodium, and fluorescent lamp ballast: accessible; type and size recommended by ballast manufacturer, wire fuse holder to primary ballast lead on ungrounded side.

E08.3.9.3 Power line radio frequency filter: in accordance with EN 55015

E08.3.9.4 All internal wiring within the lighting fixtures shall be with wires as specified in Clause E08.1.5.

E08.3.9.5 All ballast shall be capable of starting lamps at ambient temperature of 0 °C and above.

E08.3.11 Electronic Ballast for Fluorescent Lamps

E08.3.10.1 Ballast shall be the manufacturer's best sound rating, and the sound rating should be indicated on the ballast. Ballast shall be high frequency electronic type, operating lamps at a frequency of 20 kHz or higher with no detectable flicker.

E08.3.10.2 Ballast efficiency defined as the ratio of total lamp watts to total input watts shall not be less than 1.00 for single and two lamp ballast and 1.08 for three and four

lamp ballast.

E08.3.10.3 Light output regulation: ballast shall maintain consistent light output of all fluorescent lamps over operating ranges of 192 Volts to 288 Volts.

E08.3.10.4 Relative Light Output: (percentage of light emitted compared with reference tube and ballast) shall not be less than 95% and more than 100%.

E08.3.10.5 Input total harmonic content should not exceed 10%. Ballast shall withstand line transients as per IEC 61547 (Immunity Standards). Ballast case temperature shall not exceed 25 °C temperature rise over 43 °C ambient. Ballast power factor shall be 95% or above. Ballast shall provide continuous heating voltage to lamp cathodes and operate lamp(s) on a rapid start circuit unless otherwise noted.

E08.3.10.6 Flicker index shall be less than 0.01 (<5%).

E08.3.12 Electronic Ballasts for Ceramic Arc Tube Metal Halide Lamps

E08.3.11.1 Ballast shall be of the electronic type. Ballast shall be suitable for operation at the specified voltage and at a frequency of 50 Hz. Ballast ignition voltage shall be between 3 kV and 5 kV. Ballast power factor shall be 0.95 or above.

E08.3.11.2 Maximum Watt loss shall not exceed 3 Watts for 28 Watts lamps, 15 Watts for 70 Watts lamps and 22 Watts for 150 Watts lamps. The ballast case temperature shall not exceed a maximum temperature of 65 °C.

E08.3.13 Low Loss Magnetic Ballasts

E08.3.13.1 Wound ballasts for HID lamps shall comply with IEC 60922/**IEC 61347 Part 1 and 2**and IEC 60923.

E08.3.13.2 The ballast should consist of orthocyclically wound high quality enamelled copper coil, rolled steel lamination impregnated with compound polyester. The maximum permissible winding temperature, Tw should be 130 Degree Centigrade and the temperature rise above the ambient i.e. Δ T should be greater than 75 Degrees to ensure more withstand capability of the winding with respect to temperature. The construction of the ballast should be of open type to ensure quick heat dissipation and lows losses. The power factor should be more than 0.85.

E08.3.13.3 Maximum Watt loss for metal halide lamp ballasts shall not exceed 15 Watts for 70 Watts lamps, 17 Watts for 100 Watts lamps, 20 Watts for 150 Watts lamps, 24 Watts for 250 Watts lamps and 27 Watts for 400 Watts lamps.

E08.3.13.4 High-pressure sodium lamp ballasts shall be of the voltage-stabilized type with a power factor not less than 0.9 lagging. A 10% variation in line voltage shall vary the lamp wattage by no more than + 3%. Ballast shall have an adequate voltage at the lamp with a line voltage of up to 24% below nominal to prevent the lamp from being extinguished. Ballast shall be complete with 180 °C insulation and 80 °C rated capacitors. Ballast shall be capable of starting and operating lamps at 0 °C minimum and 43 °C maximum and up to 11 meters remote from the lamp.

E08.3.13.5 Ballast shall have an adequate voltage of 198 V to prevent the lamp from being extinguished.

E08.3.13.6 Maximum heat loss for high-pressure sodium lamp ballasts shall not exceed 20 Watts for 150 Watts lamps, 29 Watts for 250 Watts lamps and 44 Watts for 400 Watts lamps.

E08.3.13.7 The sound power level of ballasts in each octave band shall not exceed the room NC rating by more than 8 dB.

E08.3.14.0 LED Lights

E08.3.14.1 Scope

E08.3.14.1.1 This specification covers for supply of Light Emitting Diode (LED) lighting that shall be used as general lighting in JMRC.

E08.3.14.1.2 The lumen maintenance of the LED fittings (of the system not chip) shall not be less than 70% after 5000 hrs. i.e. (L70; B10). It shall have a warranty of 5 years after delivery and warranty of the replaced item shall restart from the date of replacement.

E08.3.14.1.3 The product should be latest state of art and compliant to relevant IEC 60598-1, 2, 3, IEC 62031and IEC/PAS 62612 or their latest edition depending on the type of luminaire. In addition to the above luminaire shall adhere to relevant BIS standards IS 15885, 16101, 16102, 16103, 16104, 16105, 16106, 16107 (Part I & II) as per the application. The product shall be of proven design should possess type test certificate / performance certificate from the accredited laboratory. The product and is major components shall be state of art and of proven design.

E08.3.14.2 Fixtures

E08.3.14.2.1 The fixture shall be suitable to work under following ambient conditions.

E08.3.14.2.2 Maximum ambient temperature of 50ºC

E08.3.14.2.3 Atmosphere - The equipment shall be designed to work in coastal, humid, salt laden and corrosive atmosphere.

E08.3.14.2.4 Housing, if not used as a heat sink shall be made of 0.5 mm thick CRCA sheet / Extruded Aluminium (2 mm) or pressure die cast (PDC-2 mm), conforming to relevant standards, polyester powder coated of at least 40 microns) and high U.V. & corrosion resistance.

E08.3.14.2.5 Heat sink used should be extruded Aluminium or Pressure Die-Cast Aluminium having high conductivity preferably ADC 12 or LM 6.

E08.3.14.2.6 Luminaries should be covered with suitable Glass or diffuser with High Transitivity.

E08.3.14.2.7 Outdoor luminaire shall be with clear toughened glass or clear polycarbonate cover.

E08.3.14.2.8 Lighting fixtures and accessories shall be designed for continuous trouble free operation under diverse atmospheric conditions without deterioration of materials. Degree of protection of enclosure shall be at least IP-65 for outdoor fixtures. However, down lighter and other internal fixture shall be provided with at least IP-20 protection.

E08.3.14.2.9 The fixture should have a surge protection of 2 KV.

E08.3.14.2.10 The fixture should conform to applicable IS 10322 / IEC 60598 (All parts & amendments) and should have the associated LM-79 report (for Electrical and photometric test methodology for LED lighting) from accredited lab. Test report shall be submitted along with relevant catalogues.

E08.3.14.2.11 The fixture shall be surface suspended or recessed type depending on the application area.

E08.3.14.2.12 Reflector (if) shall be a high quality aluminium reflector and shall have efficiency more than 85% to achieve a wide light distribution. The anodic film shall have a minimum thickness of 2.5 micron.

E08.3.14.2.13 The fixture shall be provided with separate wiring channel with cover plate and earth terminal.

E08.3.14.2.14 Provision shall be made for main connection directly at the back of housing.

E08.3.14.3 LED Features

E08.3.14.3.1 Approved makes are as per the approved list of makes.Manufacturer should have LM-80 report and projected life of the chip. Manufacturer has to submit the test report along with relevant documents.

E08.3.14.3.2 High lumen efficacy LEDs suitable for the application along with following features shall be used:

a) LED Efficacy at the chip level shall > 120 lumen/watt (For High power LED)
   I. The efficiency of the LED at 85 Degree C junction temperatures shall be more than 85%.
   II. The system luminous efficacy of LED luminaire' shall be as under:-
      - Efficacy > 60 lumen/Watt for low wattage luminaries (<45W); and
      - Efficacy > 80 lumen/watt for high wattage luminaries (>45W)
b) Adequate heat sink with proper thermal management shall be provided.
c) Minimum view angle of the LED shall not be less than 1200.
d) Power factor of complete fitting shall be more than 0.9
e) LED shall be surface mounted type duly soldered to PCB by Reflow system or COB type. The Solder used shall be ROHS compatible for environment friendliness.
f) Input frequency range shall be between 50Hz±3%.
g) Colour rendering index CRI >=70 as specified in item description.
h) Correlated Colour Temperature shall be in the range of 3000 K - 6500 K as specified in item description.
i) It shall have an SDCM (standard deviation in colour maintenance) of < 5.
j) The LED efficiency shall be more than 85% at a junction temperature of 85°C.

E08.3.14.4 LED driver and Control Circuit Specification :-

E08.3.14.4.1 LED driver shall have following features:

a) The LED driver shall be constant current type.
b) Input voltage range within 160 V (RMS) to 270 V (RMS) at 50 HZ.
c) The driver shall be able to withstand surge (EFT+ESD interference) of minimum 2 KV with a rise time of 20 nanoseconds.
d) Output voltage of the driver shall be designed to meet the power requirement of the system.
e) The driver shall have under voltage, over voltage, short circuit and earth fault protection.
f) Output over voltage protection of 125 V DC.
g) Output voltage ripple shall be within 3%.
h) It should have an option of dimming.
   i) The driver shall have an efficiency ≥ 85%
   j) Total Harmonic Distortion shall be :-
      I. For 0- 50 W for shall be less than 25% (<25% for 0-50 W)

II. Above 50 W rating shall be less than 15%. (<15% for >50 W)

k) The Current waveform should meet EN 61000-3-2
l) LED Driver shall withstand voltage of 350V for 2 hours and restore normal working when normal voltage is applied
m) The driver should comply to CISPR 15 for limits and methods of measurement of Radio Disturbance characteristics
n) The equipment should comply to IEC 61547 for EMC immunity requirements
o) The control gear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384.
p) It shall have a power factor >.9

E08.3.14.5 General

E08.3.14.5.1 The lumen maintenance of the LED lightings shall not be less than 70% after 50,000 hours i.e. L70 (B50).

E08.3.14.5.2 The supplier shall provide evidence that the LED chipset manufacturer has the patent right to produce the supplied LED chipset to avoid infringement of white LED patent.

E08.3.14.5.3 Free warranty shall commence after delivery and end at 60 months after delivery. The warranty of replaced item shall re-start from date of attending defect / replaced. Test reports for various parameters i.e.Flux, power, efficacy, chromaticity, temperature, protection etc. issued by certified agency shall be furnished. Estimation on product's life and performance shall also be furnished.

E08.3.14.5.4 JMRC reserves the right of testing of products for its conformity in accordance with above specifications.

E09 EARTHING SYSTEM

E09.1 General

E09.1.1 This section specifies the manufacture, supply, testing & commissioning and installation of the Earthing System for the Underground Metro Stations of JMRC. It covers the Earthing System requirements for AC power system except for the traction power system. The Contractor shall be responsible for preparation of the working drawings, manufacture, supply, delivery and installation, functional testing and handover of a working earthing and bonding system. **Construction of earth mat is not in the scope of this contract after the risers of earth mat all the works relatedwith earthingis in the scope of this contract.However, Bi-metallic Earth termination & lugs for cable risers should be provided by E&M Contractor.**

E09.2 Standards

E09.2.1 Relevant Codes and Standards

BS 7430: Code of Practice for Earthing.

BS 7671 - Requirements for Electrical Installations

ANSI/IEEE Std 80-2000 - IEEE Guide for Safety in AC Substation Grounding

IEC 60364 - Electrical Installations of Buildings

IEEE 1100 - Recommended Practice for Powering and Grounding of Sensitive Electronic equipment

E09.3 Technical and Installation Requirements - Earthing and Bonding

E09.3.1 General Requirements

E09.3.1.1 All metal works associated with an electrical installation but not forming part of live conductors, including exposed conductive parts and extraneous conductive parts, shall be solidly and effectively bonded and earthed.

E09.3.1.2 The design of the systems shall facilitate the rapid detection and disconnection of earth faults. Isolation of the faulty system shall be fast enough to protect human beings and to limit damage to plant and equipment.

E09.3.1.3 The earthing systems shall be capable of carrying full fault currents.

E09.3.1.4 The design of the system shall minimise the occurrence of electrical interference, particularly between power cables and communications systems.

E09.3.1.5 The maximum voltage between a live conductor under fault conditions and the general mass of earth shall be no greater than 50 V and the main earth shall have a maximum resistance to earth of 1.0 ohm.

E09.3.1.6 The materials for the earth systems shall be such as to avoid electrolytic corrosion and ensure a life of 100 Years. Earth rod electrodes and earth conductors shall be 99.9% conductivity copper.

E09.3.1.7 The earthing system shall be in compliance with the Section 61 of Indian Electricity Act and Section 4 of IS 3043:1987 with latest amendments, if any.

E09.3.1.8 Copper tapes with low smoke and halogen free over sheath shall be provided wherever directed by the Employer.

E09.3.1.9 All copper tape clips, holdfasts, clamps, earth rod clamps, etc. shall be supplied by the manufacturer of the copper tapes and rods, as far as possible.

E09.3.1.10 Separate earthing points shall be provided for all indoor Signalling & Train Control and Telecommunication installations to achieve the following objectives and requirements:

1. To provide safety for the operating & maintenance personnel against electric shock on account of any potential (voltage) appearing on exposed equipment or conductive surfaces with respect to earth due to electromagnetic or electrostatic induction.

2. To ensure safe & reliable operation of the equipment by limiting or eliminating the induced voltages in the Signalling & Train Control and Telecommunication equipments arising from within the JMRTS on account of traction voltages, traction return current, rolling stock characteristics and other extraneous sources in the vicinity of SYS01 installations.
3. To protect equipment against build up of unduly high voltages, which can cause dielectric (Insulation) breakdown or damage to the equipment or their parts.
4. To serve as a common voltage reference point.
5. The Clean Earth System shall meet or exceed the requirements of IEEE 1100, NFPA 780 and IEC 1024 or relevant international standards.
6. Any electrical joints in the earthing system shall be protected from moisture ingress by using proper wrapping, sealing with waterproof tape, or such other approved measures.
7. For the purpose of measurement of earth resistance, a small interconnecting copper strip of appropriate cross-section shall be provided in the ring earth in a small accessible chamber so that the ring earth can be broken from the loop for testing.
8. Reduction in potential to system neutrals.

E09.3.2 Main Earthing Terminal

E09.3.2.1 **Earth GI strip & electrode shall comply the BS 2874 /IS :3043-1987.**

The earthing mats and the test electrodes shall be provided prior to casting of base slab as shown on the Drawings.

For each earth mat, principal earth conductors as per design, which are interconnected together above the finished floor screed, shall be provided. Bolted bimetallic (copper / G.I) main earth terminal shall be provided at the top of the principal conductors above the finished floor screed. The links shall form the Principal Earth Terminals. **Each link shall be of bimetallic test link and shall have minimum cross-sectional area of 400 / 185 mm2**. The links shall form the connection point to the building main earth network. The links shall be labelled “Principal Earth Connection / Terminal”. While taking the riser from the earth mat to the finished base slab level, waterproofing requirements of the base slab must be taken care of.

The Contractor shall provide an earth bar, in each of the substations, of ample size near the main incoming switch or switchboard for the connection of the circuit protective conductors, the main equipotential bonding conductors and the earthing conductors to create the equipotential zone and to meet the requirements of Other / System wide Contractors. The Contractor shall use this earth as the “LV main Earthing Point / Terminal”. **The main earthing terminal complete with a disconnecting link of *appropriate size*GI bar shall be connected to the earth**

via an earthing conductor to Principal Earth Terminals. Additionally the Contractor shall provide separate clean earth as required. The Contractor shall liase and co-ordinate closely with System wide Contractors to select the most suitable locations around the station and other tunnel structures to locate earth electrodes.

E09.3.2.2 For each test electrode, one principal earth conductor above the finished floor screed will be provided by the Contractor. Bolted bimetallic links similar to those described in Clause E09.3.2.1 above shall be provided at the top of the principal conductor above the finished floor screed. The link shall be labelled “Test Electrode Connection”.

The physical arrangement of the links and their connections shall be such as to protect them against possible mechanical damage

E09.3.2.3 From the Main Earthing Point/Terminal, a main earth conductor system shall be provided. The main earth conductor system, which consists of two vertical rising main conductors with tee-off main conductors in each level of the building, shall be supplied and installed by the Contractor.

E09.3.2.3 The vertical rising main conductors and tee-off main conductors shall be GI tape conductors of size as shown on the Drawings.

E09.3.2.4 The tee-off main conductors of the main earth network shall be routed close to all plant rooms provided with main earth terminals at each level of the building. The tee-off main conductors shall be connected to the two vertical rising main conductors at each level of the building to form a closed ring network. Sub tee-off earth conductors shall be connected from the tee-off main conductors to the earth terminals provided in the plant rooms. The sub tee-off earth conductors and earth terminals of sizes as shown on the Drawings shall be provided by the Contractor. The sub tee-off earth conductors and earth terminals shall be hard drawn GI tapes.

E09.3.2.5 All joints and connections for the main earth network including vertical rising main conductors, tee-off main conductors and sub tee-off earth conductors shall be either welded or brazed connections. All joints of dissimilar metal shall be of special made

E09.3.2.6 Separate earth bus shall be provided for Neutral Earthing in the Auxiliary Substations.

E09.3.2.7 Main Earth in Signalling and Telecom Rooms: Apart from clean earths, one earth point shall also be provided from the “Main-Earth” bus in each of the Signalling & Telecom equipment rooms, Station Control room (SCR) and UPS / Battery room at the station and Control centre. This shall be used as the chassis earth. The value of this earth should not be more than 1.0 Ohm at any location and under any climatic condition.

Contractor shall provide the earthing pits for clean earths & main earth and shall connect them up to the earthing terminals inside the rooms as above. Signalling and Telecomm contractor shall set up earthing ring bus inside the rooms.

E09.3.2.7 Earth GI strip should be hot galvanized as per BS 729.

E09.3.3 Main Equi-potential Bonding Conductor

E09.3.3.1 Unless otherwise specified, main equipotential bonding conductors shall be of copper. Aluminium or copper clad aluminium conductors shall not be used for bonding connections.

E09.3.3.2 Bonding wires shall be not less than 2.5 mm^2 in cross section and the insulation shall be coloured green/yellow.

E09.3.3.3 Main equipotential bonding conductors shall connect the extraneous conductive parts ofother services within the premises to the main earthing terminal of the installation. Such extraneous conductive parts shall include main water and gas pipes, other service pipes and risers and exposed metallic parts of the building structure liable to transmit a potential. Connections shall be made as near as practicable to the point of entry of the non-electrical services into the premises concerned, and shall be on the installation side of the possible breaks in the system, such as gas meter or water meter.

E09.3.3.4 Each item of equipment shall be fitted with an earthing stud to which the framework of the cubicle shall be bonded. When cubicles form composite equipment such as a switchboard these studs shall be connected by a earthing bar.

E09.3.3.5 Bonding conductors shall be rated to carry the prospective fault currents for 3 second and to limit potential differences under fault conditions to safe levels taking into account the expected duration of any fault.

E09.3.3.6 The main equipotential bonding conductors shall be securely and reliably connected to extraneous conductive parts of the non-electrical services by means of a copper connector-clamp of an approved type suitable for the particular applications. All contact surfaces shall be clean and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

E09.3.3.7 Running joints shall be either welded or brazed such that the resistance of a short section containing the joint shall be not greater than that of a similar length of unjointed conductor. The Engineer may require any joint to be tested to prove compliance with this requirement. All joints shall be applied with protective paint finish to prevent oxidation.

E09.3.3.8 No drilling of the earth bar shall be permitted except in termination. Joints and connections to the earth system shall be so affected as to avoid undue reduction of the current carrying capacity. Precautions shall be taken to ensure that available contact area is fully utilised in all connections to plant and equipment. The contact faces of earth terminals shall be cleaned before connections are made to the earth system. The bar shall be tinned before being clamped to the earth stud. Joints to

the switchboards and sub-switchboards may be by bolts and the area of contact shall be large and the joints shall be tight.

E09.3.3.9 Earth conductors shall be flat copper strip of high conductivity. Fixing to buildings shall be by means of copper or brass clamps with brass screws and non-fibrous wall plugs. Conductors fixed in visible locations shall be run only in vertical and horizontal directions. Changes of direction in the plan of the conductors shall be by right-angled joints. Folding of the conductor shall not be permitted

E09.3.3.10 Particular care shall be taken on cable termination boxes to ensure that the cable sheath and armour is adequately bonded to the frame of the item of plant to which the cable is connected. If the earth continuity through the cable termination gland is inadequate then a special copper connection shall be made between the equipment and the cable sheath and armour.

E09.3.4 Earthingand Protective Conductor.

E09.3.5 Protective Conductors for Electrical Apparatus

E09.3.5.1 All metal parts including pipe work and cable trays, other than those forming parts of any electrical circuit, shall be effectively connected in an approved manner onto the earth system.

E09.3.5.2 All switch/distribution boards shall be earthed using earth strip to the main earth network, which shall also be used by other Contractors for earthing their equipment as generally shown on the earthing arrangement drawing. All necessary earth strips to join to the main network shall be included during preparation of Working Drawings.

E09.3.5.3 All doors shall be bonded to the cubicle framework by means of multi-stranded flexible wire. Such connections shall not obstruct the movement of doors or be stressed by the operation of the door.

E09.3.5.4 All withdrawable devices such as circuit breakers and relays shall have provision for positive earthing of the frame of the device before any plug in a main or auxiliary electrical circuit connects to the device. The clearances must be maintained between fixed conductors and conductors on the withdrawable device until the earthing connection is made.

E09.3.5.5 At each switchboard position , ***A***squared tape of Suitable sizeas per fault level shall be fitted to bond together the armouring of cables, cases of switchgear and frame of switchboard.

E09.3.5.6 All tape joints shall be sweated and bolted with GI bolts, nut and washers. Where the earth tape is bonded to any item of equipment, the tape shall be tinned and clamped (with brass bolts, nuts and washers) to bright metal smeared with a proprietary jointing compound.

E09.3.5.7 Joints shall be made so as to ensure a low resistance to earth.

E09.3.5.8 Where moulded case circuit breakers are protecting sub-main armoured cables and regulation 543 of the 16th Edition IEE Regulations is not fulfilled, an additional

single core earth conductor sized in accordance with table 54G shall be incorporated to form the return path.

E09.3.5.9 All sub-main and final sub-circuits utilising single core cables shall incorporate separate earth protective conductors hence conduit / trunking shall not solely form the earth return. Earth protective conductors shall be sized in accordance with table 54G of the 16th Edition IEE Regulations.

E09.3.5.10 Low voltage switchboards and MCCs shall be connected to the earth system by two conductors of not less than 400 mm2 cross-sectional area at both ends of the switchboards and MCCs.

E09.3.5.11 Earth connections for all items of equipment shall be made between the equipment and the distribution board feeding it.

E09.3.5.12 Where conductors could come into contact with metalwork at or near earth potential they shall either be bonded solidly or shall be insulated to withstand an alternating potential difference of 500 V R.M.S.

E09.3.5.13 All equipment, plant or pipe work, to be earthed shall be connected to the main earth conductor by subsidiary GI conductors in accordance with the following table:-

Apparatus	**Conductor**	
	No. Of Conductors Minimum	**Size (mm 2) (As per fault Level)**
415 V motor casing (5-15 kW)	2	-
415 V motor casing (over 15 kW)	2	-
Control panel (Single)	2	-
Distribution boards and other Equipment or plant (over 15 kW)	2	-
Distribution boards and other Equipment or plant (15 kW or less)	2	-

E09.3.5.14 All connections between earth conductors and equipment or plant shall be by bolts or studs so arranged that the resistance between the equipment or plant and the earth conductor should not exceed 0.1 ohms.

E09.3.5.15 No earth stud or bolt shall have a cross-sectional area at the base of the threads less than 15mm2.

E09.3.6 Supplementary Bonding Conductor

E09.3.6.1 Unless otherwise specified, supplementary bonding conductors shall be of copper. All sinks, wastes and all plumbing connections to sanitary equipment shall be bonded to earth by means of 6-mm2 cables.

E09.3.6.2 All ceiling space equipment shall be bonded in agreed positions and final bond taken to the local sub distribution board earth.

E09.3.7 Circuit Protective Conductor

E09.3.7.1 Circuit protective conductors (CPC) may be formed by a separate conductor/cable, the metallic sheath or armour of a cable, part of the same cable as the associated live conductor, rigid steel conduits or the metal enclosure of the wiring system. Flexible conduits and the exposed conductive parts of equipment shall not form part of the circuit protective conductors.

E09.3.7.2 For every socket outlet, a separate circuit protective conductor shall be provided connecting the earth terminal of the socket outlet and that inside the enclosure accommodating the socket outlet.

E09.3.7.3 For every length of flexible conduit, a separate circuit protective conductor shall be provided inside the conduit to ensure the earth continuity of the installation between the two ends of the flexible conduit.

E09.3.7.4 A copper tape of minimum 25 x 3 mm in cross section shall be provided for the entire length of a busway. The copper tape shall be bonded to the busway at intervals not exceeding 3 m and at the position of each tap-off point.

E09.3.7.5 The circuit protective conductor of every ring final circuit shall also be run in the form of a ring having both ends connected to the earth terminal at the origin of the circuit.

E09.3.8 **Earthing Mats**

E09.3.8.1 Earthing mats shall comprise of copper earthing rods or copper tapes driven or buried into the ground to a suitable depth. The actual number of earthing rods or copper tapes shall be determined during working drawing stage, depending on the measured resistivity of the soil on site to achieve an earth resistance of not greater than 0.5 ohm for the clean earth and not greater than 1.0 ohm for the main earth. The copper rod earth electrode shall be directly driven in ground in addition to mat earth electrode & connected to the main mat earth as shown in the drawing.

E09.3.9 Earth Pits and Earth Electrodes

E09.3.9.1 The earthing system within each station shall be connected to the earth mats via the Main earth bar. There shall be liaison with other Contractors to determine the best place to locate earth electrodes/pits.

E09.3.9.2 The earthing electrodes for equipment enclosures, electrical neutrals shall be separate and distinctly located within the station area from the lightning protection. The corresponding earthing bus bars shall be visually distinct and separately

identifiable. Earth bus bars shall be located so as to permit access for testing, maintenance and replacement.

E09.3.10 Plate Earthing Station

E09.3.9.1 To be used for earth pits at above ground areas and ancillary building.

E09.3.9.2 The plate earth electrode shall be 600 mm x 600 mm x 6 mm copper plate. The earth resistance shall be maintained with a suitable soil treatment & watering arrangement as per drawings or as directed at site. Excavated soft soil be thoroughly mixed with 6% by weight of common salt with 10% by weight of water and alternate layers with powdered coke shall be provided.

E09.3.9.3 The resistance of each earth station should not be more than 5 ohms.

E09.3.9.4 The earth lead shall be connected to the earth plate through copper/brass bolts as per approved working drawing.

E09.3.11 Earth Station With Copper Rod

BY CIVIL CONTRACTOR

E09.3.12 Clean Earth Conductor

BY CIVIL CONTRACTOR

E09.3.13 Not Used.

E09.3.14 Platform Design

E09.3.14.1 On station platforms all electrical and mechanical equipment that is fixed to the platform shall be kept a distance of 2.5 m or greater away from trains. An insulating membrane shall be inserted within 2.5 m of the edge of the platform to insulate it from earth (to avoid excessive touch potentials).

E09.3.14.2 Platform earths shall be connected to the main earth bar.

E09.3.15 Earthing of Electrical Services

E09.3.15.1 Incoming services to the stations in metal pipes shall be fitted with isolating joints as close as possible to the point of entry. Pipes and or armours of incoming services shall be bonded to the station's earthing system at the nearest earth bar with earthing cables or tapes on the station side of joints.

E09.3.15.2 The enclosures of all transformers and switchgear shall be earthed directly to the main earth by two independent connections.

E09.3.15.3 The star point of the standby generator shall be solidly connected to the main earth network. This earth connection shall comprise of two, separately routed GI strips/conductors.

E09.3.15.4 All frames and enclosures of AC switchboards shall be earthed directly to the main earth. Low voltage switchboards shall have two independent connections.

E09.3.15.5 The enclosures of all lighting and power panel boards shall be earthed in accordance with BS 7473.

E09.3.15.6 The metallic sheaths and armouring of all multi-cored LV cables shall be directly earthed at both ends.

E09.3.16 Earthing of Fences

E09.3.16.1 Fences shall be separately earthed from other earthing systems each side of a gate or other opening in a fence. A buried GI jumper shall bond any gate or other opening in a fence across. The resistance to earth shall not exceed 0.5 ohms.

E09.3.16.2 Fences shall be earthed at or near the location of a supply line or lines crossing them, and, additionally, at distances not exceeding 50m either side.

E09.3.17 Earthing Cable Colour Identification

E09.3.17.1 All cables used as protective conductors, including earthing conductors, main equipotential bonding conductors, supplementary bonding conductors and circuit protective conductors shall be identified by the colour combination "green and yellow". Such colour combination shall not be used for other identification purposes.

E09.3.18 Labels for Earthing and Bonding

E09.3.18.1 Equipotential bonding conductors shall be labelled “NOT CONNECTED TO EARTH” where electrical separation has taken place.

E09.3.18.2 Labels shall be fitted at the point of bonding. All bonding cables connected to the main earth terminal bar shall be identified within the earth terminal enclosure.

E09.3.18.3 Metal labels shall be fixed to all types of bonding conductor stating “Safety Electrical Connection – Do Not Remove”.

E09.3.19 Testing

E09.3.19.1 The Contractor shall be responsible for providing all necessary test equipment and consumables to complete the required tests satisfactorily. He shall at his own cost rectify and retest any installation which fails its test. Load testing or any other functional test that the Employer may require is to be conducted at no extra cost.

E09.3.19.2 Tests shall be carried out as follows:

Test shall be conducted at each station, when the ground has been excavated to the depth at which the earth rods shall be installed, prior to the commencement of the detail design to obtain the soil resistivity data,

The resistance to earth of each electrode,

The quality of metal joints (conductor tests),

Each earth termination network shall have a measured resistance no greater than its design value,

Additional earth pits or conductors shall be provided, if necessary, to achieve the required value of resistance.

E09.3.19.3 Soil resistivity tests within each site at each proposed earth mat location in accordance with BS 7430 shall be carried out by civil contractor when excavation

of the station reaches the level at which the earth rods shall be driven. Based on the soil resistivity results obtained, the preparation of working drawings will be undertaken and construction carried out accordingly.

E09.3.19.4 Earth fault loop impedance tests shall also be carried out at regular intervals and results maintained.

E09.3.19.5 Testing of earthing system shall be carried out on completion and regularly thereafter and results recorded in order that any trend towards increasing resistance can be noted and necessary action can be planned.

E09.3.19.6 The tests shall be carried out with the test link (s) located at the earth lead termination points removed, but only for so long as it takes to carry out the test. The earth mats at each location shall be tested separately and at least one earth mat shall always be connected to the earthing system during tests.

E09.3.19.7 On completion of the earthing installation the earth fault loop impedance shall be tested in accordance with BS 7671. The results shall be presented for Approval.

E09.3.20 Additional Earthing Requirements for Signalling and Telecommunication systems

E09.3.20.1 The following out door installations are required to be earthed:

i) Metallic sheath & armouring of all main S & T cables at regular intervals.

ii) Location Boxes.

iii) Signal posts and screens.

iv) AFTC tuning units.

v) Any other installation as may be necessary to cover complete scope of works under S & T Contractor.

An Earth bus shall be provided all along the wall of the tunnel. This Earth bus of adequate size shall be separate from the Main Electrical Earth & shall run on the side of the tunnel wall .The earth bus shall be so designed so as to give an earth resistance of not more than ***One Ohm*** under dry condition. The earth bus shall be connected to a minimum of two earth pits, one on each side of the tunnel. If necessary, the additional earth pits may be made in the Tunnel X-passages. The earthing shall use Cu-electrodes in order to reduce corrosion & the maintenance efforts in the underground section. All the line side CATC installation including the line side signals shall use this earthing bus.

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E10 LIGHTNING PROTECTION

E10.1 General

This Section specifies the manufacture and installation of a complete lightning protection system for above ground structures of an Underground Stations of Jaipur Metro. The general routing of the air termination network and the locations of the earth electrodes shall be as indicated on the Drawings. The contractor shall carry out preparation of Working Drawings, Supply, Installation, Functional Testing and Handover of a working Lightning Protection System.

E10.2 Standards

E10.2.1 Relevant Codes and Standards

E10.2.1.1 Design and provision of the whole of the lightning protection system shall be in accordance with the following standards:

BS 6651 /**IS 2309 :**Code of Practice for Protection of Structures against Lightning.

BS 7430: Code of Practice for Earthing.

BS 7671: Wiring regulations for Electrical Installation.

E10.3 Technical and Installation Requirements

E10.3.1 General Requirements

E10.3.1.1 A lightning protection system shall be provided to protect the following:

- Above-ground structures from a direct lightning strike,
- The equipment located within the zone of protection,
- Personnel working within the zone of protection.

E10.3.1.2 A lightning protection system shall be installed at all above ground stations, ancillary buildings and structures as specified.

E10.3.1.3 The lightning protection system shall convey lightning discharges to ground without electrification of the structure. It shall be designed in accordance with the recommendations of BS 6651 /**IS 2309**.

E10.3.1.4 The complete lightning protection system shall consist of a network of air terminals at roof level, interconnected by horizontal tapes. The whole air-termination system shall be connected to down conductors, which shall preferably run outside of the building. The down conductors shall be bonded to a number of dedicated earth electrodes, which do not make contact with any part of the structures or buildings. The bond should be mechanically and electrically effective and protected from corrosion in and erosion by the operating environment.

E10.3.1.5 Any protrusion from the sides of a structure, which may obstruct the vertical path of the down conductor, shall be sleeved to allow the down conductor to pass through.

E10.3.1.6 Lightning conductors for the protection of structures and buildings shall not be electrically connected to any metallic part of the structure or building and shall be connected to a dedicated earth electrode, which does not make contact with any part of the structures or buildings.

E10.3.1.7 Routing of conductors of Lightning Protection System should be such that the side flashing be avoided (BS 6651/**IS 2309** for clearance distance between lightning protection system and locally exposed metalwork). Side flashing with earthed structural members should also be avoided by suitable measures as mentioned in BS 6651 /**IS 2309**.

E10.3.1.8 The lightning protection system shall conform to BS 6651/**IS 2309** and shall consist of the following principal component parts:

(a) Air terminations,

(b) Down conductors,

(c) Joints and bonds,

(d) Test joints,

(e) Earth terminations, and

(f) Earth electrodes.

E10.3.2 Air Termination

E10.3.2.1 An air termination shall consist of vertical conductors, horizontal conductors or a system of vertical and horizontal conductors.

E10.3.2.2 For larger horizontal dimensions, the outer perimeter and the flat roof shall be covered by an air termination network mesh with conductor separation of 10 m and 20 m in two directions, so that no part of the roof shall be more than 5 m from the nearest horizontal conductor. All salient points of the roof structure shall be incorporated in the air termination network. All metallic projections, ducts, vent pipes, railings, gutters, etc., on or above the main surface of the roof of the structure, shall be fixed to, and form part of, the air termination network. Horizontal conductors shall be fixed to the roof structure at regular intervals of not more than 1 m by means of suitable spacer saddles.

E10.3.2.3 Air terminals shall be of multiple pointed types consisting of tinned copper rods having an overall length of not less than 450 mm and diameter of 12.5 mm. The air terminals shall be widely spaced on the highest points of the structure and mounted on a gunmetal base plate. The air terminals shall be directly connected to the roof GI tape air termination network. The GI tape for air termination network shall be made of soft, high conductivity copper having a cross section area of 25 mm by 3 mm.

E10.3.2.4 Roof tape shall take the most direct route between the air terminals and be secured with non-ferrous fasteners spaced on horizontal runs.

E10.3.2.5 Radioactive air terminals will not be allowed in the protection system.

E10.3.3 Down Conductor

E10.3.3.1 Unless otherwise specified, down conductors shall be of ABS / XLPE sheathed 32x5 mm GI strips.

E10.3.3.2 Down conductors shall be fixed on the external walls at regular intervals of not exceeding 1 m apart by means of heavy gauge non-ferrous spacer saddles. They shall follow the most direct possible path between the air termination and the earth termination with the minimum number of bends between the air termination system and the earth electrodes. Bends shall be gradual and not less than 200mm radius. Sharp bends in the down conductors at the edge of roofs will be permitted. However, re-entrant loops in a conductor can produce high inductive voltage drops, which could lead to the lightning discharge jumping across the side of the loop. To minimise this problem the length of the down conductor forming the loop shall not exceed eight times the width of the open side of the loop.

E10.3.3.3 The number of down conductors to be installed shall depend on the building base area or the building perimeter. At least two down conductors shall be installed. The number of down conductors shall be one for each 20 m or part thereof of the perimeter at roof level or ground level, whichever is the greater. For building over 20 m high, one per 10 m or part thereof shall be provided.

E10.3.3.4 Down conductors (a conductor connecting an air terminal with an earth terminal) or connecting wires of lightning electrodes to lightning earth electrodes shall be at least 1.5 m away from any power, control or communication cables.

E10.3.3.5 The Down Conductor shall be connected directly via Test Link to a 20 mm diameter, 3m long electrodes directly driven to Earth. The Electrode shall be placed at a distance of 1500mm from the building. Down conductors shall not be connected to other earthing conductors above Ground level.

E10.3.3.6 The down lightning conductor shall be connected to main earthing terminal through a main eqipotential bond. Two tined GI tapes shall be connected from the nearest two down conductors (above the test points) to the principal main earth terminals. The two insulated GI tapes shall be arranged to run on two separate routes to the principal main earth terminals as direct as possible. Each GI tape shall have minimum cross sectional area of 75 Sq. mm.

E10.3.3.7 Each down conductor shall be complete with test joint and connection to an earth termination.

E10.3.3.8 The use of coaxial cables as down conductors shall not be allowed.

E10.3.3.9 The down conductors shall be symmetrically installed around the outside walls of the structure starting at the corners. Routing to avoid side flashing shall be given particular consideration while preparing working drawings and during installation.

E10.3.3.10 Down conductors shall be bonded to metalwork, which encroaches on the isolation distance as defined in BS6651/**IS 2309**

E10.3.3.11 Reinforcing bars used as part of the structure shall not be used as down conductors. Where the insulated down conductors are proposed to be concealed within the concrete structure, the installation method shall be approved by the Employer's Representative / Engineer.

E10.3.4 Test Joint

E10.3.4.1 Test joints shall be of phosphor bronze, gunmetal or copper and shall be installed in each down conductor not less than 2000 mm above ground level, designed to enable continuity and earth resistance measurements to be made. They shall comprise a heavy circular base, to which a heavy circular cover of the same material shall be bolted. The flat GI conductor shall be overlapped and placed so that they are clamped between the cover by means of at least four screws or studs.

E10.3.4.2 No connections, other than one direct to earth electrodes shall be made below a testing point.

E10.3.5 Earth Termination

E10.3.5.1 The earth electrodes for Lightning Protection shall be made of either copper or copper clad low carbon steel rods, the steel having a high tensile strength of approximately 600N/mm^2 grade 43A of BS EN 10137 /**BS EN 10025**. The copper

shall be of 99.9% pure electrolytic copper molecularly bonded to the steel core, and having a thickness not less than 0.25mm.

E10.3.5.2 The earthing clamp body shall be of silicon aluminium bronze construction, having a phosphor bronze screw for securing the tape to the earth electrode.

E10.3.5.3 The whole assembly shall have a strong resistance to corrosion.

E10.3.5.4 Each earth termination shall have a resistance to earth not exceeding the product given by 0.5 ohms times the number of earth termination to be provided. The whole of the lightning protective system shall have a combined resistance to earth not exceeding 0.5 ohms. Where it is difficult, due to local conditions to obtain a value of less than 0.5 ohms by the sole use of rod electrodes, alternative or additional methods, e.g. the installation of tape or plate electrodes may be used subject to review by the Engineer.

E10.3.6 Spacer Saddle

E10.3.6.1 Spacer saddles shall be of high quality metal. For GI conductors, brass or gunmetal shall be used. For aluminium conductors, pressing or casting aluminium alloys shall be used.

E10.3.6.2 Non-metallic spacer saddles shall only be used when down conductors are provided with non-metallic sheathing.

E10.3.7 Joints in Conductors

E10.3.7.1 Joints in roof conductors and/or down conductors shall be made by brazing. When clamps are used, the tape clamps shall each be provided with at least 4 screws or bolts. All such joints shall be tinned and shall have negligible resistance and good mechanical strength.

E10.3.7.2 Alternatively, connectors may be jointed together by means of exothermic or thermit welding utilizing the high temperature reaction of powdered copper oxide and aluminium, provided that the proper material and equipment are used in accordance with the manufacturer's recommended process.

E10.3.8 Testing

E10.3.8.1 The Contractor shall be responsible for providing all necessary test equipment and consumables to complete the required tests satisfactorily. He shall at his own cost rectify and retest any installation which fails its test. Load testing or any other functional test that the Engineer may require, shall be done.

E10.3.8.2 The Contractor shall carry out tests to demonstrate to the Engineer that the combined resistance to earth of the earth electrodes is not greater than 0.5 ohms.

E10.3.8.3 The complete lightning protection system shall be checked for correct installation methods including the fixing and mechanical strength of:

- Air terminal,
- Connecting tapes,

- Down conductors,
- Test links.

E10.3.8.4 The earth terminations, joints and bonding throughout the system shall be thoroughly examined for secured termination and welding.

E10.3.8.5 An electrical continuity test shall be carried out on the whole system after completion of the work.

E10.3.8.6 The method of testing the lighting protection system shall comply with BS 7430 and BS 6651 /**BS 62305-1**.

E11. UNINTERRUPTIBLE POWER SUPPLY

1 Detailed Description and Application in DMRC

1.1 This section specifies the manufacture, supply, testing, installation and commissioning of Uninterruptible Power Supply System, hereafter referred to as UPS. The UPS system shall consist of the UPS unit, Input and Output switch gear and Battery. The UPS systems shall maintain a continuous AC Power supply to the loads classified as of Emergency category loads for the Metro station in all possible power failure scenario.

1.2 The UPS, Battery and Input/output power supply switchgear are in the scope of different vendors and comes in the category of Vendor approval for the Contractor.

1.3 A metro station is either elevated/on ground or underground. Emergency loads at a station are as follows:

(a) About 25% of the Lighting load.
(b) X Ray/Baggage scanning machine.
(c) Lighting and control load of Lift & Escalator
(d) Platform Edge door
(e) Fire Alarm control panel
(f) Door frame metal detector

1.4 A separate room is identified to house the UPS.

1.5 The UPS system in general shall consist of the following

(a) Input/ Output power supply panel (for underground stations).
(a) Rectifier/Charger.
(b) Battery System.
(c) Battery Circuit Breaker.
(d) Inverter.
(e) Static Bypass Switch.
(f) Built In / External Manual Bypass Switch.
(g) Control Units and Interconnections between different UPS Elements.
(h) Data logger, Digital Display and annunciation.

This is only for guidance and may vary with technological advancements.

2. Governing Specifications

2.1 The UPS and its system constituent shall comply with the governing specification, as given in the table below:

UPS	
Specification for Uninterruptible power systems (UPS)	IEC 62040 – 1,2 and 3 or latest
Surge Protective Devices EMC - Immunity EMC - Emission Electromagnetic compatibility Testing and Measurement Techniques	IEC 61643-1 or latest EN 61000-4-3 or latest IEC 61000-3-2/ 61000-3-3 or latest IEC 61000-4 or latest
Sound Level of Noise Source	ISO 3746-2010 or latest
Flammability Tests	IEC 60695-11-20 or latest
Radio frequency interference (RFI) levels	BS 55014-1 or latest
Degree of Protection provided by Enclosures	IEC 60529, EN 60529
Valve Regulated Sealed Lead Acid Rechargeable Single Cells	BS 6290, BS 60896
Low Voltage Switchgear and Panels	
Low-voltage Switchgear and Control gear Assemblies	IEC 61439 or latest IEC 60947 or latest
IEE Wiring Regulations	BS 7671 or latest
Code of practice for Earthing	BS 7430 or latest

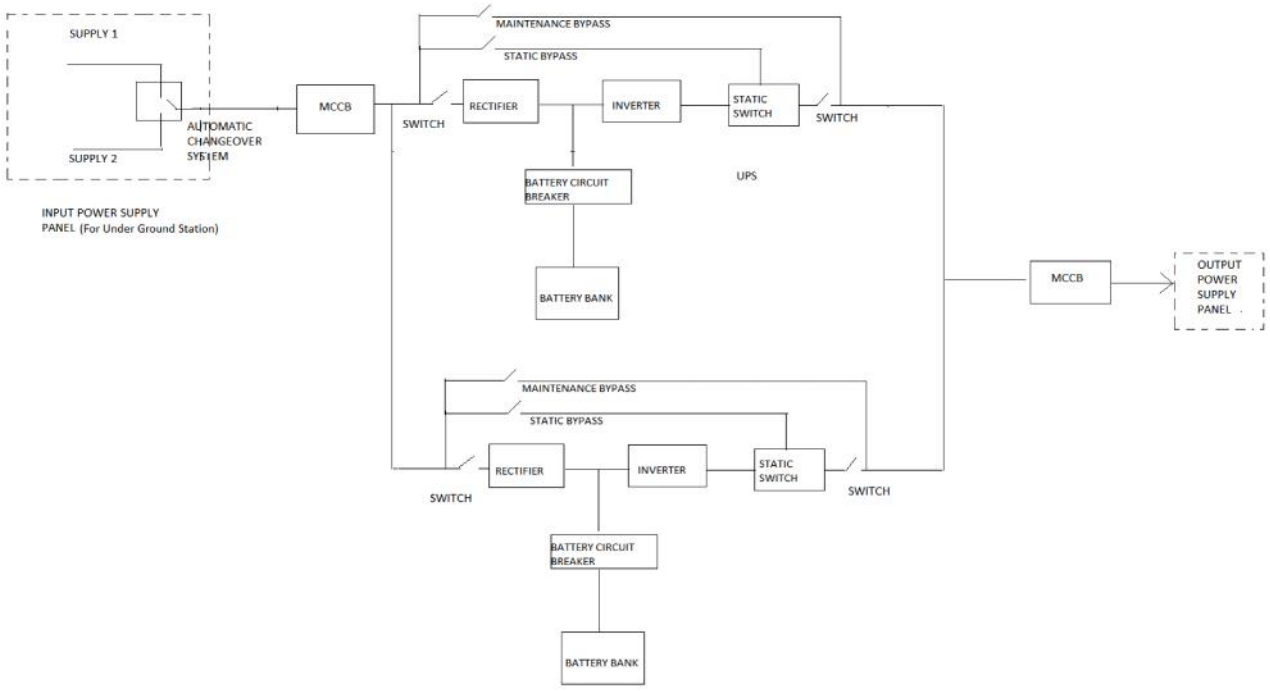
3. Requirements

3.1 Functional Requirements

3.1.1 UPS

3.1.1.1 Features: The UPS shall be a true parallel redundant,(Clause 3.1.35 of IEC 62040-3) Double Conversion (Clause 3.2.16 of IEC 62040-3)(VFI technology Online type.) and shall configure to A.3.2.2 of the IEC 62040-3 as Parallel Redundant with bypass. The

UPS system shall consist of the components as defined under clause 3.1 of IEC 62040-3 and the basic configuration of each UPS shall be as shown below:-



GENERAL BLOCK DIAGRAM OF UPS SYSTEM

The loads are generally linear to clause 3.2.6 of IEC 62040-3 but shall cater to non-linear loads to clause 3.2.7 of IEC 62040-3. UPS shall be compatible to take non-linear loads and capable to handle high crest load. The UPS shall be suitable for taking unbalanced load vide clause 3.5.22 of IEC 62040-3. UPS shall be provided with input power factor correction features.

3.1.1.2 Capacity: The capacity of the UPS shall be as per the BOQ. However, in general the ratings of UPS standardized for Delhi Metro applications are 20 kVA, 30 kVA, 60 kVA and 80 kVA.

3.1.1.3 Modes of Operation

The UPS shall operate in the following modes:-

3.1.1.3.1Normal Mode (Mains Up) Clause No. 3.2.13 of IEC 62040-3

3.1.1.3.2 Stored Energy Mode (Mains Down) Clause 3.2.14 of IEC 62040-33.1.1.3.3Battery Recharge (Mains Restored)

(a) When mains supply is restored from failure or restored via automatic supply changeover switch, the rectifier / charger shall resume the supply of DC power to the Inverter and batteries. During this period, no interruption or disturbance shall be caused to the inverter output.

(b) When the battery system is fully charged, the rectifier / charger shall automatically adjust the output voltage to float charge the battery system.

3.1.1.3.4 Automatic By-pass Mode (Static By-pass Switch)

as defined vide clause 3.2.15 of IEC 62040-3 and also as following:

(a) In the event of overloads exceeding system capabilities (short-circuits, heavy inrush current or battery capacity being exhausted upon rectifier / charger supply down) or the detection of internal faults, the static by-pass switch shall instantaneously synchronize with the inverter output and transfer the loads to the bypass supply source without load interruption.

(b) Retransfer of the load to the UPS shall be accomplished, after the restoration and stabilization of the output power modules to the specified tolerances, without disturbance to the load.

In both these transfers, UPS output voltage and frequency tolerances must remain within the specified limits.

3.1.1.3.5 Built In / Manual By-pass mode(Maintenance)

as defined vide clause 3.2.15 of IEC 62040-3 and also as following:

The independent manual bypass switch shall be manually operated to perform, make-before-break switching of the UPS load to either the UPS or the Mains supply source without load interruption, for UPS maintenance purposes. On UPS load being connected to by-pass supply, full access to the UPS input / output equipment shall be possible.

3.1.1.3.6Maintenance of Batteries

For maintenance purposes, it shall be possible to isolate the battery system from the rectifier / charger and the Inverter by means of a circuit breaker. In such a case, the UPS shall continue to supply the load as specified herein, except in the event of mains supply outage.

3.1.2 Sub components of UPS system

3.1.2.1 Automatic Supply Changeover System (For UG stations)

Automatic Supply Changeover / Transfer System shall be provided in underground stations, with break-before-make switches. It shall switch the UPS to one of the two mains supply sources. When the selected mains supply source fails, the supply changeover unit shall automatically switch the rectifier / charger to the other mains supply source following a preset delay period.

3.1.2.2 Rectifier/Charger

The input of the rectifier / charger shall be protected by a circuit breaker with adjustable settings. A walk-in circuit shall be provided at the rectifier / charger input to eliminate sudden inrush current from the mains supply or changeover of supply

source. The current walk-in shall take place to allow a gradual increase in the loading in the mains supply source.

3.1.2.2.1 The UPS shall have IGBT rectifiers to remove harmonics. The converter should be solid state PWM converter with IGBT rectifiers. The converter should have the following important features.

a) Power Conversion

b) Battery Charging

c) Power Factor Improvement

d) Current Harmonic Reduction

e) Voltage Regulation

f) Transient Recovery

g) Automatic Synchronization

h) Over-current Protection

i) Over Temperature Protection

j) Control Power Failure Protection

k) Short Circuit Protection

l) Current limiting function of battery charging to prevent the battery from being damaged.

3.1.2.2.2 The rectifier / battery charger shall provide a regulated DC output for the inverter and the battery. The rectifier/charger regulation shall ensure that the DC output voltage fluctuations are less than 1% of rated value, irrespective of load and mains supply voltage variations.

3.1.2.2.3 The rectifier / charger shall be equipped with a filter limiting the DC ripple voltage to a value less than 1% of the DC voltage.

3.1.2.2.4 The rectifier / charger shall have sufficient capacity to enable simultaneous supplying of full load to the inverter and recharging a fully discharged battery to 100% rated value within 10 hours.

3.1.2.2.5 A protective circuit shall be provided to prevent battery overcharge. After the rectifier / charger has recharged the battery to 100% capacity, the rectifier / charger shall float charge the battery.

3.1.2.2.6 Provision shall be made to prevent the battery from over-charging due to battery charger rectifier fault. An adjustable battery current limiting device shall limit the battery recharge current to the maximum value recommended by the battery manufacturer. The rectifier/charger shall be electronically current limited to protect the connections to the Inverter input and to prevent damage to the battery.

3.1.2.2.7 The battery low-volt cut-off shall be set to suit the battery manufacturer's recommendation to ensure the battery is not damaged by a deep

discharge.**3.1.2.2.8** The rectifier/charger unit shall be equipped with an over-voltage protection device.

3.1.2.3 Inverter

The inverter shall be a solid state device with proven Pulse Width Modulation technique utilizing Insulated Gate Bipolar Transistors and microprocessor controls, capable of accepting the output of the rectifier / charger or the battery system and provide a 3-phase alternating current output complying with the performance requirements.

3.1.2.3.1 The inverter shall utilize the latest and reliable technology to achieve high efficiency and reliability, and to cope with non-linear loads. The inverter should incorporate following essential features:

a) Voltage Regulation
b) Transient Recovery
c) Automatic Synchronization
d) Over-current Protection
e) Over Temperature Protection
f) Short Circuit Power Protection
g) High Speed switching
h) Frequency Control
i) Inverter Output voltage Harmonic distortion
j) Inverter Overload protection
k) Each inverter leg shall be protected from over-current to prevent damage to the solid-state devices in the inverter bridges.

3.1.2.3.2 The inverter output shall be electronically current limited.**3.1.2.3.3** The inverter shall be protected against over voltage and under voltage surges introduced at the output of the uninterruptible supply system by load switching and transfer to the bypass. If the bypass AC line deviates by more than 50 Hz ± 3%, the inverter logic shall automatically revert to 50 Hz ± 1 Hz and initiate an alarm condition The time taken to recover from transient to normal voltage shall not be more than 20 milliseconds.

3.1.2.4 Automatic Static Bypass Switch

3.1.2.4.1 The UPS shall be provided with a static by-pass switch(make before break type) which is synchronized with the UPS. In the case of inverter failure, sub-circuit failure, load start-up inrush or battery capacity being exhausted upon rectifier / charger supply down, the static bypass switch shall transfer the load to the mains automatically within 4 milli-seconds. The UPS shall withstand the switching transient or fault energy produced during operation of the static bypass switch

parallels two different supply sources. Full protection discrimination shall be achieved on the bypass circuit. In case of a single sub-circuit fault, the capacity of the static by-pass switch shall withstand the fault energy until the protective device of the sub-circuit clear the fault. The continuous capacity of the Static bypass switch shall be equal to the 100% continuous rating of the inverter. The overload capacity shall be equivalent to the overload characteristics of the UPS. The current handling capacity of switch shall be 10 times for 20 milliseconds. **3.1.2.4.2** The means of operation shall ensure an uninterrupted transfer of load to or from the by-pass supply source under both automatic and manual mode of operation.

3.1.2.4.3 Transfer conditions

The static bypass switch shall transfer from the inverter to the by-pass supply source under the following conditions:

(1) Inverter under voltage (less than 90 % of nominal),
(2) Inverter over voltage (greater than 110 % of nominal),
(3) Inverter overload,
(4) Inverter shut down for any reason (including failure)
(5) Manual signal.
(6) DC circuit under voltage or over voltage.
(7) Final end voltage of the system battery is reached.

At the same time, the inverter output shall be isolated to prevent the bypass supply source from back feeding power to the inverter.

3.1.2.4.4 Retransfer to Inverter

The static by-pass switch shall be capable of automatically retransferring the load back to the Inverter after the Inverter has returned to normal voltage and stabilized for a period of time or the overload due to short-circuit or high inrush current has disappeared. The system shall only retransfer the load to the inverter provided all the following conditions are met:

(1) The inverter and the bypass supply source are synchronized.
(2) Inverter voltage is within ± 5% of nominal for 2 to 30 seconds (adjustable).
(3) Manual transfer signal off.
(4) The overload current disappears within 1 to 10 minutes (adjustable).

3.1.2.5 Independent Manual By-Pass Switch

A manually operated mechanical manual bypass switch shall be provided for the for maintenance on UPS and battery. The transfer scheme shall be make-before-break uninterrupted transfer of the load from the static bypass switch output to the manual bypass supply source or vice versa. The switching arrangement shall be designed to electrically isolate the UPS from the distribution board. The current switching capacity of the manual bypass switch shall be at least four times the UPS

rated output current. Key interlock between manual bypass switch and the inverter switch shall be provided such that the inverter output cannot be changed over with the manual bypass supply source directly. In addition, the manual bypass switch shall be pad-lockable.

3.1.2.6 Battery System

For specifications and requirements, refer to the battery specifications DMES-E-0003

3.2 Environmental conditions

All equipment shall be capable of withstanding any combination of the following external environmental conditions without any mechanical or electrical damage or degradation / deterioration in performance:

(1) Operating ambient temperature: 0^{o}C to 40^{o}C

(2) Relative humidity: Up to 95 %

(3) Storage temperature 0^{0} C to 50^{0} C

(4) Operating altitude: As per IEC 62040-3.

The equipment shall be designed to provide rated output at the extreme environmental conditions specified above.

3.3 Performance requirements

3.3.1. Input Parameters

(a) Input Voltage**:-** 415 V (AC) / 240 V (AC) (As per requirement). Each with input voltage tolerance of (–10% to + 10%).

(b) Wiring**:-** 3-phase, 4 wire and earth for Three Phase input/ Single phase and Neutral for Single Phase input.

(c) Input Frequency**:-** 50 Hz ± 5%

(d) Input Power Factor**:-** The total power factor of UPS as a load shall be from 0.99 lagging to unity, with rated load, fully charged battery, and input voltage within (–10% to + 10%)of the nominal value.

(e) Harmonics on Input Voltage**:-**Input voltage distortion factor shall not exceed 0.08 and harmonic components shall not exceed values given in IEC 62040-3, Clause 5.2.1 d

(f) Reflected Input Current Harmonics:- The rms value of all harmonics in the input current waveform contributed by UPS shall be less than 5%.

(g) Current Limiting:-The system shall be provided with inrush current limiting to 125% of the rated UPS load current

3.3.2 Output Parameters

(a) Rated voltage: 415 / 240V, 3 Phase 4 wire / single phase respectively.

(b) Steady state voltage regulation: ± 1% for a load between 0 and 100% of full rated value, irrespective of value of the normal mains supply voltage and DC voltage, provided these voltages are within the limits specified.

(c) Transient voltage regulation*:* Should be less than 3%.

(e) Output Voltage harmonic distortion: An output filter to be provided to limit total distortion to less than 5% with no single harmonic greater than 3%, irrespective of load and normal mains supply, provided these are within the limits specified.

(f) Steady state voltage unbalance (difference between phase voltage and the arithmetic average of the three phase voltage): ±1% maximum for balance load, ± 3% maximum for 50% unbalance load.

(g) Phase displacement: 120°±½° for balanced load; 120°±1° for 50% unbalanced load.

(h) The output voltage shall not dip more than 20% in case of any fault on the load side of UPS.

(i) Output Frequency shall be as following:-

(1) Rated frequency: 50 Hz.

(2) In normal operation, the output frequency of the inverter shall be synchronized to that of the bypass supply source within the limits of 3% (settable)

(3) For frequency variations exceeding these limits, the inverter shall switch over to free-running mode, with regulation, providing an output frequency to within 1 Hz of the rated value without switching to batteries.

(4) Frequency slew rate: 2Hz/second maximum.

(j) Load Current Crest Factor: A crest factor up to 3:1 for the load current shall be anticipated.

(k) Load Unbalance Capacity:-The UPS shall have the capability to accept up to 50% load unbalance with the ratio of current in the most loaded phase to the current in the least loaded phase not exceeding 2, provided that the most loaded phase current does not exceed the rated line current.

(l) Overload Capability :-The UPS shall be able to supply 110% for 60 minutes, 125% rated load for at least 10 minutes and 150% rated load for at least 1 minute

(m) Output power factor:- 0.9 and above.

3.3.3 Noise Level

Noise emanating from the UPS during operation shall not exceed

(a) 70 dBA for 80 kVA UPS

(b) 65 dBA for 60 kVA & 30 kVA UPS

(c) 55 dBA for 20 kVA and below UPS

at a distance of 1.5 m from the enclosure, over a load range of 10% to 100% of the rated full load and measured as per the standard.

It should be possible to change the internal parameters of the UPS(initially set by the manufacturer) in order to vary the output parameters, if required.

The UPS shall automatically analyze the condition of the battery string on a programmable period. It shall detect and enunciate the battery failure condition locally and remotely. The periodic test shall not impair the battery readiness in case of normal supply outage.

4. Additional Requirements

4.1 Diagnostics

4.1.1 The UPS shall be fitted with a Microprocessor based Supervision and Diagnostic System, which monitors all aspects of the UPS operation. The system shall aid in the rapid identification of internal faults.

4.1.2 UPS shall be provided with RS 485 compatibility for remote monitoring and to extend alarm & status indications, annunciation and metering to BMS System located in Station Control Room. It shall be provided to communicate with an external computer for remote monitoring and diagnostics. The communication protocol shall be clearly documented and submitted for approval by the Engineer. Contractor must interface with the BMS Contractor regarding this

4.1.3 All the necessary software and accessories shall be provided at the Station for the monitoring and diagnostics of the UPS via the RS 485 data interface.

4.2 Display

4.2.1 All the modules and accessories shall be integral part of the main cubical and provide controls, metering & monitoring system and self-fault diagnostic / annunciation system for healthy/faulty status, data logger with suitable display and power monitoring software for operational status locally. The UPS shall be fitted with an integral control and indication panel.

4.3 Instrumentation

The UPS shall be provided with, digital instrumentation to indicate, as a minimum, the following information. All readings shall have an accuracy of at least ± 0.5% of true value and the settling time shall be less than 1 second. If certain meter is used to display more than one parameter, a manual selector switch shall be provided for reading selection.

(a) True RMS voltage

(1) UPS input voltage with phase selection,

(2) Rectifier output voltage,

(3) DC battery voltage, and

(4) UPS output voltage with phase selection.

(b) True RMS current (crest factor – 3:1)

(1) UPS input current with phase selection,

(2) DC battery charge/discharge currents,

(3) UPS output current with phase selection, and

(4) By-pass source current with phase selection.

(c) Frequency

(1) Mains frequency, and

(2) UPS output frequency.

(d) Power (kW)

(1) UPS output power with phase selection.

(e) Power Factor

(1) Inverter output power factor

(f) Elapsed operating time.

4.4 Indications and alarms

(a) The UPS shall include a mimic diagram with suitable display indication for the UPS equipment status and audible and visual alarm alerting annunciation. The status indication and alarm annunciation with the associated protection and control circuits shall include, but not be limited to, the following status and alarms.

Equipment Status Alarms

UPS Input Voltage

UPS Output Voltage

Dual Supply, Healthy Status

Rectifier/Charger

- Rectifier Normal/Failure
- Rectifier Failure
- Boost / Float Charge

Battery

- Battery Charging / Discharging
- Circuit Breaker Open
- Battery Test Run
- Battery Discharging
- Battery Low Voltage

- Battery Earth Fault
- Battery Test Fail
- DC Over voltage

Inverter

- Inverter Normal/Failure
- Inverter Failure
- Inverter Overloaded
- Output over voltage / under voltage.

Static By-pass

- By-pass Normal / Failure
- Load on Inverter / Bypass
- By-pass Failure
- Synchronous Failure
- Static switch on manual

Manual Bypass

- Load on UPS / Bypass
- Manual Bypass Off / On
- Transfer Inhibited

Ventilation

- Fan Normal / Failure, or
- Over temperature alarm / shutdown (two stages)
- Fan Failure, or
- Over temperature alarm (adjustable)
- Over temperature shutdown (adjustable)

Emergency Pushbutton

- UPS On/Emergency Shutdown
- Emergency Shut Down with protective cover.

Common Alarm

- Alarm triggered - Common Alarm

Also, the following control should be present:

(h) Alarm test/reset push buttons

(ii) Lamp test/reset push buttons,

(iii) Alarm silence push button.

(b) There should be an alarm upon the occurrence of any faults or failures as mentioned above, along with an indication at the remote BMS panel. Audible and visual annunciation shall be activated at the indication panel when an alarm has occurred. Such annunciation shall be latched on alarm occurrence and shall be such that it can only be cleared by pressing a manual reset button.

(c) The alarm state indications on mimic diagram shall remain until a manual reset switch is operated and the alarm state has been cleared.

(d) Remote monitoring status:- The following critical status and alarms of UPS shall report to Station Building Management System (BMS) controller for remote monitoring via volt-free contacts rated 24 V DC, 1A provided in the UPS modules:

(i) Supply A normal / failure

(ii) Supply B normal / failure

(iii) Load on inverter / bypass

(iv) Battery charging / discharging

(v) Manual bypass off / on

(vi) UPS (rectifier / charger / inverter / bypass switches) common alarm

(vii) Battery common alarm

(viii) Fan normal / failure or Over temperature alarm / shutdown

(ix) UPS on / emergency shutdown.

(e) Remote Control:-There will be no remote control for the UPS except Emergency shutdown push buttons in readily accessible locations, fitted with non-lockable covers or shrouds.

(f) There should be a system of communication provided with the UPS for transferring the battery run test and inverter failure data to mobile telephone of OCC in the elevated stations and through BMS in underground stations.

5. Safety

5.1 UPS shall be designed for low impedance, less than 50V touch voltage and limited ripple content. Two independent and distinct earth connections shall be provided for earthing of UPS connections comprising 50 x 4 mm Copper strips / 50 x 6 mm GI strips or as required / approved. Surge protective devices shall be provided at the inputs and output of the UPS to protect the UPS and the load equipment against any power surge due to lightning, switching, etc

The UPS system shall be equipped with an interlocking system to prevent parallel operation of any non-synchronized sources activated either by any manual switches or automatic switches.

The UPS output shall be supplied via means of isolation with suitable protection, sufficient to supply the full rated output load.

The module shall be designed such that if there is a single fan failure or over temperature, an alarm shall sound, but it will in no way produce degradation of performance. In case of unavoidable shutdown due to excessive temperature rise, a warning alarm shall be given out before the shutdown.

All cabinets shall be solidly bonded to earth in accordance with BS 7430(or latest) using adequate section of cable or bus bar. The earth connection at the cabinets/enclosures shall be made to the frame earth provided or alternatively to a substantial part of the basic frame rather than a bolted - on panel.

5.2 Circuit Protection

Means of isolation with suitable protection shall be provided at both input and output within the UPS, which fully discriminate with upstream and downstream circuit breakers. The system shall be provided with component protection, to minimize damage and downtime in the event of component failure, against:

a) AC Supply voltage transients and transfers.
b) Internal faults.
c) Sustained overload.
d) Load switching transients.
e) Current surges.

The system shall be provided with interlocks to prevent accidental damage to the UPS during maintenance or normal operation.

5.3 UPS system shall be designed with protection & annunciation system for monitoring the following:

1. Phase sequence.
2. Overload and short circuit trip.
3. Earth fault.
4. Reverse Power Flow.
5. Low battery voltage.
6. Fault indication alarm through suitably designed hooter.
7. Self-diagnostic annunciation system.
8. Ventilation Failure
9. Temperature monitoring

The manufacturer shall provide the scheme of operation of various protective devices for the above mentioned conditions.

5.4 Emissions in case of fire

The equipment shall produce low smoke and no toxic emissions in case of internal or external fire/over-heating.

The equipment shall not have any component which bursts with smoke or toxic emission. The AC and DC capacitors used shall have over pressure safety device or disconnector.

Cables, wires & insulating materials used, shall be fire retardant, low smoke and zero halogen material.

6. System efficiency

The efficiency of the proposed UPS shall be at least 90% and above from 25% load to full load. The life and efficiency is of prime importance. The manufacture may offer UPS with any new proven technology having advantage of life and energy efficiency without compromising on other parameters of specification.

7. Reliability, maintenance, spares & life

7.1 The system shall have high operating efficiency, front access and self-diagnostic features. There shall be sufficient redundancy in all vital parts to achieve a breakdown free operation of the system. The reliability shall be greater than 99.9%. The manufacturer shall provide data confirming to the required reliability.

7.2 The UPS shall be designed for maintenance free working. The conditioning monitoring system through sensing of all parameters of working equipments shall be designed to take care of incipient faults to undertake any unscheduled repairs without causing consequential damages.

7.3 Equipment shall be designed and manufactured in modular manner to facilitate the fault diagnosis and replacement of each modular part. Each module shall be capable of being interchanged with other modules of the same type without affecting the rest of modules in place

7.4 The service life of the UPS system shall be at least 20 years. The manufacturer shall submit the list of those items whose life does not match with the service life of UPS. The life of such spares shall be advised with a certificate from the manufacturer of the spares. The firm shall provide purchase specification of these items.

7.5 The manufacturer shall submit a list of all the spare parts with price list to be kept after the expiry of defect liability period.

7.6 The vendor shall provide the Annual Maintenance cost of UPS system (including batteries) for their full service life, in blocks of 5 years or year wise.

8. Material and manufacturing

8.1 **Quality Assurance and Controls** The Contractor's Management Systems shall emphasize quality assurance and controls. The programme shall be adequate to

ensure an acceptable level of quality of the equipment supplied. The concept of total quality assurance shall be based on the principle that quality is a basic responsibility of the Contractor's organization, and shall be visible by:

(a) Firm procurement and job performance specifications.
(b) Firm procedures for transmission of information and data to their Subcontractors and ensuring their compliance.
(c) Adequate testing to ensure repetitive product conformity to design requirements and Total programme of surveillance and verification of physical performance and configuration accountability.
(d) Adequate records shall be kept by the Contractor to provide evidence of quality and accountability. These records shall include results of inspections, tests, process controls, certification of processes and personnel, discrepant material, and other quality control requirements.
(e) Complaint handling and commitment towards customer satisfaction.

8.2 ISO certifications to which the quality standards are complied

8.3 Materials and Workmanship Requirements

All materials and processes to be used, whether incorporated in equipment at the manufacturer's works or used for installation at site, shall comply with the requirements of this M&W Specification and shall conform to good modern practice. The following requirements shall be the minimum requirements and they shall not relieve the Supplier from ensuring that his designs are fit for purpose, and that all materials and processes are suited to their intended purposes and environments.

The basic workmanship and manufacturing principles shall be visible during visual inspection such as no sharp corners, sizing of screws/bolts, cable layout and identification, bedding and rubbing of parts, clearances, user friendly switches and indication panel etc.

All equipment and components supplied under the Contract shall have proven reliability and shall be designed, manufactured and installed to meet the specified and / or relevant international or national standards. The Contractor shall submit to the Engineer for approval, a list of all supplied equipment and components with a declaration of conformance to standards.

The manufacture shall supply information about the bill of material used in the manufacturing of the product if the Engineer so desire to satisfy himself about the use of quality material.

8.4 Mounting and Enclosure

UPS shall be free standing and mounted as a whole on a heavy duty fabricated steel base frame constructed from folded channel sections with suitable mounting

pads. All air entries shall be protected with cleanable filters. The cabinets shall be vermin and dust proof with IP 20 degree protection.

8.4.2 The Cabinet shall be constructed with material of thickness 1.6 mm for non-load bearing members and 2.5 mm for load bearing members and suitably braced to form a rigid structure. Full substantiation of mechanical strength shall be provided for approval to demonstrate that the cabinet is free from distortion when equipment is mounted and support on floor. All metallic cabinets shall have treatment for corrosion protection and painted with epoxy polyester paint.

8.4.3 The dimensions of the cabinets shall be optimally sized without requiring excessive floor space.

8.4.4 The equipment shall be constructed in modular units, which shall be installed in metal enclosures designed for floor mounting. Each module shall be constructed on a rigid base frame. Sub-assemblies and components shall be mounted on pull out and/or swing out trays. Cable connections to the cable ladder and trays shall be of sufficient length to allow for easy access to all components.

8.4.5 The UPS cabinet shall have a clear area of at least 900 mm in front to allow the doors to be opened fully and maintenance to take place. Doors shall be fitted with lockable handles or other approved means of fastening and shall be provided with locking bars and guides to prevent distortion. Cabinet shall be arranged so that access doors or panels into compartment can only be opened when the locking device is in the unlocked position. Two sets of keys shall be provided for each lock.

8.4.6 Each Cabinet shall be fitted with metallic gland plates for entry of cables and an earth terminal. Foundation bolts and lifting hooks or eyes shall be provided as necessary for handling purposes.

8.4.7 It shall be fitted internally with a nameplate, which shall state the manufacturer's name, address, telephone and e-mail address, serial number, rating and year of supply.

8.4.8 Danger warning notices with red letters on a white background shall be fitted to covers, which give access to live terminals or conductors at and above 110 volts. The danger board should be provided as per Indian Electricity Rules.

8.4.9 Circuit and function labels shall be provided. All labels shall be in one language as approved by Engineer. All switches or control unit provided for operation by Operating Staff shall be labeled with prominent display by letter size of minimum 6 mm.

8.4.10 The modules shall be designed to be transported in a horizontal and/or vertical mode as may be necessary to enable installation of the modules in the positions designated on Site.

8.4.11 Each of the items shall be adequately packed and protected against damage in transit from the manufacturer's work area to the Site. Similarly, after delivery to

Site, each cubicle shall be properly protected from damage until work is completed.

8.4.12 The mechanical and electrical design of all cabinets shall be submitted for approval by the Engineer.

8.4.13 Each cubicle shall be fitted with a designation label to show voltage rating and duty on the front and rear of the cubicle.

8.4.14 Each cubicle shall be provided a space for keeping operating manual along with other documents related to the UPS with suitable labeling.

8.5 Electronic Components and Sub-Assemblies

8.5.1 Each plug-in module or printed circuit board shall be securely plugged into the main unit with guiding construct to hold the module in place. Printed edge connector shall not be used.

8.5.2 Printed circuit boards shall have sufficient thickness to ensure its mechanical rigidity and to eliminate the risk of damage during installation and maintenance. Dip switches shall be avoided as far as possible. Jumper wire is not allowed.

8.5.3 Printed circuit boards shall be designed and manufactured to the accepted standards, which shall include standards for conductor thickness, width and spacing. Different standards shall be applied to equipment operated under different conditions if applicable.

8.5.4 All plug-in modules shall be clearly and unmistakably identified. Labeling with module name, part number, serial number and revision number shall be provided.

8.5.5 LED shall be provided with each plug-in module or printed circuit board to indicate the power supply and component fault status. They shall be easily visible without any obstructions.

8.5.6 The rated voltage of insulated terminal blocks shall be 415 V between terminals, 240 V to earth. Insulated terminal blocks shall comprise brass tubular connectors with screw connections contained within a moulded block suitable for working temperature up to 100°C.

8.5.7 Terminals shall be designed to clamp the conductor between metal surfaces with sufficient contact pressure but without causing damage to the conductor. With the largest recommended conductor in position, and tightly clamped, there shall be at least two full thread pitches of the screw engaging in the connector.

8.5.8 All materials and parts comprising the module system shall be new and of current manufacture of a high grade and free from all known defects and imperfections.

8.5.9 All active electronic devices shall be solid state. All semi-conductor devices shall be hermetically sealed. Vacuum tubes shall not be used for any purposes.

8.5.10 Terminals shall be supplied suitable for the cables being used to make the power connections. Terminals shall be provided for connecting the remote alarm contacts.

8.5.11 All power semi-conductors shall be fused in a manner to prevent cascaded or sequential semi-conductor failures. Indicator lamps denoting blown fuse conditions shall be located such as to be readily observable without removing panels or opening of the cabinet doors.

8.5.12 Isolating switches shall be of the load type with ON/OFF indication and lock attachment. Critical isolating switches essential for continuity of the load power shall be pad-lockable.

8.5.13 Contactors if any shall have Contactor coils suitable for use on direct current. Rectifiers shall be of the selenium type and terminals shall be provided to external control of the contactors on the AC side of the rectifier.

8.5.14 Relays shall be housed in dust tight enclosures.

8.6 Electrical Works and Accessories

All electrical equipment in the UPS, including MCCB, MCB, cable connector, trunking, conduit and other electrical accessories, shall comply with, the sections and clauses of the M & W Specifications, relevant to these items. All the cables and wires used must be of Low Smoke Zero halogen type.

9. Testing & Commissioning

9.1 The manufacturer of the UPS must have type test certificates from an accredited/reputed third party, for all the tests specified in IEC 62040 – 3 and shall not be more than five years old.

9.2 In case these are not available, manufacturer shall arrange to get these tests executed in their factory as per clause 6.6 in presence of third party NABL certified body. The DMRC official may call for repeat of all or some of the tests during factory acceptance test.

9.3 Manufacturer will be required to carry out the routine and optional tests as specified in IEC 62040 – 3.

9.4 The UPS shall be thoroughly checked for correct operation and load tested in supplier works before dispatch. All faults created for check on satisfactory function of protection system, control functions, workmanship and site load conditions shall be simulated, checked and proved.

The equipment shall be dispatched after testing in presence of authorized representative of purchaser.

9.4 The manufacture representative shall be available at the time of commissioning and testing of UPS at site. The manufacture shall issue a certificate to the affect that the UPS has been installed and commissioned as per his approved scheme for the purpose.

10.0 Training:

10.1 The contractor shall ensure training of DMRC staff as decided by DMRC at DMRC workplace or at his workplace as considered necessary. Training booklet along with audio-visual presentation shall be supplied to each trainee.

10.2 The contractor shall supply Handing over bound booklet consisting of the details of the UPS, operating manual, extracts of the warrant/DLP, details of service center, list of staff trained on the said design of the UPS, training material booklet or any other item considered necessary by the purchaser. The first page of the booklet shall be signed by the manufacture, contractor and DMRC Engineer.

11 Battery System

11.1.1 Storage battery banks shall be provided for the UPS with sufficient ampere-hour capacity to maintain the UPS output at the rated output capacity for not less than the duration of 30 minutes.

11.1.2 The overall capacity of the battery system shall be such as to meet the specified performance and technical requirements throughout the life of the battery. The battery capacity shall be designed for long life with uniform charging and discharging rates. In calculating the battery capacity, an ageing de-rating factor, advised by the supplier, shall be taken into account. This factor shall not be more than 0.8. Battery sizing calculations shall assume an ambient temperature of up to

40^0Cand room temp. of 25°C. The battery cell shall be of heavy duty, rechargeable, valve regulated lead acid and maintenance-free type and the performance shall comply with latest amendment of relevant code or IEC 60896-21&22 having an intended design life of at least 20 years.

11.1.3 The battery bank shall be protected from internal fault by a circuit breaker. The UPS shall be automatically disconnected from the battery bank when the discharge limits of volts per cell are reached, or when signaled by other control functions. The battery circuit breaker installed at the battery room should be complete with a metal enclosure conforming to an Ingress Protection Classification of IP 54.

The battery shall be supplied with:

(a) Inter-cell connectors and terminals which shall be of high conductivity and shall be enclosed with insulated corrosion-free material.

(b) A mild steel rack for shelving the batteries. The rack shall be designed to provide easy access to all components for maintenance and to minimize floor space requirements.

(c) Special tools and fittings required to assemble the batteries.

(d) Battery storage cabinets or racks shall be insulated from the floor to achieve the electrical insulation for a minimum voltage of 5 kV.

11.1.4 Temperature monitoring equipment shall be incorporated in the UPS system to optimise the charger voltage as a function of battery room temperature, to generate alarm in case of room temperature exceeding the preset permissible temperature and to predict the battery backup time.

11.1.5 The rectifier/charger shall follow recommendation of battery manufacturer for battery recharge. It shall also be equipped with facilities to carry out in-situ tests for battery (full and partial) discharge.

11.1.6 ***Not Used***

11.1.7 The cells shall be housed in containers of approved material of ample strength with flame retardant self extinguishing characteristics to IEC 60707 rating FV0 and of sufficient depth to prevent possible short circuit of the plates by the deposition of any sediments.

11.1.8 The battery shall have sufficient capacity and discharge characteristic to meet the requirement listed. The battery shall be suitable for the following charging duties:

A fully discharged battery shall be charged to 75 % of its rated capacity within 8 hours under float charge conditions.

A fully discharged battery shall be charged to 100 % of its rated capacity within 14 hours under boost charge conditions.

11.1.9 ***The battery shall be contained within the opaque container with impact resistant and flame retardant properties.Thecells being arranged in tiers to***

enable a rapid visual check. Terminal shall be shrouded to prevent accidental contacts. The battery enclosure shall be corrosion resistant and ventinated.

11.1.10 The standard battery operating temperature shall be of 25 °C. When the ambient air temperature exceeds 25 °C, the charging voltage shall be reduced to prevent overcharge and increased, as the temperature falls, to avoid undercharge.

11.11.1 ***Not Used***

11.1.12 The battery stand shall be constructed to give maximum support to the cells.

11.2 Battery Circuit Breaker

11.2.1 Batteries shall be mounted on racks to allow access to all terminals. In reaching the terminals, maintenance staff shall not be required to stretch unduly over other batteries, with the risk of shorting battery terminals. A localized battery circuit breaker shall be provided for each battery bank.

E12. MOTORS

E12.1 General

E12.1.1 This Section specifies the manufacture and installation of motors.

E12.1.2 Unless otherwise specified or approved, all motors shall be of the totally enclosed fan-cooled type with Class F insulation to BS 4999 and BS 2757/BS 60085 or IEC 60034-5, impregnated with non-hygroscopic oil-resistant insulating varnish. Motors for fire services pumps shall be of class F insulation and of IP 55 construction. Insulation materials shall be suitable for the climatic conditions available in Jaipur. Particulars of all motors shall be submitted for approval.

E12.1.3 Motors shall be adequately rated to meet the service demands of associated driven units under all conditions and as limited by electrical and mechanical protective devices. The cooling fan of the motor shall be of aluminumor as per manufacturer standard and protected by a metal fan cover.

E12.1.4 Motors powered by AC shall comply with BS 4999 and BS 5000: Part 99 and shall be of squirrel cage, induction type. Voltage for motors shall be 415V 3-phase or 240V 1-phase, as required. Motors rated 0.37kW and larger shall be rated 415V, 3-phase, 50Hz. Motors rated smaller than 0.37 kW shall be operated at 240V 1-phase. Direct-on-line motor starters shall be used for motors up to and including 3.75 kW at 415 volts, 3 phase. All motors over this limit shall be equipped with reduced voltage starters of the star delta type.

E12.1.5 The starting current shall not exceed 6 times of the full load current when direct-on-line starting at full voltage is applied.

E12.1.6 All motors shall be capable of accelerating the driven plant from standstill to rated speed with a terminal voltage of 80% of the nominal supply voltage at 50Hz in less than 4 seconds. All motors shall be capable of operating continuously or, for short-time rated motors, for the duration of the short-time period, at rated torque at any supply voltage between 90% and 110% of the nominal supply voltage at any frequency between 48Hz and 52Hz. They shall be capable of delivering the rated torque when running at 70% of the nominal voltage for a period of 10 seconds without injurious overheating and under these conditions the slip shall not exceed 10%.

E12.1.7 Vertically mounted motor shafts shall be supported by approved thrust bearings.

E12.1.8 All bare steel internal parts except bearings shall be painted unless otherwise protected against corrosion.

E12.1.9 Motors shall be designed for low shaft current and shall have adequate provision to prevent bearing damage by shaft current.

E12.1.10 Anti-condensation heaters shall be provided for motors, which are to operate on non-regular basis or being exposed to high humidity environment. The heaters shall be terminated in a robust terminal box electrically and mechanically separate from any other terminal boxes. The anti-condensation heater terminal box shall be

fitted with an undrilled gland plate suitable for conduit termination or cable entry. Heaters shall be single phase. Heater circuits shall have an indicating lamp on corresponding motor control panel. Heaters shall be turned off automatically when the motors are operating.

E12.1.11 An auxiliary marshalling box, electrically and mechanically separated from the power supply terminal boxes, shall be securely mounted on the motor frame for marshalling all small wiring for motor control or monitoring.

E12.1.12 For axial fans, external copper grease leads shall be provided for lubrication of motor bearings unless totally sealed bearings are used.

E12.1.13 The maximum motor efficiency shall be at the normal operating condition. Motors in all cases shall be entirely suitable for the duty intended. A margin of not less than 5% for compressors, 15% for fans and 10% for water pumps shall be provided for equipment over the continuous rating of the motor (without over-loading) under the normal operating condition unless otherwise specified. The motor efficiency at normal condition shall be greater than 85% for motor rating below 15kW and 90% for motor rating of 15 kW and above ormotor efficiency shall be as per manufacturer's design .

E12.1.14 The power factor of motors shall not be less than 0.85 lagging at the operating condition. Otherwise suitable power factor correction facilities shall be provided to improve the power factor.

E12.1.15 All steel works, supporting brackets and members, which are required for the pump motor installation, shall be hot-dipped galvanized to BS 729 or equivalent Indian Standard. Motors shall be factory-painted to the appropriate finish.

E12.1.16 Unless otherwise specified in this M&W Specification, in normal ambient conditions bearings shall be designed for 50,000 hours operating service (L10 life, Anti-Friction Bearing Manufacturer's Association) and provided with a grease outlet connection for in service lubrication. Grease fittings shall be brought to outside of fan housing and provided with covers, which shall effectively exclude water and dirt.

E12.1.17 Motor terminals shall preferably be of the stud type, totally enclosed both from atmosphere and from the motor winding and be fully insulated from the frame. Rubber insulation shall not be used for connections between the windings and the terminals.

E12.1.18 Each motor terminal box shall be fitted with sealing chamber, conduit gland or adaptor plate, as required, together with the necessary fittings to suit the cable entry. Terminal markings and rating plates shall be in accordance with BS 4999. The terminal box shall be large enough for the specified cable sizes of the respective motor.

E12.2 Standards

E12.2.1 Reference Codes and Standards

E12.2.1.1 BS 729: Hot Dip Galvanized Coatings on Iron and Steel Articles

E12.2.1.2 BS 2757: Method for Determining the Thermal Classification of Electrical Insulation

BS 60085: Electrical insulation. Thermal evaluation and designation

E12.2.1.3 BS 4999: General Requirements for Rotating Electrical Machines

E12.2.1.4 BS 5000: Rotating Electrical Machines of Particular Types or for Particular Applications

E12.2.1.5 BS EN 60034-9: Rotating Electrical Machines Part 9: Noise Limits

E12.3 Technical and Installation Requirements

E12.3.1 Noise level shall meet BS EN 60034-9 or IEC 60034-9.

E12.3.2 The degree of protection of the motors shall conform to IP55 defined in BS 4999: Part 20 with the following additional requirements:

E12.3.2.1 Motor frames shall be steel or aluminium alloy for motors inside station areas as appropriate. (As per manufacturer Design)

E12.3.2.2 Motor frames shall be of Die cast Aluminium for motors in tunnels and Ancillary Buildings.

E12.3.2.3 Earthing terminal shall be provided.

E12.3.2.4 Unless otherwise specified, red oxide zinc chromate primer with two finish coats of grey paint shall be painted.

E12.3.2.5 All motors shall be squirrel type and shall be suitable for DOL or reduced voltage starting as specified on the Equipment Schedules and/or Drawings.

E12.3.3 Termination boxes of adequate size shall be die cast aluminium alloy or cast iron diagonally split type and suitably gasketed to prevent ingress of moisture and dirt with the following additional requirements:

E12.3.3.1 Rotatable in any of the four 90^{o} positions;

E12.3.3.2 Threaded holes suitable for mounting brass cable glands;

E12.3.3.3 Stud type terminals for terminating electric cables as specified; and

E12.3.3.4 Internal wiring connections to the main terminal boxes and auxiliary marshalling boxes.

E12.3.4 Bearings shall be double shields and have the following additional requirements:

E12.3.4.1 Ball or roller bearings with grease fittings and minimum pressure relief fittings for in service lubrication.

E12.3.4.2 Guide and thrust bearings for vertical motor drive units shall be subject to Approval.

E12.3.5 Lifting eyes shall be provided for motors with a weight of 20kg and above.

E12.3.6 Tests shall be carried out before shipment to demonstrate that the equipment complies fully with specified requirements. Test certificates shall be provided for approval.

E12.3.7 Type tests certificates for tests, as defined in BS 5000: Part 99, be provided for first motor of each type and rating supplied. For motors of the same type having different ratings but identical in all essential details, test certificates for motors with the highest rating shall be supplied. In case type test from accredited third party laboratory are not available, the same may be required to be carried out.

E12.3.8 If tests to determine the starting current are under-taken at reduced voltage, due allowance shall be made for the effects of saturation and the estimated value of starting current at full voltage shall be stated on all test certificates.

E12.3.9 Installation

E12.3.9.1 Motors shall be installed as required by the driven equipment.

E12.3.9.2 Lifting equipment shall be provided for the installation of motors.

E12.3.9.3 Any additional steel works, supporting brackets and members which are required for the motors installation shall be provided by the Contractor at no extra cost to the Employer.

E12.3.9.4 The frames and supports shall be accurately set and levelled.

E12.3.9.5 Each motor shall be provided with an emergency stop push button in the immediate vicinity of the associated motor drive at the approved location. For outdoor installation, all emergency stop push buttons shall be of weatherproof type.

E12.3.9.6 All moving or rotating parts of motors, which can be accessed by personnel, shall be properly covered by steel wire mesh guards.

E13.SANDWITCHED TYPE LT BUS DUCT AND LIGHTING BUS TRUNKING

E.13.1 SANDWICH TYPE LT BUSDUCT

LT Bus Duct (Sandwitched type) shall be provided between LV Terminals of transformer and LT Main incomer panels . LT Bus Duct shall be of Copper Conductor, 5000A, 70 kA short Circuit rating and *IP - 65* enclosure for 3150/3500 kVA transformers.

Contractor shall submit the Bus Bar Sizing calculation (Considering temperature correction if any), verification of the structural strength.Voltage drop calculation and short-circuit calculation for LT Bus Duct . Class of Insulation shall be 'F' ($155^{O}C$).

Temperature rise at any point in the bus duct shall not exceed $55^{O}C$ over ambient temperature of $50^{O}C$. LT Bus Duct shall comply with Latest edition of IEC-61439

SCOPE

This specification is intended for design, manufacture, testing, transporting to site of 4l5V, 3 phase, 50 Hz compact sandwich type Copper conductor LT Bus Trunking Systems, suitable for Indoor / outdoor installation

The equipment shall be of type tested design at CPRI / Independent test house for short circuit, temperature rise and dielectric tests of the ratings required as per BOQ or manufacture shall have facility of conducting these tests at their works

E.13.1.1 CODES AND STANDARDS

The equipment specified in the specification shall be designed, manufactured and tested in accordance with latest relevant British standards or IEC codes. In the event of any contradiction between this specification and IS/IEC codes then the more stringent of the two shall govern.

lEC 61439 (part-I)	:Low-voltage switchgear and control gear assemblies:Part-1 General Rules
lEC 61439 (Part-2)	:Low-voltage switchgear and control gear assemblies:Part-2 Power switchgear and control gear assemblies
lEC 60529	:Degree of protection provided by enclosures.

IEC 61439 :Low-voltage switchgear and control gear assemblies: (Part-6)Busbartrunkingsystems (busways)

lEC 529 : Degree of protection provided by enclosures.

E.13.1.2 DESIGN AND CONSTRUCTION REQUIREMENTS

GENERAL

415 V, 3 phase, 50 Hz, self cooled, sandwitch construction Copper bus duct as per the specific requirements shall be supplied. Quantities specified are indicative only. The same are subjected to change during detailed engineering.

E.13.1.3 BUSBARS

E.13.1.3.1 Bus bar shall be of high conductivity copper of 99.9% pure ETP grade.

E.13.1.3.2 Rating of bus bar shall be as specified in drawings / schedule of quantities.

E.13.1.3.3 Each bus bar shall be individually insulated with multilayer of insulating film or by means of epoxy insulation or better to give minimum class F insulation.

E.13.1.3.4 Each bus bar shall be jointed to the adjacent section by single bolt-joint clamps without drilling the bus bar. Joint between two sections shall be such that complete sub assembly is removable so that isolation of individual sections is possible without disturbing only sections. The joints shall be of one bolt type which utilizes a high strength steel bolt and washers to maintain proper pressure over a large contact surface area. The bolt shall be torque indicating and at earth potential, it shall be two headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.

E.13.1.3.5 Access shall be required to only one side of the bus bar trunking for tightening joint bolts. Flexible connections shall be provided by multi leafed conductors for termination.

E.13.1.4 ENCLOSURE

E.13.1.4.1 Ingress protection for the enclosures shall be**IP54** for Indoor Bus Duct & Rising Mains and Min IP65 (with canopy) for outdoor Bus Duct & Rising Mains.

E.13.1.4.2 The enclosure of Bus Duct system and Rising Mains shall be fabricated from 1.6mm thick CRCA sheet steel/GI/Extruded AL and shall be provided with a finish of RAL 7032 Grey Epoxy Paint or as approved by Engineer-in-charge. Firm should provide Certificate of Flame propagation/ Fire proofing.

E.13.1.4.3 The Bus Trunking System shall be manufactured in convenient (not exceeding 3m in length) section to facilitate easy transportation and installation. The sections shall be connectable to form vertical or horizontal runs as required. Each section shall be provided with suitable support arrangement from walls / ceilings as required.

E.13.1.4.4 Expansion joints may be provided as per manufacturer's design and recommendation.

E.13.1.4.5 The internal earthing shall be of 50% copper run along the length of Bus Duct.

E.13.1.4.6 End covers shall be provided as required.

E.13.1.4.7 Neutral shall have same cross-section as phases.

E.13.1.5 GROUNDING

E.13.1.5.1 Two separately run of ***GI*** flat of ***calculated / appropriate size*** or as specified shall be run externally along the length of the bus duct as earth bus.

E.13.1.5.2 All parts of the bus enclosure, supporting structures and equipment frames shall be bonded to the ground bus.

E.13.1.6 NAME PLATE

E.13.1.6.1 Suitable name plate shall be provided for each piece equipment as required for easy identification of bus duct.

E.13.1.6.2 Material of the name plate shall be ***Metallic***, 3mm thick or approved equivalent. Letters shall be white on black background or as approved.

E.13.1.7 PAINT FINISH

E.13.1.7.1 RAL 7032 Grey Epoxy Paint or as approved by Engineer-in-charge.

E.13.1.8 ACCESSORIES

Bus trunking system shall be complete with all accessories like bends, busduct, expansion joints, flexible connections etc. to suit site requirements. Rising main in addition shall be complete with tap off points, end feed units, end covers, thrust pads and spring hangers at each floor. Bus trunking systems shall be complete in all respects whether any item is individually listed in schedule of quantities or not. All accessories shall be deemed to be included in the unit rate of straight length of the bus duct and rising mains.

E.13.1.9 TYPE TEST CERTIFICATE

Rising Mains I Bus Duct configurations offered shall be CPRI I Independent test house tested. Copies of the test certificates for same rating & identical switchgear shall be submitted by successful biders at the time obtaining of vendor approval. This shall not be more than 5 years old.

E.13.1.10 TESTINGAT MANUFACTURERS WORKS

The rising mains and bus ducts shall be tested in accordance with IEC 61439and the related test certificate shall be from an national I international recognized test house/ authority or carried out and witnessed at manufactures premises.

E.13.1.11 INSTALLATION

Installation of the Bus Duct shall be carried out as per manufactures instruction.

For Bus Duct horizontal runs, a horizontal expansion units shall be provided every 40m if required by design and at expansion joints of the building structure and the system shall be supported at every 1.5m.

Annular space around Rising Mains and / or Bus Ducts while crossing floors and walls shall be filled up by sealing material made in accordance with manufacture’s instruction.

E.13.1.12 TESTING AT SITE.

Physical check including checking damage/crake in any components, tightness of bolts and connections etc.

Insulation test after installation according to manufactures test procedures.

Testing earth continuity.

SPECIFIC REQUIREMENTS FOR SANDWITCH CONSTRUCTION TYPE COPPERBUS DUCT & RISING MAINS

System nominal voltage	415V
System frequency	50Hz
Number of phases	TPN/TP2N
Rated Continuous current	Refer BOQ/ Drawings
Minimum phase to phase Clearance(Clear)	As per standards if required
Phase to body Clearance(Clear)	As per standards
Phase to neutral (clear)	As per standards
Neutral Grounding	Solidly earthed
Insulation level	As per standards
Short time rating(Sym. KA)-(1 sec)	Refer BOQ / Drawings
Dynamic withstand current	100KA peak
Cooling	Self-Cooled

Bus bar joints	Bolted type
Flexible / expansion	To be provided at all joints equipment terminations and between bus dust tight
a. Material b. Short circuit & continuous Rating c. Cover over chamber	a. Copper b. Refer BOQ and Drawings c. Required
Enclosure joints gaskets	Circumferential neoprene rubber gaskets shall be provided for dust tight joints.
Disconnecting link	Required
Insulators	As specified or Epoxy between conductors or better

E.13.2 TECHNICAL SPECIFICATIONS OF LOW POWER LIGHTING BUS TRUNKING SYSTEM

The Bus Trunking System shall be halogen free Air Insulated; Simple, Compact & Maintenance Free Design. The Operating Voltage/ Insulation Voltage of Bus Trunking System shall be 415+-10% Volts max with insulation voltage minimum 690 V. The Short Circuit Current Withstand Capacity of the Bus Trunking System shall be 2.5 kA min for 0.1 sec (Icw) and 9.6 kA pk. Ingress Protection of Bus Trunking System shall be IP 55 and therefore Resistant to the Ingress of Dust & Water. Bus Bars in the Bus Trunking System shall be adequately placed in the Insulating Channel throughout their length to keep Bus Bars in position and avoid any possible chance of Short Circuiting. Provision of six Plug in Holes to be made in the Standard Length of 3 Mtrs. for 8 Wire System with accessibility on both sides and three Plug in Holes in Standard Length of 3 Mtrs for 2 Wire Sysem. The Copper Conductors used shall be Electrolytic with 99.9% Purity. The Enclosure shall be made of Stainless Steel/ hot galvanized steel with excellent Mechanical Strength to take the Weight of Luminaries etc. The Bus Trunking System shall have Integral Earth System and an External Earth throughout the length of the Bus

Trunking. The Earth shall be tapped by Tap 0ff Boxes to be connected to the load. The Bus Way System shall be assembled together to give Excellent Electro Mechanical Characteristics and Heat Dissipation Properties. The Tap Off Boxes shall be of Plug in Type, It shall be possible to replace the Tap Off Boxes on to the Bus Trunking System without shutting off the Power Supply. The Tap Off Boxes shall be Mechanically Locked and to be Plugged in and Out from Live Bus bar. Tap Off Outlets shall be provided with Safety Shutters to prevent Access to Live Bus Bars when not in Use. The Bus Trunking System shall be completely Type Tested and shall comply the CEI/En Standards to confirm Short-Circuit Withstand Capacity, Temperature Rise, Dielectric Properties, Insulation Resistance, Degree of Protection, Clearance&Creepage& Mechanical Operation.

E14. PUMPS FOR WATER SUPPLY / WATER TREATMENT

E14. 1 General

E14. 1.1 This Section specifies the manufacture and installation of cold water supply pump sets, drainage sump pump and sewage ejector pumps system.

E14. 1.2 Pumps shall be electrically operated and directly driven.

E14. 1.3 The pump heads specified on the Drawings and / or Bill of Quantities are for guidance and information only, and are calculated based on assumed equipment pressure drops. The exact pump head based on the pipe run and the offered equipment shall be carefully checked and re - calculated for each pump before ordering the equipment. Calculation shall be submitted for approval. No modification to the piping system shall be allowed without prior approval. Any additional cost for the modification of the system (pumps, motors, switchgears, cables, panel boards, switchboards, etc.) necessary to meet the specified duties, special conditions and the offered equipment shall be provided at no extra cost to the Employer.

E14. 1.4 For pumps in parallel operation at any particular time, the pumps selected shall have a steep characteristic. For single pump operation at any particular time, the pump selected shall have a flat characteristic. Pumps with curve indicating excessive shut-off head shall not be used.

E14. 1.5 The pump construction shall meet the maximum required working conditions, liquid temperature, test pressure, and nature of the liquid to be handled as specified.

E14. 1.6 All pumps and motors shall be of minimum vibration and noise level during operation so as to meet the respective noise criteria.

E14. 1.7 Additional vibration isolators and sound attenuators shall be provided by the contractor as may be required by the Engineer at his own cost if the noise level is found excessive and not within the requirements.

E14. 1.8 Each complete pump unit including motor and drive shall be supplied from a single manufacturer as a complete factory manufactured package. All guarantees and test certificates shall apply to the entire assembly.

E14. 1.9 All pumps shall be factory painted in accordance with the manufacturer’s recommendations. Any damage to finishes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

E14. 1.10 The physical water level indicators should be provided in all tanks and the accordance with the manufacturer’s recommendations. Any damage to finishes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

E14. 2 Standards

E14. 2.1 Relevant Codes and Standards

E14. 2.1.1 BS 599/ISO 9946: Methods of Testing Pumps

E14. 2.1.2 BS 5316: Acceptance Tests for Centrifugal Mixed Flow and Axial Pumps

E14. 3 Technical and Installation Requirements

E14. 3.1 Quality Control

E14. 3.1.1 Nameplate: Each pump and motor shall have an identification plate showing the code number and a specification plate showing full details of the pump size, rated speed, rated kW, class of insulation, impeller diameter, pump characteristics, flow and any other pertinent information required by the Engineer.

E14. 3.2 Cold Water Supply Pump Sets

E14. 3.2.1 The pump sets shall be complete with, motor starter panel and control unit. Pump sets shall be of package type, being designed and manufactured by manufacturers normally supplying this type of equipment, and who can show evidence of having furnished such equipment that has been in successful operation for at least ten years. Locally assembled pump sets will not be accepted.

E14. 3.2.2 Capacity of each pump and motor shall not be less than that specified and designed for all conditions of parallel operation. Each motor shall be of sufficient capacity to operate over the entire head capacity range of its respective pump without exceeding the name plate power rating.

E14. 3.2.3 The pump casings shall be of close-grained cast iron, accurately machined and assembled with metal-to-metal joints.

E14. 3.2.4 The casting feet shall be integrally cast with the lower casing and be immediately adjacent to suction and discharge flanges in order to transmit pipe load to the base and foundation.

E14. 3.2.5 The impellers shall be of gunmetal or bronze, mechanically balanced and keyed to shaft. Renewable guide rings shall be provided in the casting, keyed to prevent rotation.

E14. 3.2.6 The shafts shall be stainless steel to BS 970 Grade 410. Gunmetal sleeves shall be provided to protect the shaft in the water space and through the shaft seal. The sleeves shall be keyed to prevent rotation and secured against axial movement for leakage of water along the shaft.

E14. 3.2.7 The bearings shall be of ball or roller type protected against ingress of water, dirt and other matter.

E14. 3.2.8 Leakage of water along the shaft to be prevented with a mechanical seal.

E14. 3.2.9 Mechanical seals shall be specifically designed for pump working pressures and shall be of stainless steel construction with S.S. springs and tungsten carbide seats.

E14. 3.2.10 The pump sets shall be complete with inter-connecting pipework, isolating and check valves, and flexible connectors and with flanged connection ready for connection to the pipe work system.

E14. 3.2.11 Pumps & motors shall be assembled on galvanized base plate of rolled steel &sloping channel type, with tapped drain connection at pump end. The base plate shall be designed & supplied by the pump manufacturer.

E14. 3.2.12 Strainers shall be installed at suction side as shown on the drawings.

E14. 3.2.13 Discharge (and in suction line, where shown in the drawings) pressure gauges complete with isolating cock shall be provided.

E14. 3.3 Drainage Sump Pumps and Sewage Ejector Pumps

E14. 3.3.1 Pump sets shall be provided for the locations and duties, as required.

E14. 3.3.2 The pump sets shall be of the sewage or dirty water type in accordance with their duty requirement. The sewage pumps shall be of the non-clog type with open impellers. The dirty water (seepage) pumps shall be of the semi openimpeller or vortex type. The submersible pumps shall be rated in accordance with IP 68 and shall have corrosion class in accordance with appendix A of IEC 364-5-51.

E14. 3.3.3 The efficiency of the pump set at duty point shall not be less than 90% of the maximum efficiency for the pump or as per manufacturer's design.

E14. 3.3.4 The pumps shall be of the centrifugal type, vertically mounted, close coupled to their fully submersible electric drive motors. Pump impellers shall be cast iron to GG 25 confirming to ASTM 35B or cast stainless steel. Shaft, studs, nuts, screws and washers shall be Stainless Steel Grade 304, S15.Pump body shall be of cast iron.

E14. 3.3.5 The bearings shall be of the rotating element type, grease packed and sealed for life.

E14. 3.3.6 The pump shall have two mechanical seals. The seals shall work independently of each other, one to seal off the motor, one to seal off the pumped fluid. An oil chamber shall act as a buffer between the seals and a coolant for the seals. A moisture detection probe in the oil chamber shall detect the presence of water in the chamber and thus the deterioration of the lower seal. The probe shall operate a remote alarm.

E14. 3.3.7 A lifting chain with shackles, rings etc. shall be fitted to each pump, which shall support the weight of the pumps during installation and removal from the sump. The chain shall comply with BS 1663 and be hot-dipped galvanized.

E14. 3.3.8 Motors shall be submerged and cooled by the liquid in which it is submerged. The windings shall be protected against burnout by a thermostat or thermistor arranged to trip the pump. Motor insulation shall be class 'H', motors upto 5.0 H.P shall have DOL starters and above 5.0 H.P shall have star delta starting.

E14. 3.3.9 The submerged cable for drainage sump pumps and sewage ejector pumps shall be fully insulated LSHF to BS 7211 or EBXL type (Electron Beam Cross Linked) cable (As per manufacturer Design). The cable shall be sealed and glanded into the motor before the pump leaves the factory. The cable junction box shall be sealed from the outside. The cables shall be supplied long enough to reach the

starters. For all low point seepage sumps the starters are quite far from the nearest station seepage sump. Therefore the cable shall go into a waterproof isolation socket, which shall be cabled to the starter. The isolation sockets may be a composite arrangement, but in either case the Pump Number shall be clearly labelled on the plug and the socket.

E14. 3.3.10 The pump sets shall be complete with boltless self-aligning duck-foot assembly, which allows removal of the pumps without disturbing the pipe work. Guide rails on which to raise and lower the pumps shall be of galvanized steel and complete with all fittings and support brackets.

E14. 3.3.11 Pump duties shall be achieved with the impeller shaft speed not exceeding 2900 rpm unless otherwise specified.

E14. 3.3.12 Pump connections shall be screwed to BS 21/ BS EN 10226:2004 up to DN 50 and flanged to BS EN 1092-1, PN 10 for DN 65 and above.

E14. 3.3.13 The permissible service pressure of cast iron pump casings shall be generally in accordance with the manufacturer's recommendations. No pump part or component part shall be subjected to a gauge pressure in excess of 10 bar, except where specifically listed in the Equipment Schedule.

E14. 3.3.14 Impellers shall be keyed to the drive shaft, the impeller being retained by a hexagonal nut.

E14. 3.4 Water Supply Pump Sets Control

E14. 3.4.1 There shall be duplicated pump sets in the system, one duty and one standby. The pumps shall be automatically controlled to maintain the water pressure in the system as indicated on the Drawings.

E14. 3.4.2 The pump control shall have the following features:

(a) An overriding float switch of differential type shall be provided in the water tank to cut off the pumps operation when the tank has been exhausted.

(b) Automatic change - over facility shall be provided, the standby Pumps shall automatically start on the failure of the duty pump.

(c) Lead / lag selection and automatic alternation shall be provided for the control circuit. After one pump has finished one operation, the other pump shall stand as the duty pump for the next cycle.

(d) Duty / standby and auto / off / manual selectors shall be provided.

E14. 3.5 Sump Pumps Control

E14. 3.5.1 For the two-pump arrangement, one pump shall act as duty and the other one as standby. The pumps shall be automatically controlled to transfer the soil and / or waste water to the manhole or the nearest drainage pipe connections.

E14. 3.5.2 Automatic controls shall be of float - type mercury switches suitable for use with soil or waste water. Each pit shall be fitted with four switches at different levels to

correspond with the required depths of water and to initiate the relevant controls to operate the pump and / or raise the alarm suitably.

E14. 3.5.3 The pump control operation shall be:-

a) When the water level in the sump pit reaches the first pre-determined high level, the duty pump shall be started and continue to run until the water level falls back to the low level.

b) For duplicated pump sets, if the water level continues to rise to the second pre-determined level, the second pump shall also be called to operate in parallel with the first pump. The pumps shall only be stopped when the water level drops back to the low level.

c) Automatic and manual change-over facilities shall be provided for the pumps.

d) A lead / lag selection and an automatic alternation facility shall be provided. After one pump has finished one operation, the second pump shall act as duty pump for the next cycle.

e) An extra high level alarm shall be provided at the vicinity of the pit or one of the control panels, when the water raises up to the extra high level, an audible and visual alarm shall be raised.

(f) Remote monitoring and control shall be required as follows:-

(1) Run / Stop status of the sump pumps such as sewage pumps and waste sump pumps.

(2) Overload alarm for the above pumps

(3) High water level for the sump pits.

(4) Power supply failures for the above pumps.

(5) Auto / Manual mode status of the pumps.

(6) Run / Stop control of the above pumps.

E14. 3.6 Float Switches

E14. 3.6.1 Provide all float switches required for pump control and alarm system. (The high / low level alarm.)

E14. 3.6.2 Provide all cables and conduit between the float switches in the water tanks and sump pits and the BMS or LMCP, as required.

E14. 3.6.3 All the alarms of the sump pits shall be wired back to the associated LMCP in the pump rooms or at the vicinity of the pit respectively, as instructed by the Engineer. Should any one of these alarms be actuated, an audible and a visual alarm shall be indicated on the LMCP and transmitted to the Station BMS.

E14. 3.7 Speed of Pump

E14. 3.7.1 Unless otherwise specified, all pumps shall be selected for lowest noise level in operation and shall not exceed 2900 r.p.m. Bearings shall be of the silent type.

E14. 3.8 Pump / Motor Couplings

E14. 3.8.1 A coupling shall be provided between the pump and motor and shall be semi-flexible of the steel pin / rubber bush type accurately aligned. The coupling shall be used solely to reduce shock to the bearings and shall not be utilized to compensate for misalignment. Pin and bush couplings shall be provided to the same accuracy of alignment as rigid couplings, and the Contractor shall demonstrate correct alignment.

E14. 3.9 Maintenance Facilities

E14. 3.9.1 Pump installations shall be complete with adequate facilities for maintenance and future replacement of plant. Lifting eyes shall be provided for pumps and motors. Details of any requirements for overhead runways and hoists shall be submitted for approval.

E14. 3.9.2 Each pump shall have a pressure gauge installed to indicate discharge pressures. Gauges shall be 100 mm dial calibrated to read directly in kPa of range to match the respective pump duties.

E14. 3.10 Installation

E14. 3.9.1 Pumps and appurtenances shall be installed in the space provided and made readily serviceable.

E14. 3.9.2 Provide drains for bases and stuffing boxes piped to and discharging into floor drains and drain funnels.

E14. 3.9.3 Provide air cock and drain connection on pump casing.

E14. 3.9.4 Reduction in line size shall be by utilizing long radius reducing elbows or reducers. Support piping shall be provided adjacent to pumps such that no weight is carried on pump casings. Supports shall be provided under elbows on pump suction and discharge line sizes of 100 mm and over.

E14. 3.9.5 Base mounted pumps shall be checked, aligned and certified prior to start-up.

E14. 3.11 Site Testing

E14. 3.10.1 Test pumps in actual operating conditions to verify compliance with this Specification. Check all wiring for connection and continuity. Test performance of all relays and logic.

E14. 3.10.2 Promptly correct all excessive vibration, noise, rattles or other objectionable factors or replace the defective item and retest the systems.

E14. 3.10.3 Check controls in the presence of the control manufacturer's authorized representative and make all necessary adjustments to secure proper control.

E14. 3.12 Testing at Manufacturer's Works

E14. 3.11.1 Pumps shall be tested over the full range of their capacities. The range shall be from closed valve condition to a point corresponding to a discharge of 15 % in excess of the maximum discharge in the specified range of duties. Testing shall

determine the output, power consumed and mechanical efficiency. Copies of the NPSH design curve shall also be provided.

E14. 3.11.2 Head / quantity curves pump efficiency / quantity curves, overall efficiency / quantity and power / quantity curves shall be drawn. The curves produced shall be used to demonstrate that the pump will be capable of meeting the full range of operating conditions at Site.

E14. 3.11.3 All pump components subject to pressure shall be hydraulically tested to a pressure of 1.5 times the sum of the closed valve head plus the maximum suction pressure for 5 minutes.

E15. WATER TREATMENT PLANT

E15. 1 General

E15. 1.1 This Section specifies the furnishing and installation to complete and operate softening plant for reducing the Hardness of raw water to below 5mg/lit commercial zero so as to generate water fit for make up requirements for Cooling Towers of HVAC system.

E15. 1.2 All materials shall be new and of the best quality conforming to specifications and subject to the approval of Engineer-in-charge-in-Charge.

E15.1.3 All equipment shall be of best available make manufactured by reputed firms.

E15. 1.4 All equipment shall be installed on suitable foundations, true to level and in a neat work-man-like manner.

E15. 1.5 Equipment shall be so installed as to provide sufficient clearance between the end walls and between equipment to equipment.

E15. 1.6 Piping within the pump houses shall be done so as to prevent any obstruction in the movement within the pump house.

E15. 2 Standards

E15. 2.1 IS: 8419 Requirements for water filtration equipment: Part I Filtration media – sand and gravel.

E15. 2.2 IS: 2825 Code for unfired pressure vessels

E15. 3 Quality Control

E15. 3.1 Engage the services of a specialist for initial cleaning and pre-treatment.

E15. 3.2 Specialist's services shall include monthly laboratory testing of water samples and adjustment of water treatment system.

E15. 3.3 A complete testing report regarding the quality of the supplied water together with the recommended water treatment system shall be submitted for Approval prior to ordering.

E15. 4 Deleted

E15. 4.1.1 Softening Plant

The softener vessel shall be made of Mild steel (rubber lined) pressure vessel conforming to IS:2825, upflow "Cation" Ion Exchange typ.

The softener plant shall be designed to generate water commercial zero hardness at rated output at given raw water quality without any operational problem. Any additional provision required to make the item complete shall be deemed to be included in the price.

The softening plant shall be complete with Initial charge of Ion Exchange resin, regeneration assembly comprising of power valve, ejector, brine suction valve, and

all necessary piping. The Contractor is required to submit the make, grade and quantity of resin being offered by him and the quantity of regenerant required for each regeneration.

The Softening System shall consist Dual Media Filter (DMF) pressure vessel type pre-filter of made of mild steel (rubber lined) conforming to IS:2825. The rate of filtration of DMF shall not be more than 15 cu.m/hr/sq.m. Working and test pressures shall be as per BOQ. Thickness of vessel rubber lining not less than 3mm.

E15. 4.1.2 Under drain system

E15. 4.1.2.1 Each filter shall be provided with an efficient under drain system comprising of collection pipes, polypropylene nozzles of manufacturer's design. The entire under draining system shall be provided on M.S. Plate or cement concrete supports provided by the contractor

E15. 4.1.3 Face piping

E15. 4.1.3.1 Each filter shall be provided with interconnection face piping comprising of inlet, outlet and backwash complete with diaphragm valves/ball valves.

E15. 4.1.4 Accessories

E15. 4.1.5.1 Each vessel shall be provided with the following accessories:

a) Air release valve with connecting piping.

a) 100mm diabourden type gunmetal pressure gauges with gunmetal isolation cock and siphon on inlet and outlet.

b) Sampling cocks on raw water inlet and filtered water outlet.

c) Individual pressure tight manhole, drain connection with ball valves.

e) Connection with valve for air scouring.

f) Rate of Flow Indicators in the raw water inlet line.

g) Quantity meter in the filter water outlet line

E15. 4.1.6 Filter media

E15. 4.1.6.1 Each filter shall be provided with clean and washed filter media, conforming to IS: 8419 (Part-I) following is recommended.

Coarse SilexPabbles	6.0 - 10.0mm size	(150mm deep)
Fine Silex Sand	1.4 - 2.5mm size	(600mm deep)
Anthracite	0.80 - 1.6mm dia	(600mm deep)

E15. 4.1.6.2 The above filter media arrangement may be altered to suit contractor's own design for the most efficient performance.

E15. 4.1.7 Test kits

E15. 4.1.7.1 Provide one test kit with initial requirement of reagents for the following:

a) Hardness Test Kit

b) Residual Chlorine Indicator

c) PH meter (electronic)

The contractor shall supply the details of equipment (Including Test kit) with literature for the equipments quoted by him along with.

E15. 5 PAINTING AND FINISHES

E15. 5.1 General

E15. 5.1.1 All exposed metal surfaces, after inspection and testing either in the factory or on Site shall be thoroughly cleaned of all dust, oil, grease, dirt, scale and rust by grit or shot-blasting to the satisfaction of the Engineer.

E15. 5.1.2 Surfaces of castings, steel work, piping and plant and machinery which are to be in direct and permanent contact with concrete shall be properly painted and covered, prior to dispatch from the Contractor's premises, with a substantial coating of cement wash or other proprietary coating plus a lapping of weatherproof tape. The method of coating and waterproof tape shall be approved by the Engineer.

E15. 5.1.3 Except where otherwise specified, all embedded pipes and fittings located in inaccessible positions (e.g. in pipe trenches, pits) shall be externally coated by dipping in acid-free hot bituminous compound. The coating thickness shall be approved by the Engineer. The pipe or fitting shall then be lapped with a layer of anti-corrosion tape which shall be approved by the Engineer.

E15. 5.1.4 The internal surfaces of all oil service ferrous pipes and fittings shall be carefully inspected to ensure that all scale and other particles or contaminants have been removed and shall then be protected in a manner approved by the Engineer to prevent deterioration during transport and subsequent erection.

E15. 5.1.5 The external surface of accessible ferrous pipes and fittings shall be treated with two coats of primer paint approved by the Engineer prior to dispatch from the place of manufacture.

E15. 5.1.6 The external surfaces of all Building Services Equipment in damp environments shall, unless made of non-ferrous metal, be coated with a bituminous compound approved by the Engineer. All access ladders and platforms and associated supporting steelwork provided by the Contractor shall be galvanized.

E15. 5.1.8 All other exposed surfaces, except where otherwise specified, shall be thoroughly cleaned of all dust, oil, grease, dirt, scale, rust or other contaminants by power tool operated metal brush, or preferably by shot or grit blasting, and shall then be coated immediately with one coat of primer paint.

E15. 5.1.9 Any damage to priming coats made good by the Contractor on completion of installation shall be finally painted in colours approved by the Engineer.

E15. 5.2 Paint Finish Schedule

E15. 5.2.1 Unless otherwise specified in the particular specification, a paint finish to a colour to be approved by the Engineer shall be applied to all exposed services including but not limited to supporting rods and brackets, cable ladders, cable trays, trunking, lighting fittings, pipework, ductwork, access doors / panels, surface conduits and accessories and other equipment installed in the following areas

(a) Station concourse public area;

(b) Station platform public area;

(c) Station entrances, passageways; public areas and subways and passenger exits; and

(d) Back of house areas, offices and staff areas without suspended ceilings.

E15. 5.2.2 Unless otherwise specified, all machinery / equipment shall be finished in a colour to be specified by the Engineer at the time of installation / manufacturing. Unless conforming to the general colour scheme specified, the manufacturer's standard finish colour may not necessarily be accepted.

E15. 5.2.3 The requirements of paint finish shall be as follows:-

(a) All equipment casings and metal parts shall undergo different stages of pre-treatment such as chemical cleaning, abrasive blasting, acid pickling, galvanizing or electro-galvanizing before painting. There shall be at least one coat of corrosion resistant primer, one undercoat and two finish coats to suit the intended duty and operating requirements. Details of pretreatment shall be submitted to the Engineer for approval prior to application.

(b) If damage to paint is found during transportation, storage or installation, the contractor shall repaint the whole equipment without extra cost.

(c) Replace all damaged parts or components and repaint the whole equipment without extra cost if rust is found on any equipment due to inadequate painting material or poor workmanship or incorrect handling during transportation, storage or installation. Removal of all the existing paint, chemical cleaning, rinsing and other necessary pretreatment shall be included in repainting before applying primer, undercoats and top coats. Details shall be submitted to the Engineer for approval.

E15. 5.3 MATERIALS

E15. 5.3.1 Primer Paint

E15. 5.3.1.1 For synthetic finishing paints on internal and external metalwork, paint shall be zinc chromate primer or metallic zinc-rich primer to BS 4652, Type 2.

E15. 5.3.1.2 For synthetic or non-toxic paints on galvanized metal, use an etching primer with a zinc chromate base.

E15. 5.3.1.3 For polyurethane paint on internal and external metal work, paint shall be metallic zinc-rich primer to BS 4652, Type 2.

E15. 5.3.2 Undercoat Paint

E15. 5.3.2.1 For metal work installed internally, paint shall be a linseed oil modified alkyd based undercoat highly pigmented to appropriate shade.

E15. 5.3.2.2 For metal work installed externally and exposed to weather, paint shall be a polyamide epoxy pigmented with titanium oxide.

E15. 5.3.3 Finish Paint

E15. 5.3.3.1 For metal work installed internally paint shall be a linseed oil modified alkyd with glossy finish and fungus resistant characteristics.

E15. 5.3.3.2 For metal work installed externally and exposed to weather, paint shall be a polyamide epoxy.

E15. 5.3.4 Identification Colours

E15. 5.3.4.1 All finish coat colour shall be to BS 381C and identification colour shall be as per para E.27.5.3.7 below. Colours not covered in clause shall be agreed with the Engineer.

E15. 5.3.5 Valves

E15. 5.3.5.1 All valves shall be painted as the same colour as the pipe to which it is fixed, except that handles installed in plant rooms or on roofs shall be painted red, No. 540 regardless of the service.

E15. 5.3.6 Colour Bands / Materials and Workmanship

E15. 5.3.6.1 Colour bands shall be provided at intervals not exceeding 2 m and whenever necessary at bends, tees, when pipes pass through from one room or zone to another, and when two or more pipes run in parallel. Colour bands for each pipe shall be at the same locations.

E15. 5.3.6.2 Bands shall be of 100 mm width.

E15. 5.3.6.2 Hangers, spring isolators, and supports shall be painted as for the equipment unless otherwise specified.

E15. 5.3.7 Colours Schedule

E15. 5.3.7.1 All equipment, unless otherwise specified, shall be finished in a colour to be specified by the Engineer at the time of installation. The Contractor shall obtain the Engineer’s requirements on this in good time.

E15. 5.3.7.2 After painting and cleaning of piping and insulation (in case of Hot Water Pipes) is complete, exposed services systems shall be finished generally in accordance with BS 1710 and shall be identified by means of coloured stenciled or prefabricated legends with flow arrows as follows unless otherwise specified. The colour numbers as stated below are those of BS 4800 for ready mixed paints.

Service	Colour	Colour No. (Reference to BS 4800)
Water Pressuriesed (Salt)	Sea Green	16 C 37
Water Pressurised (Fresh & cleansing)	Dark Blue	18 F 53
Drainage	Black	00 E 53

E16. PUMPS FOR FIRE PROTECTION SYSTEM

E16. 1. General

E16. 1.1 This Section specifies the manufacture and installation of Fire pumps.

E16. 1.2 Provide pumps with duties, quantity and type as shown on the Drawings and / or Bill of Quantities.

E16. 1.3 The pump heads specified on the Drawings and / or Equipment Schedules are for guidance and information only and are calculated based on assumed equipment pressure drops. The exact pump head based on the pipe run and the offered equipment shall be carefully checked and re-calculated for each pump before ordering the equipment. Calculation shall be submitted for approval. No modification to the piping system shall be allowed without prior approval. Any additional cost for the modification of the system (pumps, motors, switchgears, cables, panel boards, switchboards, etc.) necessary to meet the specified duties, special conditions and the offered equipment shall be provided at no extra cost to the Employer.

The specification of motors for pumps shall be referred to in section E12 of M & W Specifications for Motors.

E16. 2 Standards

E16. 2.1 Reference Codes and Standards

E16. 2.1.1 BS 599: Methods of Testing Pumps.

E16. 2.1.2 BS 970: Wrought Steels for Mechanical and Allied Engineering Purposes.

E16. 2.1.3 BS 1400/BS EN 1982: Copper Alloy Ingots and Copper Alloy and High Conductivity Copper Castings.

E16. 2.1.4 BS 1452: Flake Graphite Cast Iron.

E16. 2.1.5 BS 3100/BS EN 10293: Steel Castings for General Engineering Purposes.

E16. 2.1.6 BS EN 1092-1: Circular Flanges for Pipes, Valves and Fittings.

E16. 2.1.7 BS 5316: Parts 1 and 2 : Acceptance Tests for Centrifugal Mixed Flow and Axial Pumps

E16. 2.1.8 BS EN ISO 5198: Centrifugal, Mixed Flow and Axial Pumps - Code for Hydraulic Performance Tests - Precision Class.

E16. 2.1.9 NFPA 20: NFPA standard for installation of fire pumps

E16. 2.1.10 UL-448: Standard for Centrifugal Stationary Pumps for Fire Protection Services.

E16. 2.1.11 BS EN ISO 9906 : Rotodynamic pumps. Hydraulic performance tests. Grades 1 & 2

E16. 3 Technical and Installation Requirements

E16. 3.1 All main & Standby pumps of Fire protection system shall be horizontal, split casing type complete with spacer coupler, centrifugal type. Jockey pumps shall be vertical

in-line type ,All Main & Standby fire pumps shall be UL Listed / FM approved & comply with NFPA-20, and where applicable shall also comply with BS 5257.

E16. 3.2 Each pump unit including motor and drive shall be supplied from the manufacturer as a complete factory-assembled package. All guarantees and test certificates shall apply to the entire assembly.

E16. 3.3 Material of Construction: The pumps shall be constructed with materials specified below as per their relevant BS/EN standards or approved equal, unless otherwise specified.

Fluid to be handled:	**Clear WaterMaterial:**
Casing	Cast iron
Impeller	Bronze/ SS-304 or as per manufacturer's practice
Shaft	SS 410 /SS-304 or as per manufacturers practice
Shaft sleeve	SS 410
Wear rings	Bronze
Bolts, studs, dovels, nuts, Washers and other fixing Accessories	Stainless steel Grade 316 S 16

E16. 3.4 Nameplate: Each pump and motor shall have an identification plate showing the code number and a specification plate showing full details of the pump size, rated speed, rated kW, class of insulation, impeller diameter, lubricants, head and flow at duty point and any other pertinent information required by JFA / state authority or the Engineer.

The pump construction shall meet the maximum required working conditions, liquid temperature, test pressure and nature of the liquid to be handled, as specified.

Capacity of each pump and motor shall not be less than that specified and designed for all conditions of parallel operation. Each motor shall be of sufficient capacity to operate over the entire head capacity range of its respective pump without exceeding the name plate power rating.

The pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shut off head shall not exceed 140 percent of rated head.

Alignment: Alignment to be done at the time of start-up, using dial indicator with accuracy of plus or minus 0.05 mm. Further, it shall be certified in writing that alignment work has been performed by competent personnel of the contractor and that the pumps are operating in accordance with the design requirement.

E16. 3.5 All pumps shall be factory painted in accordance with the manufacturer's recommendations. Any damage to finishes shall be made good in the manner recommended by the manufacturer and to the satisfaction of the Engineer.

E16. 3.6 Pump case shall be designed for 1600 kPa working pressure or the figure specified on the Drawings whichever is the greater, tested and guaranteed to withstand 1.5 times the specified working pressure.

Pump casing shall be close grained, cast iron accurately machined and assembled with metal to metal joining.

The casing feet shall be internally cast with the lower casing and be immediately adjacent to suction and discharge flanges in order to transmit pipe load to the base and foundation.

E16. 3.7 Enclosed impeller shall be statically, dynamically and hydraulically balanced, non-overloading and correctly designed for all conditions of service. Impeller shall be machined to a high degree of surface finish and shall be securely fixed to the shaft and protected by shaft sleeves of compatible materials.

Impeller shall be internally coated with Fluiguide system with dry film for anti corrosion.

E16. 3.8 Wearing rings on both casing and impeller shall be of renewable type, made of dissimilar bronze metals and of hardness to insure maximum protection against galling.

E16. 3.9 Renewable shaft sleeves shall be suitable for use with mechanical seals.

E16. 3.10 **Gland packing shall be provided as per UL/FM requirement.**

E16. 3.11 Pumps and motors shall be assembled on galvanized base plate of rolled steel and sloping channel type, with tapped drain connection at pump end. The base plate shall be designed and supplied by the pump manufacturer.

E16. 3.12 Flexible spacer coupling shall be self-aligning, all metal type, of approved design, between pump and motor, to enable removal of impeller without disturbing the driving motor or its mounting.

E16. 3.13 Electric motors for pump drives will be of the totally enclosed, fan cooled squirrel cage induction motor with Class F insulation. Totally enclosed fan cooled motors shall be dust and moisture protected to IP 55. **Technical and Installation requirements** Motors shall be as specified in Section E12 of Technical Specifications.

E16. 3.14 Pumps/Motor Coupling

E16. 3.14.1 A coupling shall be provided between the pump and motor, and shall be semi-flexible, of steel pin / rubber bush type and accurately aligned.

E16. 3.14.2 The coupling shall be provided to reduce shock to the bearings and not to compensate for misalignment. The pin and bush coupling require the same accuracy of alignment as rigid couplings. Demonstrations of correct alignment shall be provided.

E16. 3.15 Pump Set Auxiliary Equipment

Each pump set shall be provided with the following auxiliary equipment.

E16. 3.15.1 Discharge pressure gauges each complete with isolating cock and syphon. Pressure gauge on the suction side also to be provided wherever shown in the drawings.

E16. 3.15.2 Drains, vents, primary plugs, all necessary water seal connections and all installation materials including fixing bolts and anti-vibration mountings.

E16. 3.15.3 Emergency stop push button shall be provided for each pump at a location approved by the Engineer.

E16. 3.15.4 Strainers shall be installed at suction side as shown on the Drawings.

E16. 3.15.5 High / low level float switches shall be provided at each of the fire service tanks for the control of the respective pumps. Indicator lights and buzzers shall be provided on the automatic and manual fire alarm control panel to indicate water level of the tanks. The switches shall be submersible, maintenance free bulb type.

E16. 3.16 Installation

E16. 3.16.1 Fit pumps and appurtenances to the space provided and make readily serviceable.

E16. 3.16.2 Provide hot-dipped galvanized steel framework, hangers, anchor bolts and vibration isolators for pumps.

E16. 3.16.3 Pump bases mounted on the inertia blocks shall be fixed on the concrete plinths by means of the approved spring isolators.

E16. 3.16.4 Provide flanges and flexible pipe connectors to the suction and discharge connections of pumps.

E16. 3.16.5 Provide supports to both sides of the flexible connection to prevent undue strain on pumps. Such support shall be mounted so as not to transmit vibration to the structure.

E16. 3.16.6 Each pump shall be fitted with air cocks, drain plugs and a pressure gauge on both suction and discharge sides of the pump.

E16. 3.16.7 Except in the case of glandless pumps, provision shall be made for collecting gland leakage via a copper drain pipe fitted from the pump to the nearest gully or drain point. A copper tundish shall be used to collect the drips at the gland packing.

E16. 3.16.8 Provide galvanized angle iron wire mesh guards to all exposed shafts, couplings and moving parts. The guard shall be stoutly constructed with lifting lugs for easy removal.

E16. 3.16.9 Pump installations shall be complete with adequate facilities for maintenance and future replacement of plant. Lifting eyes shall be provided for pumps and motors. Details of any requirements for overhead run-ways and hoists shall be provided to the Engineer.

E16. 3.16.10 Pipe connections to the pump should not impose any load on the pump which is liable to disturb shaft and bearing alignment. The pump/pipework connection ends shall be of final closure joints, and thus ensuring the pipework is independently supported.

E16. 3.16.11 Demonstration of free pump rotation before and after pipe connection shall be provided.

E16. 3.16.12 All necessary steps shall be taken to ensure that noise and vibration are not transmitted from any part of the installation to any part of the structure at such a level as deemed to be objectionable.

E16. 3.16.13 Equipment shall be selected for minimum noise and vibration, and rotating machinery shall be fully statically and dynamically balanced.

E16. 3.16.14 Pumps shall be isolated from their associated pipework by means of flexible pipework vibration isolators, of suitable stiffness, and mounted with the isolators axis at right angles to the direction of maximum vibration amplitude. These isolators shall be mounted as close as possible to the pump, and as such may be used as the final closure joint. However, the isolators should not be used to compensate for misaligned pipework.

E16. 3.16.15 Automatic priming equipment shall be included where necessary to ensure that the pumps are primed at all times.

E16. 3.16.16 Long radius reducing elbows or reducers at the locations where pipe size decreases shall be provided. Provide support to pipework adjacent to pumps such that no weight is carried on pump casings. Provide supports under elbows on pump suction and discharge line of 100 mm diameter and over.

E16. 3.16.17 The straight pipe length for the suction side shall be a minimum length of 5 diameters of the suction pipework size.

E16. 3.16.18 Motor starter for all pumps shall be provided as specified.

E16. 3.16.19 Shaft Coupling Alignment

(a) Carefully and accurately align shafts of all machinery, utilizing shaft couplings between drivers, speed reducers and the equipment. Test the direction of rotation of the driver before final shaft coupling connection is made.

(b) Type of Shaft Mis-alignment:

(1) All necessary corrections to eliminate both types of shaft mis-alignment defined as below shall be made at no extra cost to the Employer.

(2) Angular Mis-alignment - Shafts having axis concentric but not parallel.

(3) Parallel Mis-alignment - Shafts having axis parallel but not concentric.

E16. 3.17 Controls

E16. 3.17.1 Fire Hydrants / Hose reel /Sprinkler System

(a) Fixed fire pumps

The fixed fire pump shall be controlled by the following:

(1) It shall be manually operable from the Local motor control panel (LMCP).

(2) Automatically started by actuation of Pressure switch.

(3) There shall be one pump in operation at any time.

(4) Automatic change-over facility shall be provided. The standby pump shall automatically start if the duty pump fails to operate at preset pressure (pressure switch setting), when there is a pressure drop.

(5) Manual / Automatic selection switch for the duty and standby pump shall be provided.

(6) Once the pump has started, it can only be stopped manually.

(7) Pump operation status shall be provided inside the Station Control Room by potential free NO/NC contact in the Local Motor Control Centre and provisions shall be made for interface with BMS..

(b) Jockey Pumps

Jockey pumps shall be controlled by the following:

(1) Jockey pump shall cycle ON/OFF automatically to maintain the system pressure. Pump shall cut in through the pressure switch when the system pressure drops to 0.5 Kg / cm^2 below the designed system pressure and stop when the system pressure restores to the designed value.

(2) It shall be manually operated on the Local Motor Control Panel (LMCP).

(3) It shall be automatically stopped when the fixed fire pump (duty or standby) starts to run.

E16. 3.17.2 Automatic Sprinkler System

Sprinkler pumps shall be controlled by the following:

(a) Sprinkler Pumps:

(1) It shall be manually operable from the Local motor control panel (LMCP).There shall be only one pump in operation at any one time.

(2) The sprinkler pumps shall be controlled by the pressure switch installed on the Air vessel of sprinkler system as shown on the Drawings. The main duty pump start point should be at least 0.75 Kg/cm^2 less than

jockey pump start point. Use 0.75 Kg/cm^2 increments for each additional pump.

(3) Automatic change-over facility shall be provided; the standby pump shall automatically start if the duty pump fails to start.

(4) Manual selection switch of the duty and standby pump shall be provided.

(5) Once the pump has started, it can only be stopped manually.

(6) Pump operation status shall be provided inside the Station Control Room.

(b) Jockey Pumps

Jockey pumps shall be controlled by the following:

(1) Jockey pump shall cycle ON/OFF automatically to maintain the system pressure. Pump shall cut in through the pressure switch when the system pressure drops 0.50 Kg/cm^2 below the designed system pressure and stop when the system pressure restores to the designed value.

(2) It shall be manually operated on the local motor control panel (LMCP).

(3) It shall be automatically stopped when the sprinkler pump (duty or standby) starts to run.

Air Vessel

One air vessel each for the Fire Hydrant System and for the Sprinkler System shall be provided in pump room to take care of pressure surges in the system. The air vessel shall be fabricated from MS plate conforming to IS: 2002 grade 2A with minimum 8 mm thickness for the shell and the dished ends and suitable supporting legs. The air vessel shall be provided with a 100 mm diameter, flanged connection from the fire pump, one 25 mm diameter drain with valve, one gun metal water level gauge and 15 mm diameter sockets for Pressure switches and pressure gauge. The vessel shall of suitable size as specified in Bill of Quantities. The vessel shall be designed, fabricated & tested as per IS: 2825.
The pressure settings, which shall be adjustable, would be as under assuming the working pressure for Hydrant and Sprinkler system as ‘p’ and ‘q‘in kg/sq.cm respectively.

Pump Status	**Hydrant System**	**Sprinkler System**
Operating Pressure	p	q
Jockey Pump Starts (Automatic)	p-0.5	q-0.5
Jockey Pump Stop (Automatic)	P	q

Main Pump Starts (Automatic)	p-1.0	q-1.0
Standby Pump Starts (Automatic)	p-1.5	q-1.5
Main & Standby Pump Stops (Manual)	Manual	Manual

E16. 3.18 **Diesel Fire Pump**

E16. 3.18.1 **General**

The diesel pump set shall be suitable for automatic operation complete with necessary automatic starting gear, for starting on wet battery system and shall be complete with all accessories. Both engine and pump shall be assembled on a common base plate.

Drive

The pump shall be only direct driven by means of a flexible coupling. Coupling guard shall also be provided. The speed shall be 1500 RPM as specified.

Fire Pump

The fire pump shall be horizontally mounted centrifugal single/ multi stage, single/ multi outlet. It shall have a capacity to deliver as specified, and developing adequate head so as to ensure a minimum pressure of 3.5 Kg/Sq.cm at the highest and the farthest hydrant outlet and 0.5 bars at remotest and farthest sprinkler. The pump shall be single/ multi stage as specified. The pump shall be capable of giving a discharge of not less than 150% of the rated discharge at a head of not less than 65% of the rated head. The shut off head shall be within 120% of the rated head.

The pump casing shall be of cast iron to grade FG 200 to IS 210 and parts like impeller, shaft sleeves, wearing-ring etc. shall be of non-corrosive metal like bronze/brass/gun metal. The shaft shall be stainless steel. Provision of gland packing seal, shall also be made.

The pump casing shall be designed to withstand 1.5 times the working pressure.

Bearing of pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water.

E16. 3.18.2 **Diesel Engine**

Engine Rating - The engine shall be cold starting type without the necessity of preliminary heating of the engine cylinders or combustion chamber (for example, by wicks, cartridge, heater, plugs etc.). The engine shall be multi cylinder/vertical 4 stroke cycle, aircooled, diesel engine, developing suitable HP at the operating speed specified to drive the fire pump. Continuous capacity available for the load shall be exclusive of the power requirement of auxiliaries of the diesel engine, and the after correction for altitude, ambient temperature and humidity for the specified environmental conditions. This shall be at least 20% greater than the maximum HP required to drive the pump at its duty point. It shall also be capable of driving the pump at 150% of the rated discharge at 65% of rated head. The engine shall be capable of continuous non-stop operation for 8 hours and major overhaul shall not be required before 3000 hours of operation. The engine shall have 10% overload capacity for one hour in any period of 12 hours continuous run. The engine shall accept full load within 15 seconds from the receipt of signal to start. The diesel engine shall conform to BS 649/IS 1601/IS 10002, all amended up to date.

a. **Engine Accessories** - The engine shall be complete with the following accessories:-

Fly wheel dynamically balanced.

Direct coupling for pump and coupling guard.

Corrosion Resistor.

Air cleaner.

Fuel service tank support, and fuel oil filter with necessary pipe work.

Elect.starting battery (2X24 v).

Exhaust silencer with necessary pipe work.

Governor.

Instrument panel housing all the gauges, including Tachometer, hour meter and starting switch with key (for manual starting).

Necessary safety controls.

b. **Fuel System** - The fuel shall be gravity fed from the engine fuel tank to the engine driven fuel pump. The engine fuel tank shall be mounted either over or adjacent to the engine itself or suitably wall mounted on bracket. The fuel filter shall be suitably located to permit easy servicing.

All fuel tubing to the engine shall be with copper, with flexible hose connections where required. Plastic tubing shall not be permitted.

The fuel tank shall be of welded steel construction (3 mm. thick) and of capacity sufficient to allow the engine to run on full load for at least 4 hours. The tank shall be complete with necessary wall mounted supports, level indicator (protected against mechanical injury) inlet, outlet, overflow connections and drain plug and piping to the engine fuel tank. The outlet shall be so located as to avoid entry of any sediments into the fuel line to the engine.

As semi rotary hand pump for filling the daily service tank together with hose pipe 5 mtr. long with a foot valve etc. shall also form part of the scope of supply.

c. **Lubricating Oil System**- Forced feed Lub. Oil system shall be employed for positive lubrication. Necessary Lub.oil filters shall be provided, located suitably for convenient servicing.

d. **Starting System**- The starting system shall comprise necessary batteries (2x24v), 24 volts starter motor of adequate capacity and axle type gear to match with the toothed ring on the fly wheel. Bi metallic relay protection to protect starting motor from excessively long cranking runs suitably integrated with engine protection system shall be included within the scope of the work.

The capacity of the battery shall be suitable for meeting the needs of the starting system.

The battery capacity shall be adequate for 10 consecutive starts without recharging with cold engine under full compression.

The scope shall cover all cabling, terminals, initial charging etc.

e. **Exhaust System** - The exhaust system shall be complete with silencer suitable for outdoor installation and silencer piping including bends and accessories needed for a run of 15 metre from the engine manifold.(Adjustment rates for extra lengths shall also be given). The total back pressure shall not exceed the engine manufacture's recommendation. The exhaust piping shall be suitably supported.

f. **Engine shut down mechanism-** This shall be auto/ manually operated and shall return automatically to the starting position after use.

g. **Governing System**- The engine shall be provided with an adjustable governor to control the engine speed within 5% of its rated speed under all conditions of load up

to full load. The governor shall be set to maintain rated pump speed at maximum pump load.

h. **Engine Instrumentation**- Engine instrumentation shall include the following:-

i) Lub. oil pressure gauge.

ii) Lub. oil temperature gauge.

iii) Water pressure gauge.

iv) Water temperature gauge.

v) Tachometer.

vi) Hour meter.

The instrumentation panel shall be suitably resident mounted on the engine.

Engine Protection Devices- Following engine protection and automatic shut down facilities shall be provided:-

i) Low lub.oil pressure.

ii) High cooling water temp.

iii) High lub.oil temperature.

iv) Over speed shut down.

i. **Pipe Work** - All pipe lines with fittings and accessories required shall be provided for fuel oil, lub.oil and exhaust systems, copper piping of adequate sizes, shall be used for Lub.oil and fuel oil. M.S. piping will be permitted for exhaust.

j. **Anti Vibration Mounting**- Suitable vibration mounting duly approved by Project Manager shall be employed for mounting the unit so as to minimise transmission of vibration to the structure. The isolation efficiency achievable shall be clearly indicated.

k. **Battery Charger**-Necessary float and boost charger shall be incorporated in the control section of the power and control panel, to keep the battery in trim condition. Voltmeter to indicate the state of charge of the batteries shall be provided.

E16. 3.18.3 **Pump Sets Assembly**

On the main fire sprinkler and hydrant headers near pump sets a 150 mm dia by-pass valve located in an accessible location shall be provided along with a rate of flow rota meter calibrated in 1 pm and able to read 200% of the rated pump capacity. The delivery shall be connected to the fire tank.

Each and every pump set assembly shall be provided with suction valve (only for positive suction head), discharge valve, non-return valve and 150 mm dia Bourdon type pressure gauge with isolation valve.

E16. 3.18.4 . **Flexible Connectors**

On all suction and delivery lines double flanged reinforced neoprene flexible pipe connectors shall be provided. Connectors should be suitable for maximum working pressure of each pipe line on which it is mounted and tested to a test pressure of 1:5 time the operating pressure. Length of the connector shall be as per manufacturers standard.

E17. PIPE WORK FOR FIRE FIGHTING SYSTEM

E17. 1 General

E17. 1.1 This Section specifies the manufacture, installation and material requirements of pipework systems.

E17. 2 Standards

E17. 2.1 Relevant Codes and Standards

ANSI B16.9 or relevant IS standard: Factory –Made Wrought Steel Butt welding Fittings

E17. 2.1.1 ANSI B16.21 or relevant IS standard: Nonmetallic Gaskets for Pipe Flanges

E17. 2.1.2 ANSI B31.1 or relevant IS standard: Power Piping

ANSI B16.5 or relevant IS standard: Pipe flanges and flanged fittings

ASTM A53 or relevant IS standard: Standard specification for Pipe, Steel, Black and Hot Dipped, Zinc-Coated, Welded and Seamless

E17. 2.1.3 ASTM A 135 or relevant IS standard: Standard specification for Electric resistance welded steel pipe or equivalent IS.

E17. 2.1.4 ASTM A 795 or relevant IS standard: Standard specification for black and hot dipped zinc coated (Galvanized) welded and seamless steel pipe for fire protection use.

E17. 2.1.5 ASTM D2000 or relevant IS standard: Standard Classification System for Rubber Products in Automotive Applications

E17. 2.1.6 BS 21/ BS EN 10226:2004 or relevant IS standard Pipes threads for tubes and fittings where pressure tight joints are made on the threads.

BS 143 & 1256 or relevant IS standard: Malleable Cast Iron and Cast Copper Alloy Threaded Pipe Fittings

BS 476 or relevant IS standard: Fire tests on Building Materials and Structures

E17. 2.1.7 IS 1239 & 3589: Steel tubes and tublars suitable for screwing.

E17. 2.1.8 BS 1560: 1989 or relevant IS standard Circular flanges for pipes, valves and fittings (Class designated). Steel, cast iron and copper alloy flanges. Specification for steel flanges.

BS 1965 or relevant IS standard: Butt welding pipe fittings for pressure purposes

E17. 2.1.9 BS 7874:1998: 1990 or relevant IS standard Specification for elastomeric seals for joints in pipe work and pipelines.

E17. 2.1.10 BS 2633: 1987 or relevant IS standard Specification for Class-I are welding of ferritic steel pipe work for carrying fluids.

E17. 2.1.11 BS 2971: 1991 or relevant IS standard Specification for Class-II is welding of carbon steel pipe work for carrying fluids or equivalent IS.

E17. 2.1.12 BS 3601: 1987 or relevant IS standard Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes

BS 3974 or relevant IS standard: Pipe Supports

BS EN 1092-1 or relevant IS standard: Circular Flanges for Pipes, Valves and Fittings (PN designated)

BS EN 1514-1 or relevant IS standard: Dimension of Gaskets for Flanges to BS EN 1092-1

BS CP 2010 or relevant IS standard: Codes of Practice for Pipelines

E17. 2.1.13 IS: 817: Part 1: Approval Testing of Welders for Fusion Welding: steels.

E17. 2.1.14 BS EN 499: 1995 or relevant IS standard: Welding consumables. Covered electrodes for manual metal are welding of non-alloy and fine grain steels. Classification.

E17. 2.1.15 BS EN 970: 1997 or relevant IS standard Non-destructive examination of fusion welds. Visual examination.

E17. 2.1.16 BS EN 1092-2: 1997 or relevant IS standard Flanges and their joints. Circular flanges for pipes, valves fittings and accessories, PN designated. Cast iron flanges.

E17. 2.1.17 BS EN ISO 1461: 1999 or relevant IS standard Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

E17. 2.1.18 ISO 7483: 1991 Dimensions of gaskets for use with flanges to ISO 7005.

E17. 3 Technical and Installation Requirements

E17. 3.1 Installation General

E17. 3.1.1 Pipes shall be heavy quality galvanized pipe. Following the welding and hydro testing the complete Fire Protection Piping System shall be wire brushed and applied with two coats of red oxide and then painted with 2 coats of Post office Red enamel paint.

E17. 3.1.2 The fittings will have wall thickness not less than those of the pipes.

E17. 3.1.3 The installation shall be neat and tidy, with accurate spacing between pipes, valves and joints, whether running in straight routes or turning through bends.

E17. 3.1.4 Particular care shall be taken that all pipework is erected and secured truly parallel with the building structure, clear of obstructions, preserving headroom and keeping passageways clear and that all vertical drops are plumb.

E17. 3.1.5 No bends or curves in any pipe shall be made so as to diminish the waterway or alter the internal diameter of the pipe.

E17. 3.1.6 Wherever possible, horizontal pipes shall be fixed to 'fall' to aid venting and draining down of the pipework. Eccentric reducing sockets shall be used on horizontal runs of pipe to prevent the formation of air pockets. On vertical pipes, concentric reducing sockets shall be used.

E17. 3.1.7 Drain outlets shall be provided at all low points of the system to enable emptying and to facilitate maintenance of the pipework.

E17. 3.1.8 Automatic or manual air vents shall be placed at each high point of each water line and discharge pipe shall be terminated at 50 mm above floor drain.

E17. 3.1.9 Pipe runs, where exposed, shall be positioned at least 100 mm from the finished wall surfaces to enable subsequent cleaning and painting of all surfaces. Where pipe runs are installed at an angle, they shall be positioned 40 mm from the finished surfaces.

E17. 3.1.10 All pipes shall be fitted clear of the floor to permit cleaning beneath the pipes. Where possible, a 125 mm clearance shall be provided between the underside of the pipe and the finished level of the floor and in no case shall the pipe be less than 100 mm clear of the floor.

Site welding shall be applied with pipe work unrestrained and each joint hydraulically tested at 1.5 times working pressure plus 350 kPa for 60 minutes without loss of pressure followed by application of appropriate protective coating, both internally and externally, prior to final installation.

E17. 3.1.11 All pipe runs when buried underground shall be tested and Approved before being covered.

E17. 3.1.12 Where it is not possible to install the pipework with setting out dimensions as shown on the Drawings, minor deviations will be allowed, subject to prior Approval.

E17. 3.1.13 Where pipes pass through walls and floors, steel pipe sleeves shall be provided to allow free axial movement of the pipes. Sleeves passing through walls shall be of sufficient length to fully enclose the pipe, from one side of the finished wall to the other side. Sleeves passing through floors shall protrude at least 50 mm above and below the finished floor and soffit to enclose the pipe.

E17. 3.1.14 All pipes passing through the roof shall be provided with at least 2.0 mm lead flashing sandwiched between the layers of waterproofing roofing membrane, and secured to the pipe with a galvanized spring clip.

E17. 3.1.15 Where pipes pass through water-containing chambers, puddle flanges of Approved design shall be provided.

E17. 3.1.16 Accessible pipes shall be flanged or with grooved coupling connected in sections of three nominal lengths for dismantling. Embedded pipework shall be in straight lengths as far as possible. Pipes with screwed joints shall be installed with grooved couplings at suitable positions for easy removal of equipment.

E17. 3.1.17 All pipe installations shall be provided with removable sections to facilitate pipe-cleaning operations.

E17. 3.1.18 Pipework shall rest freely upon supports and be carefully aligned prior to final connection.

E17. 3.1.19 All pipes on straight runs shall be lined up with facilities for pipes to be rotated for the process of welding joints to avoid welding from the bottom as far as possible.

E17. 3.1.20 During storage, all pipes shall have end covers fitted to prevent the ingress of any unwanted particles or waste.

E17. 3.1.21 During installation, all open ends of pipes shall be blanked off with blank flanges or pipe caps. These shall be removed only immediately prior to connecting to adjacent sections. As soon as pipes have been installed, all open ends shall be covered to prevent entrance of materials that would obstruct the pipes. Covers shall be left in place until removal is necessary for completion of the installation.

E17. 3.1.22 Damage to coatings or linings during material transport or handling on Site shall be repaired to the Engineer-in-charge's satisfaction before installation of the pipework and fittings commences.

E17. 3.1.23 The Engineer-in-charge reserves the right to reject any material deemed to be unsuitable for installation and such material shall be removed from the Site and be replaced with Approved material at no extra cost to the Employer.

E17. 3.2 Cleaning Procedures

E17. 3.2.1 Precautions shall be taken to avoid introducing foreign matter such as welding beads and slag or dirt into the piping system. Completed welds shall be hammered to loosen debris. Prior to assembly, all piping, valves and fittings shall be internally cleaned of oil, grease and dirt by wire brush and swabs.

E17. 3.2.2 Following fabrication and installation, all piping of 150 mm and smaller shall be cleaned by flushing with clean water, run to waste, until thoroughly free of all dirt, oil and cuttings. Generally, each size of pipe shall be flushed separately before being joined with larger size piping.

E17. 3.2.3 Piping of 200 mm and larger shall be cleaned by pulling through a steel brush for the entire length of each pipe size, followed by fibre brush or swabs. Brushes and swabs shall be slightly larger than the inside diameter of pipe being cleaned.

E17. 3.2.4 All cleaning operations shall be continuous throughout the piping system, except at joints required for final jointing of various sections of cleaned piping. After cleaning and until final joints are made, the end of sections of piping shall be tightly sealed off to prevent any dirt, water and other foreign matter from entering the pipes.

E17. 3.2.5 Before submitting completed piping systems for Approval, all strainers shall be inspected and thoroughly cleaned. Temporary strainers shall be provided where required for cleaning and flushing operations.

E17. 3.3 Installation

E17. 3.3.1 Steel welded fittings shall be of the same weight as the piping with which they are to be used complying with ANSI B 16.9 and ASTM A 234. Long radius welded

elbows shall be used at changes in the direction of the pipework. Welded tees shall be used for branches of the same size as the main pipe. Long radius reducing elbows shall be used at pumps. Reducing outlet tees shall be used for branches of smaller size than main pipe. Where the branch size is three or more pipe sizes smaller than the main pipe, steel gussets to provide full pipe strength shall be used. Where a branch is connected to screwed piping, a steel welded threaded socket shall be used. Eccentric welding reducing fittings shall be used at changes in pipe size for horizontal piping, with the top level in a horizontal line for water piping.

E17. 3.4 Jointing - General

E17. 3.4.1 All pipe jointing systems used shall comply with the requirements of this clause and the Particular Specification.

E17. 3.4.2 Pipes shall be cut in a neat manner without damaging the pipe. Unless otherwise approved by the Engineer-in-charge, cutting shall be done with an Approved type of mechanical cutter. Wheel cutters shall be used when practicable. Pipe ends shall be reamed to remove burrs.

Joints shall be in accordance with clause 3.2.3 of BS CP 2010 : Part 2 and clause 3.6 of BS CP 2010: Part 3.

E17. 3.4.3 Flanges and bolting for pipes, valves and fittings shall comply with BS EN 1092-1: Part 1 PN 1.6, or to other higher ratings as required by the system for which they are used.

E17. 3.4.4 For special applications in which couplings are required for jointing plain end pipes, grooved joints or slip-on-type couplings BS CP 2010: Part 2 Appendix B or similar couplings shall be used.

E17. 3.4.5 Mechanical Grooved Joints

E17. 3.4.5.1 M.S. pipe for working temperature upto 82^0C. of suitable wall thickness may be jointed by use of mechanical grooved pipe and couplings. Only jointing systems approved by the Loss Prevention Council, Bureau Vertitas or other similar authorities are acceptable.

E17. 3.4.5.2 Installation shall be by operatives trained by the manufacturer. The coupling shall consist of a combination of coupling pieces, water sealing gaskets, special nuts and bolts and grooves in pipe walls and shall be self-centering.

E17. 3.4.5.3 Grooves shall be properly cut or rolled at the pipe ends by machine and fully in accordance with the manufacturer's instructions and recommendations. Grooves shall be dimensionally compatible with the coupling.

E17. 3.4.5.4 Joint assembly, support details and positions shall be made in accordance with the manufacturer's instructions/descriptive leaflets.

E17. 3.4.6 Bellow expansion joints shall be provided for expansion and contraction in the pipework and also provided where the pipes cross construction expansion joints. The expansion joints shall be capable of absorbing axial and lateral movements.

Confirmation shall be obtained from the proposed expansion joint manufacturer on the suitable choice of the proposed joints.

E17. 3.4.7 Insulated joints shall be provided to all piping entering the boundaries of the Railway under Construction, including pipe connections to the city make up pipes and for pipes entering the tunnels. Details shall be submitted for Approval.

E17. 3.4.8 Flanges and unions shall be faced true. Flanges shall be provided with Approved gaskets, and made square and tight.

E17. 3.5 Gaskets

E17. 3.5.1 Gaskets shall be suitable for the temperature, service and pressure of the system and shall be, installed in accordance with the manufacturer's recommendations. Made up flanged joints shall be fabricated from one-piece ring gaskets, 3 mm thick, neoprene rubber.

E17. 3.5.2 For flanged joints between dissimilar metals or insulating flange joints; insulating gaskets, sleeves and washers between flanges, bolts and nuts respectively shall be used. Insulating material shall be "Teflon" or approved equal.

E17. 3.5.3 Joint rings and gaskets shall comply with the requirements of BS 7874 :1998 or BS EN 1514-1 but other materials may be used if they have been proved to be more suitable for their duty as recommended by the manufacturer, and Approved by the Engineer-in-charge.

E17. 3.6 Jointing-Particular

E17. 3.6.1 Where flanged joints are required for jointing galvanized steel pipes, galvanized steel screwed boss flanges complying with IS 6418 shall be used.

E17. 3.6.2 Screw joints shall be made with tapered threads properly cut. Joints shall be made tight with a stiff mixture of litharge and glycerin, or polytetrafluoroethylene tape, or other Approved thread joint compound applied to the male threads only. Not more than three threads shall show after the joint is made up.

E17. 3.6.3 Welded joints shall be fusion-weld in accordance with ANSI B 31.1, unless otherwise stated. Welded fittings shall be used when changing direction of piping. Mitring or notching pipe to form elbows and tees or other similar construction will not be permitted.

E17. 3.6.4 Branch connections shall be made with welding tees or forged welding branch outlets.

E17. 3.6.5 Site and shop bevels shall be in accordance with the recognized standards and shall be carried out by mechanical means or flame cutting. Where bevelling is carried out by flame cutting, the metal surfaces shall be cleaned of scale and oxidation prior to welding.

E17. 3.6.6 Before welding, the component parts to be welded shall be aligned so that no strain is placed on the weld when finally positioned. Align the height so that no part of the pipe wall is offset by more than 20 % of the wall thickness. Flanges and

branches shall be set true. Alignment shall be preserved during the welding operation.

E17. 3.6.7 All defective welds shall be removed and replaced at no additional cost to the Employer. Repairing of defective welds by adding new material over the defective welds or by peeling will not be permitted.

E17. 3.6.8 Electrodes shall be stored in a dry area and kept free of moisture or dampness. During fabrication operations the electrodes shall be stored in a heated container. Electrodes that have lost part of their coating shall not be used.

E17. 3.6.9 Flanges and unions shall be faced true. Flanges with Approved gaskets shall be provided and made square and tight. Union or flange joints shall be provided in each line immediately preceding the connection to each place of equipment or material requiring maintenance such as pumps, control valves, and other similar items. Gaskets shall conform to ANSI B 16.21 and ASTM D 2000.

E17. 3.6.10 Flanges

Fabricated Slip-on flat face flanges with or without hub conforming to ANSI B 16.5 class 150 can be used.

Welded piping: Steel, welding neck pattern,150 (1035 kPa) or 300(2070 kPa) WSP class, complying with ASME B-16.5, ASTM A 181 Grade 1,or BS EN 1092-1 shall be used.

Screwed piping; Flanges and flanged fittings on screwed and wrought iron piping shall be cast iron, standard weight, complying with ASME B-16.1, extra heavy weight complying with ASME B-16.2.

E17. 3.7 Supports General

E17. 3.7.1 Unless otherwise specified or indicated, all brackets, stays, frames, fixed and roller supports and hangers necessary to carry and support all pipes and valves shall be provided.

E17. 3.7.2 Structural steel required for proper installation shall be provided. All pipe supports shall be steel, adjustable for height and prime coated with antirust paint.

E17. 3.7.3 Supports shall only be attached to structural framing members. Where supports are required between structural framing members, a suitable intermediate metal framing shall be provided.

E17. 3.7.4 Piping shall be supported independently from all equipment so that equipment is not stressed by the weight of the pipe or expansion.

E17. 3.7.5 Valves or other heavy items of pipework equipment shall be fitted as near as practicable to a point of support, or fitted with their own supports.

E17. 3.7.6 Hangers, supports, guides and anchors shall be designed to allow expansion and contraction within stress limits of codes for pressure piping in accordance with Section 1 on Power Piping of ANSI B 31.1.

E17. 3.7.7 Supports shall be located to ensure that pipework branches of fittings are not restrained by the support during expansion or contraction of the pipework service.

E17. 3.7.8 Contact of dissimilar materials shall be avoided. Steel piping shall have steel supporting member actually in contact with the pipe. Pipes shall be supported on either side of changes of direction and pipeline mounted equipment.

Vertical piping shall beguided or supported in the centre of each riser with approved steel brackets to prevent swaying, sagging, vibration and resonance. Strain that causes lines to snake or buckle between supports or anchors shall be avoided.

Where piping is subject to a vertical movement due to thermal expansion of 3 mm ormore, hangers shall be of variable spring design. Variation of hanger force during operation shall range between 85 % and 120 % of the actual load.

E17. 3.7.9 Pipes fixed to walls or floors both vertically and horizontally shall be supported by brackets fixed to walls or supported from the floor.

E17. 3.7.10 All pipes in ducts shall rest on rollers and chairs, or hangers and be suitably arranged and supported to allow for expansion and contraction. All supports shall be fixed so that the full thickness of lagging can be applied in all places.

E17. 3.7.11 Pipe work supports and hangers shall be generally to BS 3974:Part 1 & 2. Details of all supports, hangers and accessories shall be submitted for Approval before installation.

E17. 3.7.12 In generally, all supports, hangers, anchors and fixing accessories shall be hot-dipped galvanized.

E17. 3.7.13 Design of the hangers shall be compatible with pipe or tubing to be supported.

E17. 3.7.14 The supports shall be of sound construction and shall be adequate for the weight to be carried and shall permit free expansion and good appearance and also permit piping runs to be readily dismantled where appropriate.

E17. 3.7.15 Support spacing. Unless otherwise specified, pipe supports shall be provided at intervals in accordance with the following table:-

(a) For Steel Pipes (Black or Galvanized)

Size of Pipe(mm)	**Maximum Intervals for Vertical Runs(m)**	**Maximum Intervals fo Horizontal Runs(m)**
15	2.5	1.8
20-25	3.0	2.5
32	3.0	2.7
40-50	3.6	3.0
65-80	4.5	3.6

100	4.5	4
150 and above	5.5	4.5

Also for each length of pipe minimum 2 supports should be provided.

E17. 3.8 Hanger Rods

E17. 3.8.1 Hanger rods of steel threaded and fitted with two removable nuts at each end for positioning rod and hanger and locking each in place shall be provided.

E17. 3.8.2 Unless otherwise specified, hanger rods shall be of the following sizes:**-**

Size of Pipe(mm)	**Single Rod Dia(mm)**	**Double Rod Dia(mm)**
15 to 50, inclusive	10	10
65 and 80	13	10
100 and 125	15	13
150	20	15
200, 250 and 300	22	20

E17. 3.8.3 Secure hangers from metallic inserts cast into concrete. When these inserts are not available, attachment by anchor bolts to be placed with fast setting high strength grout shall be used.

E17. 3.8.4 Hanger shall be placed close to the point of change of direction of a pipe in either a horizontal or vertical plane.

E17. 3.8.5 Supports and hangers for ductile iron pipe shall be placed as close as possible to joints. When hangers or supports are not within 300 mm of a branch line fitting, additional hangers or supports shall be provided.

E17. 3.9 Welding

E17. 3.9.1 Preparation for welding shall comply with the following requirements:-

(a) Welding of steel pipes

(1) Steel piping shall be mill-bevelled on both ends before welding, bevelled to $37\frac{1}{2}^{0}$.

Weld spacing on all butt welds shall comply with the following table:-

Nominal Pipe Wall Thickness	**Spacing**	**Bevel Angle**
6.35mm or less	3mm	$37\frac{1}{2}^{0}$
Over 6.35mmto 19.5mm	5mm	$37\frac{1}{2}^{0}$

(2) Backing rings shall be used on all butt-welded joints.

(3) Before starting any welding, all corrosion products and other foreign material from surfaces to be welded shall be removed by scraping, brushing, chipping and swabbing.

(4) Welding process: Welding shall be carried out by either manual shielded metallic arc process or automatic submerged arc process using direct current. All pipeline welding shall conform to Chapter 4,section VI,"Welding of Pipe Joints", of ANSI Code for pressure piping, ANSI BN 31.1 and in accordance with latest accepted practice applicable to the particular service. Welding procedure specifications shall be submitted for the Approval.

(5) Welding operation: Electrodes, voltage, current, thickness and number of passes or beads, shall be as previously specified. After deposition, each layer of weld metal shall be cleaned to remove all slag and scale by wire brushing and grinding and chipped where necessary to prepare for deposition of the next layer. Welded reinforcement shall be not less than 1.6 mm nor more than 3.18 mm above the normal surface of sections being welded. Reinforcement shall be crowned at centre and tapered on each side of surfaces being jointed. Exposed surfaces of weld shall present workmanlike appearance and be free of depressions below surface of jointed members.

(6) Weld metal shall be thoroughly fused with base metal at all sections of weld. Penetration of weld shall include unbevelled portion and extend to inside walls of pipe.

(7) Inspection: All welds shall be inspected visually and non-destructively by the Engineer-in-charge. The Engineer-in-charge reserves the right to order at random the examination of 2 % of the number of the welded joints for ultrasonic test by an independent firm nominated and paid by the Contractor. Should any one of the above welds prove faulty in materials or workmanship, further test of welds will be ordered up to a total of 4 % of the welded joints. If the number of welds failing the tests within the above 4 %, it is sufficient to suggest that an operative is not consistent in standard, the Engineer-in-charge may order any number of that welds to be removed and rectified at no extra cost to the Employer.

(8) Certification on the qualification of each welder in accordance with BS EN 287: Part 1 shall be submitted.

E17. 3.10 Testing

E17. 3.10.1 At Manufacturer's Premises or Testing Stations

(a) Samples of pipes and fittings shall be tested and certified to the relevant BS / IS. Test certificates shall be submitted for each batch/type of pipe and fitting to the Engineer-in-charge.

E17. 3.10.2 At Site after Installation

(a) All pipework, including valves and fittings shall be hydrostatically pressure tested at 1.5 times the duty head of the system or 1.5 times the closed delivery valve pressure of the pump whichever is greater. The pressure shall be held for a minimum period of 24 hours.

(b) The Contractor shall perform hydrostatic testing of all piping. Preliminary tests shall be carried out to demonstrate that the work is satisfactory. The Engineer-in-charge and all authorities having jurisdiction shall be notified in ample time to be present for final testing of all piping. Testing shall be carried out before painting or concealing any piping takes place. Defects disclosed by tests shall be repaired and the complete test repeated. Tests shall be carried out in stages if so ordered by the Engineer-in-charge to facilitate work of others. Use of wick in tightening leaking joints is not permitted.

Seismic Design Consideration

Seismic design shall inter alia provide for all the requirements given below:

a) Equipment shall be anchored i.e. its motion restrained and isolated from vibration as called for below:

i) All equipments and electrical panels shall be provided with restraints using resilient pads as shown in the drawings.

ii) Anchor bolts/expansion anchors shall not be less than 12 mm in diameter with 100 mm length of embedment in concrete.

b) Seismic provisions for pipes andconduits shown in the drawings are provisional and contractor shall have to make all provisions to meet design requirements.

i) Flexible connections shall be provided for all piping with equipment.

ii) Flexible connections shall also be provided for all piping and their supporting system at points of crossing at the building separation joints.

iii) Flexible connections/plenty of slack in wires and cables shall be provided at all connections with equipment and the same shall not be pulled tight.

iv) Flexible connections/plenty of slack in wires and cables shall also be provided for all cabling and their supporting system at points of crossing at the building separation joints.

v) Longitudinal bracing shall be provided for all cable trays at about 10 m c/c using mild steel angles.

c) Static analysis shall be done as per the formula given below to establish the lateral force developed by an earthquake.

Fp = Fo. I. Cp. Wp

Where,

Fp = Horizonatl seismic force developed in N.

Fo = Seismic zone factor to be taken as 0.25

I = Importance factor to be taken as 1.50

Cp = Horizontal force factor

= 0.75 for all equipment and associated conduit, piping and machinery rigidly mounted

= 2.0 for all equipment and associated conduit, piping and machinery resiliently mounted

The value of Cp for elements, components and equipment laterally self supported at or below ground level to be taken as two-third of the value given above.

The design lateral force determined using the above formula shall be distributed in proportion to the mass distribution of the element or component.

Forces determined using the above formula shall be used to design members and connections which transfer these forces to the seismic resisting system.

Forces shall be applied in the horizontal direction which results in the most critical loading for design.

Provisions for seismic requirements shall not be measured and paid for separately but shall be deemed to be a part of the equipment, piping, appliance, system etc.

E18. PIPING ANCILLARIES

E18. 1 General

E18. 1.1 This Section specifies the manufacture and installation requirements for gate valves, check valves, butterfly valves, motorized valves, gauge cocks, automatic air valves, strainers, stopcocks, pressure reducing valves, ball float valves, safety and pressure relief valves, pressure gauges, pipe sleeves, expansion loops, expansion joints, pipe anchors, gaskets for pipe separation and water closet connector.

E18. 1.2 All valves, taps and cocks shall be of the types and working pressures suitable for the systems to which they are connected and shall be approved by the Engineer. Valves shall be rated to withstand the system hydraulic test pressure.

E18. 1.3 Brass, bronze or cast iron valves shall generally be of 16 bar working pressure rating type. In addition, all valves at discharge side of transfer water pumps shall be of minimum 16 bar pressure rating.

Where valves are provided at the discharge side of 2 or more pumps, each valve shall be so selected to withstand effectively the anticipated system pressure under the worst case scenario.

E18. 1.4 All valves shall comply with British Standards or equivalent standards in respect of tests and working pressures, dimensions and materials of construction.

E18. 1.5 Wheel head valves shall be arranged for clockwise operation of the handle to close the valve.

E18. 1.6 Screwed valves shall have taper threads to BS 21/ BS EN 10226:2004 Flanged valves shall have dimensions and bolting in accordance with BS EN 1092-1:3.1.

E18. 1.7 Connections shall be made between each valve and the adjoining pipework or equipment with flanges for 65mm size pipework and above. Flanges shall be selected to suit working pressure and temperature.

E18. 1.8 Screwed connections shall be made between each valve and the adjoining pipework or equipment for 50 mm size pipework and below. A union shall be fitted on each side of all screwed valves.

E18. 1.9 All valves shall be suitably located in accessible positions for operation and maintenance purposes.

E18. 1.10 All drain outlets and manual air vents shall have connection pipes leading to the nearest drain.

E23.1.11 Valve packing shall be suitable for the service intended. Valve packing consisting of asbestos or asbestos based materials shall not be used.

E18. 1.12 Inverted mounting of valves shall not be permitted without prior approval of Engineer-in-charge.

E18. 1.13 All valves provided for manual operation shall have a hand wheel or other suitable device which shall be fixed to the valve. Hand wheels shall be rotated clock-wise to close the valves and shall be clearly marked with the words "OPEN" and "CLOSE" and arrows pointing in the appropriate directions. The rims of hand wheels shall be machined to a smooth finish.

E18. 1.14 Valves of identical make, size, type and duty shall be fully interchangeable.

E18. 2 Standards

E18. 2.1 Relevant Codes and Standards

E18. 2.1.1 BS 21/ BS EN 10226:2004: Pipe Threads for Tubes and Fittings where Pressure-Tight Joints are made on the Threads (Metric Dimensions)

E18. 2.1.2 BS 1010: Draw off Taps and Stop valves for Water Services (Screw down Pattern)

E18. 2.1.3 BS 1212: Float Operated Valves (Excluding Floats)

E18. 2.1.4 BS 2456 : Floats (Plastics) for Floated Operated Valves for Cold Water Services

E18. 2.1.6 BS EN 1171:2002: CastIronGateValves / Sluicevalve

E 30.2.1.7 BS 5152 : Cast Iron Globe and Globe Stop and Check Valves for General Purposes

E18. 2.1.8 BS 5154/ BS EN 12288:2003 : Copper Alloy Globe ,Globe Stop and Check, Check and Gate Valves

E18. 2.1.9 BS 5155: Butterfly Valves

E18. 2.1.10 BS 2879: Draining Traps (Screw Down Pattern)

E18. 2.1.11 BS EN 1092-1: Circular Flanges for Pipes, Valves and Fittings (PN Designated)

E18. 2.1.12 BS 5163: Predominantly Key – Operated Cast Iron Gate Valves for Water Work Purposes.

E18. 2.1.13 BS EN 1982: Copper and Copper alloy ingots and casting.

E18. 2.1.14 API-594 :Double Plate Check Valve

E18. 3. TECHNICAL SPECIFICATIONS

E18. 3.1 Globe Valves

E18. 3.1.1 Globe valves generally shall be used on service pipework as specified.

E18. 3.1.2 Globe valves up to and including 50 mm nominal diameter shall be generally rated, manufactured and tested to BS 5154/ BS EN 12288:2003. Valves over 50 mm nominal diameter shall be to BS 5152/ BS EN 13789:2002. Valves shall be of the same nominal bore as the pipework in which they are installed.

E18. 3.1.3 Bronze bodied valves shall be cast to BS 1400/ BS EN 1561. Valves with cast iron bodies shall be made to BS 1452/BS EN 1561. The bodies shall be of an even thickness throughout, clean and free from scale and flaws. Generally, valves up to and including 50 mm nominal bore shall have bronze bodies and valves of 65 mm

bore and larger shall have cast iron bodies, though bronze bodied valves may be used at any size.

E18. 3.1.4 Globe valves when used for circuit regulation shall have characterised plug discs. The discs shall be free to rotate, readily removable from the valve stem and renewable. Discs may be manufactured using proprietary composition type materials if approved.

E18. 3.1.5 Valves shall have packed stuffing boxes or alternatively shall be fitted with 'O' rings.

E18. 3.1.6 Valves up to and including 50mm nominal bore shall have BS 21/ BS EN 10226:2004 taper screwed ends, valves of 65 mm nominal bore and larger shall have BS EN 1092-1:3.1 flanged connections.

E18. 3.1.7 Regulating valves shall be fitted with a lockable indicator on the spindle to show the proportional opening.

E18. 3.2 Gate Valves

E18. 3.2.1 Gate valves generally shall be used on service pipe work, and shall be fitted as necessary. Valves shall be rated, designed and tested in accordance with BS 5154/ BS EN 12288:2003 for bronze valves and BS EN 1171:2002 / BS 5163 for those of cast iron manufacture. Valves shall be of non-rising stems and same size as the nominal bore of pipeline in which they are installed.

E18. 3.2.2 Bronze bodied valves shall be cast to BS 1400/ BS EN 1982. Valves with cast iron bodies shall be made to BS 1452/ BS EN 1561. The bodies shall be of an even thickness throughout, clean and free from scale flaws. Valves up to and including 50 mm nominal bore shall be bronze bodied, 65 mm nominal bore and larger may be bronze or cast iron.

E18. 3.2.3 Valve wedges may be of cast iron, bronze, nickel alloy or stainless steel. Cast iron wedges shall have bronze trim and seating. Slide valves shall be fitted with stainless steel springs. Wedges shall be renewable and free to rotate on the valve spindle.

E18. 3.2.4 Valves shall have packed stuffing boxes, or alternatively shall be fitted with 'O' rings.

E18. 3.2.5 Gate valves of 80 mm nominal bore and above for use in water supply system shall be of cast iron body with nickel alloy faces and stainless steel spindle or with nitrite resilient facing wedge gate and aluminium bronze stem and shall be entirely suitable for use with sea water.

E18. 3.2.6 Gate valves shall be tested as follows at the place of manufacture prior to dispatch to Site:-

a) Body Test

(1) With both ends closed and the gate in the open position, the body shall be tested to one and a half times the maximum working pressure for a minimum of 30 minutes. There shall be no visible leakage.

(b) Seat Test

(1) With one end open to the atmosphere and the gate in the closed position, the seat of the valve shall be tested for tightness when one and a half times the maximum working pressure is applied to the other end of the valve for a minimum of 30 minutes. The seat test shall be carried out in both directions. There shall be no visible leakage past the gate.

E18. 3.3 Check Valves

E18. 3.3.1 Check Valves shall be installed in the specified locations. Care shall be taken to ensure that the valves provided are suitable for installation in the plant required. In general, double plate check valve conforming to API 594 Specifications shall be used unless otherwise specified. Disc shall be centre guided and operated with stainless steel spring and trim to ensure smooth, positive opening and closing of valves with minimal pressure drop. Check valves shall not be installed in vertical pipes with downward flow.

E18. 3.3.2 Check valves generally shall be of 16 bar nominal pressure rating (working pressure).

E18. 3.3.3 Bronze bodied valves shall be cast to BS 1400 / BS EN 1982. Valves with cast iron bodies shall be made to BS 1452 / BS EN 1561. The bodies shall be of an even thickness throughout, clean and free from scale and flaws. Valves up to and including 50 mm nominal bore shall be of bronze. Valves on 65 mm nominal bore and larger shall be of cast iron.

E18. 3.3.4 Check valves shall be tested as follows at the place of manufacture prior to dispatch to Site:-

d) Body Test

(1) With both ends closed the body shall be tested to one and a half times the maximum working pressure for a minimum of 30 minutes. The pressure shall be applied to the inlet side of the body. There shall be no visible leakage.

(b) Seat Test

(1) With the inlet open to atmosphere, the seat of the valve shall be tested for tightness when one and a half times the maximum working pressure is applied to the outlet end of the valve for a minimum of 30 minutes. There shall be no visible leakage.

E18. 3.3.5 Inverted mounting of valves shall not be permitted without prior Approval by the Engineer.

E18. 3.3.6 Valves of identical make, size, type and duty shall be fully interchangeable.

E18. 3.4 Butterfly Valve

E18. 3.4.1 General: 16 Bar tight closing, wafer type, with resilient seats. Provide seats that cover inside surface of body and extend over body ends; or provide O-rings so that the valve body may be bolted and sealed between raised faced flanges with minimum bolt loading and without additional gaskets; or provide integral pipe ends to suit piping used, with pipe end faces concentrically grooved to seal against concentric protrusions in seat.

E18. 3.4.2 Butterfly valves shall comply with BS EN 593:1998.

E18. 3.4.3 Bodies: Ductile iron, cast steel, aluminum, or cast iron.

E18. 3.4.4 Seats: Material EPDM and shall be suitable for the temperature rating of the systems served.

E18. 3.4.5 Discs: Ductile iron or stainless steel grade 316 for fresh water.

E18. 3.4.6 Shaft Stems: Stainless Steel to ASTM A167, Type 316 for fresh water.

E18. 3.4.7 Control Handles / Levers: Suitable for locking in any position, or with 10 degree or 15 degree notched throttling plates to hold valve in selected position. Provide worm gear operators with large sized hand wheels for size 150 mm and larger.

E18. 3.4.8 A short piece of pipework with flanged ends shall be coupled to the butterfly valve to facilitate future isolation and dismantling of equipment for servicing.

E18. 3.5 Gauge Cocks

E18. 3.5.1 Gauge instruments shall be fitted with a gauge cock between the instrument and the service pipe.

E18. 3.5.2 Gauge cocks bodies shall be constructed from bronze and have a polished finish.

E18. 3.5.3 Gauge cocks shall be of the straight pattern ground plug type with lever handle.

E18. 3.5.4 All gauge cocks shall be of the 3 port type with the pipework on the drain / vent port extended to discharge clear of all equipment and insulation.

E18. 3.5.5 Gauge cock connections shall be in accordance with BS 21/ BS EN 10226:2004.

E18. 3.6 Automatic Air Vents

E18. 3.6.1 Automatic air vents shall be provided at all high points of the system as directed by the Engineer or as indicated on the Drawing. Connections to the service pipes shall be made at the highest point to ensure complete venting. Automatic air vents shall be mounted so that the inlet connection is in an exact vertical plane. A lock shield valve shall be located between the service pipe and the automatic air vent.

E18. 3.6.2 Automatic air vents for water systems shall have bodies of brass, gunmetal or malleable iron, non-ferrous or stainless steel floats and guides, and non-corrodible valves and rubber seats.

E18. 3.6.3 All automatic air vents shall be 20 mm diameter unless otherwise specified and shall be of the single large-orifice type suitable for the release or admission of air during system filling or draining. Automatic air vents bodies shall be constructed of

cast iron to BS 1452 Grade 14 and float guides from grade 316 stainless steel. Connections to the pipe work shall be via a screwed BSP connection.

E18. 3.6.4 A gate valve shall be provided between the automatic air vent and the connected pipe work to enable isolation of the automatic air vent for maintenance.

E18. 3.6.5 Units shall be designed to facilitate dirt removal while in service.

E18. 3.6.6 Automatic air vents shall be designed to open to discharge air or air / fluid mixture and to close firmly against fluid.

E18. 3.7 Strainers

E18. 3.7.1 Strainers shall be provided in pump suction pipes, water tank outlets and in the locations specified in the drawing. Strainers shall be of the same nominal bore as the pipeline in which they are fitted. Strainers shall be installed in a plane to ensure that filtered matter is retained within the screen.

E18. 3.7.2 Strainers shall be full line size, "Y" or "BASKET" type as specified and readily removable for cleaning.

E18. 3.7.3 Strainers of up to and including 50 mm shall be bronze bodied and have screwed end caps with a brass drain plug. Strainers of 65 mm and over shall be cast iron bodied to the requirements of BS 1452 with cast iron cover and mild steel stud bolts. The cover shall be complete with a 25 mm bronze drain valve, the outlet of which shall be capped with a brass plug.

E18. 3.7.4 Strainer connections shall be as for the pipeline in which they are installed.

E18. 3.7.5 Screens and baskets shall be of brass or stainless steel to suit the service intended. The total free area of the installed screen shall not be less than 5 times of the internal cross sectional area of the inlet pipe. Openings in the screen or basket shall be less than 1.2 mm in diameter.

E18. 3.7.6 Strainers for flushing water systems shall be of cast iron body and filtering medium of the strainer of stainless steel grade 316.

E18. 3.7.7 Strainers shall be of adequate strength to withstand the working pressure.

E18. 3.7.8 Strainers at the pump suction inlet shall be fitted with removable channel magnets, secured to the screen or basket by stainless steel retaining lugs and threaded rods, and placed to provide a continuous magnetic field around the entire circumference of the screen. They shall be fitted with a breech-locking arrangement to maintain the screen in place when removing the cover plate. The screen cover plate shall be bolted using studs with hexagonal headed nuts and shall be fitted with a special hinge. Initially each strainer shall be fitted with mesh lined baskets, reinforced on both sides with an open bottom. After initial cleaning, the baskets shall be replaced with a standard basket, suitable for the service required. All Y type strainers shall be complete with screw plug for drain or blow-off.

E18. 3.8 Stopcocks

E18. 3.8.1 Stopcocks for fresh water system shall be of bronze material conforming to BS 1010: Part 2 and the materials for constructing the stopcock shall be non-dezincificable type. They shall generally be able to withstand a working pressure of 16 bar.

E18. 3.9 Sluice Valve

E18. 3.9.1 Cast iron double flanged sluice valve shall be of approved make conforming to BS EN 1171:2002.

E18. 3.9.2 Sluice valve shall be provided with wheel when they are in exposed positions and with a cap top when they are located underground.

E18. 3.9.3 Contractor shall provide suitable operating keys for sluice valves with cap tops.

E18. 3.10 Pressure Reducing Valves

E18. 3.10.1 All bronze construction, spring loaded, single seated, suitable for tight shut off under dead-end conditions. Provide with renewable composition seat discs, nylon inserted diaphragm, bolted spring chamber and threaded connection.

E18. 3.11 Safety and Pressure Relief valves

E18. 3.11.1 Safety and pressure relief valves shall be provided for pressure vessels and be located in the positions as indicated on the Drawings or as specified in British Standards or local regulations for pressure vessels.

E18. 3.11.2 Valves shall be constructed in accordance with BS 759 and shall have stainless steel trims.

E18. 3.11.3 The valve size shall be carefully selected to match the plant and to give the appropriate degree of protection.

E18. 3.11.4 Safety valves shall be of the totally enclosed spring loaded type with padlock.

E18. 3.11.5 Relief valves shall be mounted with the centre line of the valve spindle in a vertical position to ensure that the valve reseats properly after operation.

Relief pipe connections shall be of equal bore to the vessel connection or as specified.

E18. 3.11.6 Relief pipes from valves shall be run in full bore tubing of the same quality as the service vessel or pipeline with which the valve is associated. The piping shall be carried clear of any insulation and arranged to discharge to a visible and safe position Approved by the Engineer.

E18. 3.12 Pressure Gauges

E18. 3.12.1 Pressure gauges, conforming to relevant BS specification shall have black enamel iron casing of 100 / 150 mm in diameter, threaded chromium-plated brass ring with heavy glass, bronze spring tube, red pointer, precision movement and micrometer adjustment. Provide pulsation dampeners, steel pipe fittings and shut off cocks of needle point globe type, all brass, for 10.35 bar positive (15 bars positive for fire systems) or those negative working pressure as required for the installation. Where

gauges are installed on thermally insulated surfaces, stand-off mounting devices shall be provided.

E18. 3.13 Pipe Sleeves

E18. 3.13.1 Provide **galvanized** steel pipe sleeves where pipes pass through walls, floors or as indicated on the Drawings. Sleeves shall be of sufficient size to allow free movement of pipes. The space between pipe sleeves and the pipe or insulation shall be completely caulked with a soft, non-setting waterproof mastic compound to give an air tight seal.

E18. 3.13.2 Pipe shall be free to move in pipe sleeves which shall not be used as pipe supports.

E18. 3.13.3 Where pipes pass through fire walls and floor slabs, a metal fire stop in the form of a 6 mm thick flange shall be welded around the pipe and located in the centre of the slab/wall thickness. The flange shall be same diameter as the internal bore of the pipe sleeve.

E18. 3.14 Expansion Joints

E18. 3.14.1 Provide expansion joint (axial, hinged and gimbal type) wherever expansion loops or change in direction of pipework expansion and contraction of pipework where otherwise expansion and contraction of pipework is not feasible. It shall confirm to relevant BS or equivalent standard.

E18. 3.14.2 Provide expansion joint at all building expansion joints, and wherever else expansion joints are specified, additional allowance shall be made by the provision of stainless steel articulated bellows type expansion compensators complete with all necessary guides as recommended by the manufacturer to give a working life of not less than 25 years. Each compensator shall maintain at least the same cross-sectional area as adjoining pipework for its entire length.

E18. 3.14.3 Ensure the expansion joints are adequately tied, anchored or removed to avoid damage to the bellows during sectional testing.

Expansion joints shall have stainless steel membrane and carbon steel fittings.

E18. 3.14.4 Design working pressure shall be as specified on the Equipment Schedules and/or Drawings while the testing pressure shall be at least twice of the working pressure. Designed life to be 12,000 (minimum) complete cycles of movement over the entire working range without failure.

E18. 3.14.5 Joint shall be securely held by guides on both sides.

E18. 3.15 Pipe Anchors

E18. 3.15.1 Provide anchor points constructed from **galvanized** iron bolted to the building structure.

E18. 3.15.2 Anchors shall be positioned in association with pipework change in direction, expansion joints and loops so as to absorb stresses due to pipework expansion

and internal pressures by transmission of such forces to the structure at appropriate points.

E18. 3.15.3 Anchors shall be constructed to withstand the highest thrust during piping hydraulic pressure testing.

E18. 3.15.4 All details, calculations and sizes of anchors shall be submitted for Approval prior to installation.

E18. 3.16 Pump Test Assembly

E18. 3.16.1 On the main fire sprinkler and hydrant headers near pump sets a 150 mm dia by-pass valve located in an accessible location shall be provided. Along with a rate of flow Rota meter calibrated in Lpm and able to read 200 % of the rated pump capacity. The delivery shall be connected to the fire tank.

Each and every pump set assembly shall be provided with suction valve, discharge valve, non return valve and 100 / 150 mm (As specified in Bill of Quantities) diameter Bourden type pressure gauge with isolation valve.

E18. 3.17 Vortex Inhibitors

E18. 3.17.1 Vortex inhibitor shall be FOC/LPC approved type with PN 16 flanges to BS EN 1092-1: Section 3.1.It shall be suitable for operation under positive head conditions. Internal diameter shall be same as the internal diameter of pump suction pipes.

E18. 3.18 Pressure Switch

E18. 3.18.1 Pressure switches shall be incorporated in the Fire fighting system to start all the fire pumps automatically in case of pressure drop in the system. The operating range and the differential range of the switch shall meet the control requirement of the systems.

E18. 3.19 Flow Switches

Flow switch shall have a paddle made of flexible material of the width to fit within the pipe bore. The terminal box shall be mounted over the paddle / pipe through a connecting socket. The switch shall be potential free in either NO or NC position as required. The switch shall be able to trip and make /break contact on the operation of a single sprinkler head. The terminal box shall have connections for wiring to the Annunciation Panel. The seat shall be of stainless steel. The Flow switch shall have IP:55 protection

Flow switches shall be provided on sectional mains and branch lines of sprinkler system, with each fire hydrant valve and hose reel connections as indicated on the drawings or required and directed by Engineer. The logic of the flow switches shall indicate the following:

When both the switches operate: Area covered by the down stream switch is in distress.

When only the upstream switch operates: Area covered between down stream switch and the upstream switch is in distress.

Contact rating shall be 230V, 5A. Single compression cable gland shall be suitable for 1.5 sq.mm copper, armoured, fire survival cables confirming to BS 7846.

Each flow switch shall be suitably earthed.

All the cables from the flow switches shall be led to a junction box located on each floor. Each junction box shall be provided with outgoing terminals with 20% spare for the following:

Lead from the junction box to local control panel to indicate the status of each flow switch which identifies a particular area of the floor;

A visual red bulb, one for each flow switch shall be provided on each junction box to indicate that the flow switch is in operation.

E18. 3.20 Drain Cocks

E18. 3.20.1 Drain cocks up to 25 mm diameter shall be manufactured from non dezincifiable copper alloy to comply with BS 2879, gland type lockshield pattern. Outlets shall be suitable for hose connection.

Drain cocks of 40 mm and 50 mm diameter shall be key operated gland cock manufactured from non-dezincifiable copper alloy with screwed inlet to BS 21/ BS EN 10226:2004, detachable hose union outlet and bolted bonnet.

E19. FIRE HYDRANT AND HOSE REEL SYSTEM

E19. 1 General

E19. 1.1 This Section specifies the manufacture and installation of Fire Hydrant and Hose Reel System which shall be provided in accordance withthe NFPA 14/ NFPA 130 and Local Fire Regulations.

E19. 1.2 The Fire Hydrant and Hose Reel System shall comprise of fixed fire services pump sets, pump motors, starters, pressure switches, fire services inlets, pipework, valves, electrical works, automatic air vents, fire hydrants and hose reels etc.

E19. 2 Standards

E19. 2.1 Relevant Codes and Standards

E19. 2.1.1 NFPA 14: NFPA standard for fire hydrant system

E19. 2.1.2 Codes and regulations of the jurisdictional authorities.

E19. 3 Technical and Installation Requirements

E19. 3.1 Quality Control

E19. 3.1.1 All methods, principles and details for Site cutting of components shall be submitted for approval.

E19. 3.2 Fire Hydrants

E19. 3.2.1 Each Hydrant assembly shall conform to IS 5290: Part 1.

E19. 3.2.2 The Hydrants shall be of **Stainless steel, SS 304**. Each outlet of the Hydrants shall be of female instantaneous type connection.

E19. 3.2.3 Deleted.

E19. 3.2.4 Deleted.

E19. 3.2.5 Deleted.

E19. 3.2.6 Pressure reduction shall be achieved by means of hydraulic pressure balancing with metallic diaphragm.

E19. 3.2.7 Contractor shall provide for each Fire Hydrant, two numbers of 63 mm diameter, 15 m long, **UL listed**synthetic hose pipe with gun metal / with stainless steel male and female instantaneous type coupling, machine wound with GI wire and SS branch pipe with nozzle. This shall be measured and paid separately

E19. 3.3 Hose reels

E19. 3.3.1 Hose reels shall either be of fixed type or recess swing type as shown on Drawings. Hose reels shall comply with IS: 12585 Type-II.

E19. 3.3.2 The hose shall have 25 mm internal diameter & 30 .5 m length and shall be capable of being readily wound round a drum without kinking. The hose together with the connections and gland shall be capable of withstanding a bursting pressure of not less than 2700 kPa.

E19. 3.3.3 Drums shall be constructed of 2.5 mm thick pressed mild steel, hydraulically balanced and free from denting and twisting, and finished in red stove enamel. The hub and shaft shall be fitted with a device to prevent over-run of the hose and having glandless centre seal.

E19. 3.3.4 Each hose shall be fitted with a polished brass jet and spray nozzle having 4.5 mm orifice and simple two way valve to turn on and off the jet nozzle. The valve shall not be spring loaded.

Hose Cabinets

E19. 3.3.5 Each internal station hydrant shall be housed in a Hose cabinet of suitable size. The Hydrant Cabinet shall hold single headed hydrant, 2 hoses, hose reel, set of extinguishers and one branch pipe as required. Internal hydrants Cabinets located in a public area shall fit the niche made for it and shall not cause obstruction to the movement of passengers. The cabinet shall be of minimum 1.6mm galvanized steel box, equipped with frangible type glass front panel (clear glass of–**45** mm thickness) complete with lockable door. A metal or plastic striker shall be provided in the vicinity of each steel box for the purpose of breaking the glass front panel in case of emergency. The box shall have one coat of primer and two coats of finish paint, the finish shall be red. A common key shall be used for all the padlocks. Five sets of key shall be provided.

.E19. 3.3.6 A stainless steel instruction plate of 1.5 mm thick minimum with engraved English and Hindi instruction and illustration on the use of the hosereel shall be provided and fixed near the hosereel or outside the hosereel cabinet. The size of characters shall comply with the requirement of DFS. The instruction shall contain the following information in English and Hindi:

To Operate Fire Hose Reel

- ❖ Break glass of the Fire Alarm Point or actuate Fire Alarm Point
- ❖ Open valve before running out hose
- ❖ Turn on water at nozzle and direct jet at base of fire

Not suitable for electrical fires".

E19. 3.3.7 Fire Brigade Connections

Breeching inlet shall be provided to enable the Fire Department to pump water into the wet main system. The breeching inlets shall be approved by the local authorities

The storage tank shall be provided with a 150 mm fire brigade pumping connection to discharge directly into the side of storage tank, but arranged to discharge not less than 150 mm above the top edge of the tank such that the water flow can be seen. The connection shall be fitted with stop valve in position approved by the Engineer.

The fire Brigade connection shall be fitted with four numbers of 63 mm instantaneous inlets in glass fronted wall box at a suitable position at street level, so located as to make the inlets accessible from the outside of the building. The size of the wall box shall be adequate to allow the hose to be connected to inlets, even if the door cannot be opened and the glass has to be broken.

A stainless steel plate indicating the type of inlets in Hindi and English characters using raised lettering shall be fixed to the wall near wall box.

In addition to the emergency Fire Brigade connection to the storage tank, a 150 mm connection shall be taken from the four 63 mm instantaneous inlets direct to Hydrant main so that fire brigade may pump to the hydrants in the event of the hydrant pumps being out of commission. The connection shall be fitted with a sluice valve and reflex valve. Location of these valves shall be as per the approval of Engineer.

Two way collecting head with two numbers 63 mm instantaneous type inlets shall be connected to the Fire Main header & Sprinkler Header. All other details shall be as above.

E19. 3.3.8 Orifice Plates

Orifice shall be used to restrict the hydrant discharge pressure within 6.9 kg/sq.cm. The orifice plate shall be made of SSplate with hole at centre. The plate thickness shall be 3 mm for pipe size upto 80 mm, 6 mm for pipes from 100 mm to 150, dia. Each orifice plates shall have a projecting identification tag.

E20. AUTOMATIC SPRINKLER SYSTEM AND WATER SPRAY SYSTEM

E20. 1 General

E20. 1.1 This Section specifies the manufacture and installation of Automatic sprinkler system and Water spray system.

E20. 1.2 Both systems shall be of the wet type as shown on the Drawings. Automatic sprinkler system shall be provided for Escalator pits, Refuse Store Room, Cleaner's room, EmergencyEquipmentRoometc as shown in the drawings and Water spray system shall be provided for Train Undercarriage area protection. The complete sprinkler installation shall comprise sprinkler control valve sets, sprinkler heads, pipework, pressure gauges, pressure switches, flow switches, sprinkler inlets, sprinkler pumps, jockey pumps, pump motors and starters, time delay relay, etc. Unlike Automatic sprinkler system, Water spray system shall comprise of medium velocity water spray nozzles and MotorizedButterfly valve. The whole sprinkler installation shall be installed and commissioned in accordance with the latest edition of NFPA-13 &UL-199 Listed. Water spray system shall be installed and commissioned in compliance with NFPA-15.

E20. 2 Standards

E20. 2.1 Relevant Codes and standards

E20. 2.1.1 Codes and regulations of the jurisdictional authorities.

E20. 2.1.2 NFPA-13: Standard for the installation of sprinkler systems

E20. 2.1.3 NFPA-15: Standard for water spray fixed systems for fire protection

E20. 2.1.4 NFPA-25: Standard for the inspection, testing and maintenance of water based fire protection systems.

E20. 2.1.5 UL-199: Standards for Automatic Sprinklers for Fire Protection Services

E20. 2.1.6 Compliance with the local fire brigade and the fire enforcing authorities.

E20. 3 Technical and Installation Requirements

E20. 3.1 Quality Control

E20. 3.1.1 The sprinkler systems shall be arranged with drainage provision.

E20. 3.2 Sprinkler Control Valve Set

E20. 3.2.1 The sprinkler control valve sets shall be "Wet type" as specified on the Drawings and shall be in full compliance with the NFPA - 13 and DFS requirements.

E20. 3.2.2 Each control valve shall comprise the following equipment as a minimum:

(a) One installation Main Stop Valve to BS 5153 with indicator to show whether it is open or shut.

(b) One automatic alarm valve.

(c) One valve manifold, including one 80 mm Test / Drain and 15 mm test valve with a maximum of 5 meters (with bends) of 80 mm drain pipe.

(d) Two pressure gauges to BS EN 837-1 with gauge connectors.

(e) All necessary fittings.

(f) One water availability test facility to serve one installation valve set or a group of valve sets connected to a common manifold pipe comprising:

(i) 80mm test pipe branch connection, off the manifold.

(ii) Direct reading flow meter of the shunt orifice type for Ordinary Hazard III classification to LPC requirements.

(iii) Butterfly isolation valves upstream and down stream of the orifice located in accordance with manufacturer's recommended test pipe configuration, vent and drain valves etc.

(iv) Discharge pipe work into the bunded area.

Over and above main isolation valve, there shall be a branch isolation valve and flow switch actuated alarm / annunciation for each area of the sprinkler system mainifold as per NFPA and approved drawings

E20. 3.2.3 Drain pipes connecting to the system shall be led to conspicuous positions as approved by the Engineer.

E20. 3.2.4 Deleted

E20. 3.3 Sprinkler Heads

E20. 3.3.1 Sprinkler heads shall fully comply with DFS requirements. The temperature rating shall $68^0/79^0$C for quartzoid bulb type sprinkler heads. The nominal size of sprinkler head shall be 15 mm diameter.

E20. 3.3.2 The sprinkler head shall be approved by UL/FM.

E20. 3.3.3 The metal parts of the quartzoid bulb sprinkler heads shall be chromium plated brass.

E20. 3.3.4 Metallic sprinkler protective guard shall be provided to each sprinkler head which is installed lower than 2 m from finished floor level or for those liable to mechanical damage.

E20. 3.3.5 Spray Nozzles

UL listedBrass / Stainless Steel Medium Velocity Water Spray Nozzle shall be provided for water spray system. The nozzles shall be suitable for maximum effective working pressure of 7 kg / cm^2 and for minimum working pressure of 1.4 kg/$cm^{2.}$

The nozzle shall be having external deflector and shall be brass or nickel plated finished.

Contractor shall get the approval of the sample from Engineer before ordering.

The spray nozzle must be handled with due care. For best results, the nozzle should be stored in the original package in which it has been shipped.

Nozzle which is visibly damaged shall not be installed. The nozzle shall be checked for corrosion, external and internal obstruction, blockage if any and shall be cleaned or replaced if required.

E20. 3.4 Commissioning and Testing

E20. 3.4.1 Commissioning and testing of the sprinkler system will comply with NFPA guide lines.

E20. 3.4.2 Before testing all pipe lines will be checked to ensure they are clear of obstructions. All mains will be filled with water and be thoroughly flushed out prior to testing. All defects revealed by the tests, will be remedied and the test will be repeated until a satisfactory result is obtained and witnessed by the Engineer.

E20. 3.4.3 Pipe work will be adequately secured against movement for both working and test pressure.

E20. 3.4.4 The Sprinkler Installation will be subject to a hydraulic test of 2 times of the working pressure or 13.8 bar whichever is the greater, which must be maintained for a period of 24 hour.

E20. 3.4.5 During the test inspection will be made of all joints to ensure no leaks are evident. Such tests will be witnessed by the Engineer and results recorded.

E20. 3.4.6 Valves under test will, wherever possible, be secured open and the pipe end closed with a stop end or blank flange to avoid damage to the valve or its seating.

E21. MISCELLANEOUS FIRE SERVICES EQUIPMENT

E21. 1 General

E21. 1.1 This Section specifies the manufacture and installation of Miscellaneous Fire Services Equipment which shall be provided according to the Drawings for the completion of the Fire Services Installation.

E21. 1.2 The whole installation shall be installed and commissioned in accordance with DFS requirements.

E21. 2 Standards

E21. 2.1 Relevant Codes and Standards

E21. 2.1.1 BS 1042: Measurement of Fluid Flow in Closed Conduits

E21. 2.1.2 Codes and regulations of the jurisdictional authorities

E21. 3 Technical and Installation Requirements

E21. 3.1 Portable Equipment

E21. 3.1.1 Carbon Dioxide (CO_2) and Water CO_2 type& Dry Chemical type (ABC) Type Fire Extinguisher

(a) CO_2 fire extinguishers shall be ISI marked.

(b) Fire extinguishers shall be constructed of Aluminum/Stainless Steel body, stainless steel discharge lever and fixed carrying handle with a heavy duty, brass chrome-plated valve body. The cylinder shall be CCE certified and certificates from CCE shall be furnished. The nozzle, valve assembly and discharge hose shall be IS 2878 marked. The body shall be of seamless manganese steel body conforming to IS 7285. The control valve shall be conforming to IS 3224 while the discharge rubber hose shall have a minimum burst pressure of 14 bar. The carbon dioxide gas shall be as per IS 15222 and IS 307. Water type Extinguisher shall be IS 940. The body shall be deep drawn sheet conforming to IS 513. The Gas cartridge shall be conforming to IS 4947. Water fill shall be 9 litres +- 0.5 litre. The cap ring shall be to IS 318 (Lead tin bronze), while the spring shall be corrosion treated conforming to IS 4454. The cylinder shall be tested to 30 bar pressure for 2 minutes.

(c) Sturdy wall hanger shall be provided for fixing of each fire extinguisher.

(d) Dry chemical powder shall be ABC Type confirming to Relevant IS Standard.

(e) Wheeled foam type fire extinguisher shall conform to IS:10204/13386. Foam fire extinguishers shall be rated in accordance with IS Standards, Class B with a capacity up to 50 litres of AFFF biodegradable foam agent, rated 20A:20B.

Extinguishers shall be mild steel powder coated construction with pressure gauge, pneumatic tired steel carriage hand cart, pull pin, trigger and discharge hose. Foam type fire extinguishers safety standard shall be in accordance with UL 8.

E21. 3.1.2 Sand Bucket

Sand buckets shall be galvanized steel painted in red and 0.01m^3 in capacity and filled with dry sand. Wooden/steel stand shall be provided for each sand bucket.

E21. 4 FIRE FIGHTER'S PROTECTIVE GEAR

SCOPE

This document covers specification for the fire fighter's thermal protective gear providing protection to the fire fighter's upper & lower torso, neck, arms & legs and shall comprise of coat, trouser, gloves, & anti-flash hood.

COAT AND TROUSER

GENERAL

The coat and trouser shall be supplied as a matched ensemble providing protection to upper & lower torso, including neck, arms to wrist & les to the ankles. They shall be of loose fitting to facilitate the ease and speed of dressing and to increase the air circulation. They shall be constructed as multi-layer assembly permanently attached to achieve the specified performance and containing:-

- Outer shell fabric
- Moister barrier
- Thermal liner

MATERIAL

The outer fabric shall be made from inherently flame resistant fibre like meta-aramid or equivalent. It shall be resistant to cut, tear, abrasion and puncture. The moisture barrier shall be made of breathable membrane laminated to flame-resistant carrier fabric providing water and chemical resistance while allowing for perspiration to evaporate. The thermal liner shall be made from inherently flame-resistant fabric such as meta-aramid, which shall be quilted to flame resistant scrim fabric providing insulation from radiant and convective heat.

The thread used for stitching shall be of high strength made from inherently flame resistant fibre like meta-aramid.

Heavy duty moulded open-end zippers with a single slider with FR zipper tape, hook and loop Velcro fasteners of flame resistance type shall be used.

DESIGN FEATURES (COAT)

The coat shall have two bellowed pockets each 20 cm long and 18 cm wide positioned at front bottom and attached with two rows of stitching. Storm flaps 6 cm long and 20 cm wide shall be provided for these pockets. The storm flaps shall be

secured to the bellowed pockets with Velcro fasteners. One pocket 20 cm long and 9 cm wide and 6 cm deep should be provided on the left side above chest for accommodating a radio set. All pockets shall have small drain holes at the bottom corner.

The front closure shall have a heavy duty molded open end zipper with a single slider with FR zipper tape. A flap shall be provided to cover the zip front closure and be secured by a flame resistant Velcro fastener.

The reflective tape 50mm wide should be positioned around the bottom hem, chest and sleeve.

Elbow reinforcement patches shall be provided at both elbows. Sleeves shall have knitted cuffs made from inherently flame resistant fibre such as meta-aramid and adjustable tabs secured by FR Velcro shall be positioned at each sleeve hem. All seams shall be two needle seams.

The coat shall have written FIRE on the upper back with reflective shape of not less than 20 mm width. The height of letter shall not be less than 150 mm.

TROUSER

Two bellowed pocket each 21 cm long and 17 cm wide shall be positioned on each leg above the knee area using two rows of stitching. The pockets shall have 6 cm long and 19 cm wide flaps secured by two FR Velcro closure patches. Drain hole shall be provided at bottom corner of each pocket.

Knee enforcement patches shall be provided at both knee fronts.

Waist adjustment straps with FR Velcro 5 cm wide and 12 cm long shall be positioned on the waist at both sides. An elastic suspender crossed over the shoulders and secured at the front shall be provided. These shall be attached to the rear to the trouser waist by heavy duty FR meta-aramid thread stitch. The front of the suspender should run through a high density polypropylene male part, quick release buckle, which affixes into a female part and further attached to a loop of main fabric on the garment front.

Fly front closure shall be with FR Velcro closure. Hanger tab shall be positioned on waist at rear.

A 50 mm reflective tape shall be positioned on both legs at the bottom.

PERFORMANCE REQUIREMENT

All performance requirement criteria as laid down in EN 469 shall be met and a test report to this effect from an independent laboratory/test house of international repute shall be furnished alongwith the Technical offer.

SIZE

The coat and trouser shall be supplied in small, medium and large sizes. The exact measurement of chest and waist shall be given at the time of supply order.

MARKING AND LABELING

The trouser and coat shall have individual label giving following information:-

- Name & Address of manufacturer.
- Year of manufacturer.
- Wash and care instructions.
- Composition of components.

GLOVES

The gloves shall be designed to meet the requirement of EN 659 or equivalent International Standard. The multi-layer gloves shall have the outer shell made of flame and abrasion resistant material and additional layers and liner made of flame resistant fibres such as meta or para-aramid. The layers shall be such that dexterity and strength are maximized. The cuff should be made with knit Flame resistant material. The gloves shall be stitched with high strength flame resistant thread such as meta or para-aramid.

ANIT-FLASH HOOD

A universal size, knitted, elasticized, 'balavlava' type anti-flash hood shall be made of inherently flame resistant fibre such as meta-aramid or having similar properties. The hood shall be designed to provided head and neck protection against flame contact and must be comfortable to wear. It shall conform to EN 340.

NOTE

Coat, Trouser, Gloves, and Anti-Flash Hood shall met the requirements of the standard specified and certificate to this effect from an independent laboratory/test house of international repute shall be furnished alongwith the Technical offer. A sample of each item shall also be submitted alongwith the Technical bid.

FIRE FIGHTER'S PROTECTIVE GEAR (HELMET)

SCOPE

This document covers specification for the fire fighter's thermal protective gear providing protection to the fire fighter's head.

HELMET

The helmet shall be a modular helmet with lightweight robust construction designed to meet the requirements of EN 443 or equivalent international Standard. The helmet shall incorporate the ratchet nape size adjustment to allow the size of the helmet to be adjusted while in or off the head so that single size of helmet fits most of the firefighters even with the chin strap undone. The shell of the helmet should be made of lightweight, unbreakable, inherently flame resistant material like

Kevlar/equivalent. The impact liner shall be designed to provide good head protection/cranial protection of the head. ?the chin strap shall be a two part chin strap made using polyester webbling with Snap-chin buckle. The helmet shall have 2.2 mm polycarbonate Face Shield. The face shield shall be 1800 rotation type fitted directly to the shell with screw, which can restrict the height the face shield rotation. The helmet shall have Neck Protectors/Ear Flaps fixed to the helmet by hook/loop Velcro attachment and shall provide flame protection.

NOTE

Helmet shall meet the requirements of the standard specified and certificate to this effect from an independent laboratory/test house of international repute shall be furnished along with the Technical offer. A sample of each item shall also be submitted along with the Technical bid.

FIRE FIGHTERS' PROTECTIVE GEAR (BOOTS)

SCOPE

This document covers specification for the fire fighter's thermal protective gear providing protection to the fire fighter's feet, and shall comprise of boots.

BOOTS

The fire fighters boot shall be CE marked and designed to meet the requirements of EN 345 or equivalent International Standard. Boots should have an outer shell of Flame Retardant Rubber/Leather and shall have lining for better insulation and heat resistance. Loops for assisting the wearing shall be provided. The size of boot shall be provided at the time of supply order.

NOTE

Boots shall meet the requirements of the standard specified and certificate to this effect from an independent laboratory/test house of international repute shall be furnished along with the Technical offer. A sample of each item shall also be submitted along with the Technical bid.

GENERAL REQUIREMENT

The set shall be self-contained open circuit type compressed air Breathing Apparatus set fully confirming to EN 137:1993, standard.

MASS

a) The mass of the ready to use set with facemask and fully charged compressed air cylinder shall not exceed 12.0Kg.

BACK PLATE (BODY HARNESS):

a) Anti-static backplate made from glass-filled polyamide material for resilience and impact resistance, with carbon fiber for strength.

b) Fitted with a rubber shocker at the base.

c) Should be orthopaedically designed.

d) Should be chemical, heat & flame resistant, lightweight, water resistant, anti-static & should have incorporated moulded carrying handles.

e) It shall be ergonomically designed with two integrated carrying handles.

f) All securing buckles shall be of the 'quick-release' type, designed for accessibility and easy handling with gloved hands without compromising security.

g) Cam-lock universal cylinder strap which can be adjusted to accommodate all standard cylinder sizes from 4 litre 200 bar to 12 liter 300 bar.

h) Cylinder strap shall be made from a material which allows flame retardancy and heat resistance and includes divider to accommodate twin cylinder configurations.

FACE MASK:

a) Full mask assembly shall be with reverted edge seal and made of EPDM material with flame resistance requirement meeting EN 136 standard.

b) Visor shall provide wide-angle, panoramic vision and be made of replaceable shock and heat-resistant polycarbonate material.

c) Visor shall be self-demisting type through special control of inspire air.

d) It shall be fitted complete with a speech device (stainless steel speech diaphragm) which should give excellent clarity and voice reproduction. Integral inner mask shall reduce dead-space and eliminate misting of visor.

e) A single size double reflex seal on the outer mask shall be provided to enable excellent sealing to the wearer's face and a perspiration drain shall be provided on the lowest part of the outer mask.

AIR CYLINDER:

a) The air cylinder shall have a minimum water capacity of 6.8 liters and free air capacity of min. 1800 liters when filled at a pressure of 300 bar and the test pressure shall be 1.5 times the working pressure.

b) Cylinder valve to be in line type.

c) The cylinder shall be aluminum lined, fully wrapped carbon composite material.

d) The weight of the cylinder when fully charged shall not be more than 8 Kg.

e) The cylinder shall be approved by CCOE and certificate to that effect shall be submitted along with the BID.

f) The cylinder shall be supplied with valve made from nickel plated brass and shall comply with EN 44 – 2.

PRESSURE REDUCER:

a) Small, light, sturdy & encapsulated pressure reducer with high air delivery (enough for 2 users).

b) The reducer must be able to accommodate optional attachments such as airline belt manifold or decontamination hose / 2nd lung demand valve connection.

c) The pressure reducer valve shall have a provision of safety pressure relief valve.

d) The pressure reducer valve shall comply with all the safety requirements stipulated under EN 137 – 1993.

e) The reducer shall be capable of supplying air a the rate 1000 lit/min at an input pressure of 180 bars.

f) The reducer shall be of the 'balance' type, ensuring that output pressure to the demand valve is stable and constant with varying input pressure down to 20 bars.

LUNG DEMAND VALVE:

a) The set shall be provided with plug-in quick removable type lung demand valve with rubber hose having a quick connect coupling connected to the low-pressure side of pressure reducing valve.

b) The LDV should be connected from the front side of the mask.

c) The LDV shall be servo assisted, tilting diaphragm/ a balance piston design lung demand valve offering stability, quiet operation & first breath activated with a centrally located switch off button & tough wrap around silicone cover incorporated in an elegant streamlined shape for easy handling – even when wearing gloves.

d) The LDV shall have flow not less than 500 liters per minute and shall activate at first breathe at 20 – 30 mbar.

PRESSURE GAUGE

a) Should be connected to the pressure reducer by a high pressure hose (Non Metallic outer surface).

b) Should have a luminescent dial.

c) Should be encased in a rubber cover.

d) Should be integrated with the warning whistle in a streamlined hose without any manifold block.

e) Warning whistle should be a self actuating of 90Db intensity.

f) Warning Whistle should be positioned on the shoulder in front of the user & close to the ear of the user.

g) Warning whistle should be high-pressure activated & medium pressure driven.

h) Warning whistle must operate at a residual cylinder pressure 5 +/-5 bar.

HOSES:

a) All the hoses used in the set shall be flexible and non-kinking type and shall permit the free movement of the head.

b) The design of the hose shall be such that it shall not restrict or close the supply at any time and shall not collapse.

c) The hose connected to the lung demand valve from the pressure reducer including the connector shall withstand twice the operating pressure of pressure reducer safety valve or at least 30 bar whichever is higher for minimum of 15 minutes.

d) The hoses shall be provided with necessary end connections for connecting the various parts of the set.

CARRYING CASE:

a) Set should be supplied in a single moulded tailor-made LLDP Carrying Case made for the set so that all components fit in proper space within the case & cylinder does not move about.

OPERATION AND MAINTANENCE MANUAL:

a) The manufacturer should supply operation and maintenance manual with each set +2 additional set in English language.

TECHNICAL SPECIFICATIONS OF WATER JEL FIRE BLANKET

1. Heat Shield burn therapy &Fire fighting blankets shall have pure wool base soaked in sterile protective water based gel.
2. The blankets shall be non-toxic & non-irritant having positive anti bacterial action.
3. Sizes are : 96” x 72” and 72” x 60”
4. Shelf life : 4 years (min).
5. Each blanket shall be packed in sturdy plastic barrels having handle for easy portability.

Healing/Medical Properties

6. The blanket shall give relief to a burn victim through its cooling, moistening and trauma reducing properties.
7. The blanket shall be impregnated with sterile water based gel. Gel should not be harmful.
8. For the first three years it could be utilized for both medical 9First Aid) and fire fighting purposes. For next one year it can be utilized for Fire Fighting only.
9. The Technical literature / leaflets provided shall mention above properties.

Approvals

10. The item offered shall be approved by at least one of the following agencies :- (a) Defence Institute of Fire Research (DIFR), (b) Directorate General of Health Services (DGHS).

Packing

11. Necessary information regarding usage and operation should be pasted on the container.

12. Each Water Jel Blanket container should be packed separately, suitably for transportation by sea.

SPECIFICATIONS OF SNAPLIGHT EMERGENCY EVACUATION SYSTEM

SEES is used for providing emergency evacuation and rescue light during emergency situation like disaster, accident, blackout in shortest possible time.

1. Simple and easy-to-use source of light, which is dependable and intrinsically safe.
2. The unit activates instantaneously at the pull of a handle (outer cover).
3. The system consists of a wall-mounted unit made of ABS fire retarded plastic.
4. The wall-mounted unit is made of three different parts viz.
   - The container which holds two cyalume light sticks.
   - The outer cover, which works as a handle also, has a glow-in-the-dark photo luminescent sticker visible from it is 3 exposed sides with instruction on it (the photo luminescent sticker helps in locating the unit in darkness0.
   - The lid.
5. The unit has two high-intensity yellow colour cyalume light sticks, which glow for 2 hours once the unit is activated.
6. Once used the light sticks can be replaceable with other cyalume light sticks called refill sticks for SEE. The sticks are replaceable by opening the lid and sliding the light sticks from top.
7. The unit has a tamper- proof pin to avoid misuse and theft of the light sticks and will be replaced along with refill after it is used. There should be a window or a provision to check the intactness of the tamper proof pin while it is well – mounted.

8. The high-intensity cyalume light sticks (refill) are a dependable source of light with no heat, no flame, no sparks and no batteries. They are lightproof, waterproof, windproof, non-explosive and non-toxic and can be

used in the presence of flammable and explosive substances, should be visible through smoke.

9. The Cyalume light sticks to be used in the SEES should be made with the reverse technology so that they can be kept insider the SEE system unwrapped, without affecting its life and performance due to adverse and different weather situations.

10. As per the tests conducted by the U.S. Consumer Product Safety Commission, the light sticks are not hazardous substances, under the Federal Hazardous Substance Act.

11. Undamaged and originally packed refill sticks (cyalume industrial safety light sticks) have got a shelf life of minimum 3 years and are packed in airtight outer foil wrapper. (expiry date mentioned on the individual foil wrapper of light sticks).

12. A S.E.E. System is installed at a regular distance in evacuation routes, restroom, lunch rooms, production areas, utility areas along with critical areas such as near fire extinguishers, exits, stairwells, alarms etc.

13. The ideal way to use a S.E.E. System during an emergency, is to locate the unit, activate it, remove lone light stick and leave the premises and leave the other light stick within the units as a stationary light source.

E22. FIRE ALARM AND DETECTION SYSTEM

E22. 1 General

E22. 1.1 This Section specifies the scope of work, manufacture, supply, design and installation, testing, commissioning of the Fire Alarm and Detection System.

E22. 1.2 The system shall be an intelligent addressable fire alarm and detection system. NFPA 130 shall be used as the guiding standard for the fire alarm and detection system. The system shall be designed in an integrated manner in accordance with NFPA-72, 2010 Edition, British standard BS 5839, BS EN 54, BS EN 60701, BS EN 60702-2, BS 8434, or ISO 7240, as appropriate or other internationally recognized and local code of practice.

E22. 1.3 **Scope of Work**

The scope of the work is to supply, installation, testing and commissioning of intelligent addressable fire alarm and detection system in compliance with codes and standard mentioned in this specification, Outline design Criteria and International best practices for station areas including platform level, concourse area, undercroft area, Ancillary building, tunnel cross passage, back of houses etc.

The Addressable Fire alarm system will comprise of the following:

- Micro-processor based Main Fire Alarm Panel
- Sub Alarm Panel/ Repeater Panel
- Analogue addressable Multisensor Detector, smoke detectors, heat detectors, Duct detector.
- Addressable manual call points
- Addressable Hooter cum strobe
- Batteries and charger
- Electrical wiring, conduits, trunking and accessories
- Communication driver at the FACP for interfacing with the ISCS
- Voltage free fire alarm signals through voltage free normally close contacts from the fire alarm system to the ITB; the contractors shall supply and install all ITB (except for ISCS interface) and connecting cables between the fire alarm system and ITB for all interfaces.

The Addressable Main Alarm Panel will be 8 Loop with a Loop capacity of minimum 250 devices. The panel will be located in the station control room and will have LCD alpha numeric display. PC based Workstation is required for event log of Main Fire alarm Panel.

The fire alarm panel will have the capability to process and evaluate incoming signals from addressable devices such as smoke detectors, heat detectors duct detector, combined optical and heat detectors, manual call point and I/O modules via Fire Survival Cables confirming to BS 7846:2009, BS 6387 CWZ BS EN 60701-1, BS EN 60702- part 2, BS 8434-2 as applicable. Fault isolators will be provided after every 20 devices.

The Fire Alarm System will be provided with input modules for interface with flow switches, and relay module for interface with the HVAC system and Output Module to Hooter cum strobe.

Other function of Fire alarm system will include:

- Link with Public address and voice alarm system
- Stoppage to lifts to next determination level
- Stoppage of all Escalators
- Tripping of HVAC system
- Input signal from Fire Pumps operation status through pressure switches
- To provide signal for dis-alarming of AFC (automatic fare collection) gates
- To be seamlessly interfaced with SCADA system
- Audio and strobes signal to areas in the station building in case of alarm

E22. 1.4 **Abbreviations**

	Abbreviation	Full Description
1.	BS	British Standard
2.	IS	Indian Standard
3.	EN	European Norms
4	ISO	International Organization for Standardization
5	NFPA	National Fire Protection Association, USA
6	NBC	NationalBuilding Code
7	TAC	Tariff Advisory Committee
8.	UL	Underwriter’s Laboratory
9.	LPCB	Loss Prevention Certification Board
10	FACP	Fire Alarm Control Panel
11	SAP	Sub Alarm Panel
12	AC	Alternating Current
13	DC	Direct Current
14	Hz	Hertz
15	LCD	Liquid Crystal Display
16	PVC	Poly Vinyl Chloride
17	FRLS	Fire Resisting Low Smoke

18	Mm	Milli Meter
19	IP	Ingress Protection
20	ECS	Environmental Control System
21	SCADA	Supervisory Control and Data Acquisition
22	DG	Diesel Generator
23	HVAC	Heating, Ventilation And Air Conditioning
24	ISMS	Integrated Station Management System
25	LED	Light Emitting Diode
26	C	Centigrade
27	GI	Galvanized Iron
28	RI	Response Indicator
29	CO	Carbon Monoxide
30	SVGA	Super Video Graphics Array
31	Ni-Cd	Nickel Cadmium
32	IEC	Importer Exporter Code
33	NEMA	National Electrical Manufacturer Association
34	NO	Normally Open
35	NC	Normally Closed
36	ASS	Auxillary Sub Station
37	TSS	Traction Sub station
38	LSZH	Low Smoke Zero Halogen
39	ITB	Interface Terminal Box
40	ISCS	Integrated Supervisory Control System

E22. 2 Standards

E22. 2.1 BS 4683/BS EN 60079: Electrical Apparatus for Explosive Atmospheres

E22. 2.2 BS 5445: Components of Automatic Fire Detection Systems

E22. 2.3 BS 5839: Fire Detection and Alarm Systems for Buildings

E22. 2.4 BS 6387: Performance Requirements for Cables required to Maintain Circuit Integrity under Fire Conditions

E22. 2.5 BS EN 54-1: Fire Detection and Fire Alarm Systems

E22. 2.6 BS EN 55104: Electromagnetic Compatibility

E22. 2.7 BS EN ISO 9000: Quality Management and Quality Assurance Standards

E22. 2.8 BS EN ISO 9001: Quality Systems Model for Quality Assurance in Design, Development, Production, Installation and Servicing

E22. 2.9 BS EN ISO 9002: Quality Systems Model for Quality Assurance in Production, Installation and Servicing

E22. 2.10 BS EN ISO 9003: Quality Systems Model for Quality Assurance in Final Inspection and Test

E22. 2.11 BS EN ISO 9004: Quality Management and Quality Assurance Standards

E22. 2.12 BS 7846/BS EN 60702-2: – Code for Fire Survival Cables.

E22. 2.13 IS 2189: 2008 Selection, Installation and Maintenance of Automatic Fire Detection and alarm System - Code of Practice.

E22. 2.14 Codes and regulations of the jurisdictional authorities and Jaipur Fire Service.

E22. 3 Technical and Installation Requirements

E22. 3.1 Quality Control

E22. 3.1.1 Provide equipments which are products of manufacturers who have made these products for a period of at least ten years, except that the console and the intelligent analogue type detectors and modules shall be the latest developed products which have been approved / listed by UL / LPCB. The system components such as control panel, detectors, line break isolator and modules shall be of the same manufacturer and under one family design.

E22. 3.2 Control Panel

E22. 3.2.1 The fire alarm control panel (FACP) shall be multi-zone control panel of the intelligent analogue addressable type, complete with power supply, battery charger, batteries.

E22. 3.2.2 The Fire Alarm Control Panel shall be located within the Station Control Room (SCR), with an interface to the Workstation for the Fire Detection & Suppression system. All the fire detectors, alarm devices and interfaces to other systems shall be connected via this panel.

E22. 3.2.3 The FACP shall be analogue addressable in a lockable housing with illuminated function keys and capable of full “stand-alone” operation. The FACP housing shall be to a minimum protection rating of IP 54.

E22. 3.2.4 The FACP shall be at least 8 loop control panel with loops expandable feature for all seven underground stations and of intelligent addressable type with a loop capacity of minimum 250 devices, complete with all alarm loop cards and input / output control interface, at least 120 LCD character display or greater, easily operable with acknowledgement, reset and silence facility with 21 inches LED monitor and appropriate with latest configuration printer with software. Intel core i7

Processor with 3.0 GHZ or higher, 4 GB RAM or above, 1 TB SATA HDD, Integrated Sound & Graphics Media Accelerator, optical scroll mouse , multimedia keyboard ,52x DVD Read / Write, Dual LAN card, 2 Serial port, 1 parallel port, 4 USB Ports, All hardware driver as required for smooth operation, Windows 7/XP 32 bit Desktop preloaded operating system with standard MS Office package, & along with latest antivirus version with updated security pack and minimum 3 year product licence validity, Auto recovery and auto archive software and suitable for operation on 230 volts A/C. 50 Hz,

E22. 3.2.5 Detection devices shall be connected via loops with a maximum acceptable length of 1.2 km. The FACP shall have indicators for information, isolation (including device isolated), alarms and faults (including system fault, device fault, and external fault and processor fault).

E22. 3.2.6 Activation of Manual call points or detectors shall be identified on the FACP identifying the loop number and detector address number including the associated Fire Alarm zone. This information shall be provided via a textual message on a separate screen integral to the FACP. Fire alarm panels shall be lockable with alarm/reset functions; On/Off controls and alarm disable controls. A facility shall be provided to allow operating access to authorised personnel. This shall be via key or password access.

E22. 3.2.7 The FACP shall be self-checking and shall have the facility to identify faulty/ contaminated devices or system malfunctions such that faulty status/condition shall not be confused with fire alarms. The loss or failure of any detector or alarm device shall be identified and displayed within 60 seconds.

E22. 3.2.8 The processor shall be capable of polling all field devices on a loop within three seconds.

E22. 3.2.9 A facility shall be provided to isolate a single device on a loop or a group of devices on a loop on a temporary basis. An illuminated warning indication shall be provided on the FACP, which shall remain lit until the isolation is removed.

E22. 3.2.10 The FACP shall have an integral clock, which shall be synchronized with the Station centralized clock system (provided by others). A facility shall be provided to allow for an external logging printer to be connected. The printer shall be located within the SCR. The station FACP shall be equipped with monitoring/relay points to relay status and alarm messages to the SCADA system.

E22. 3.2.11 Relays points shall be provided for:

a) FAP healthy signal,

b) Fire alarm condition,

c) Fire zone of such alarm condition,

d) Fire condition link to PA automatic messaging,

e) Non-synchronizing clock.

E22. 3.2.12 These relay signals shall be connected to the station communications equipment under the signalling and communications contract.

E22. 3.2.13 The FACP shall interface with other systems including but not limited to:

a) Ventilation Control System. The FACP shall send signals to the Ventilation Control Panel advising of zones in FIRE condition. The operation of dampers and fans etc in the event of a fire in a particular zone/s shall be carried out by the ventilation control system,

b) Sprinkler Systems. The system shall monitor waterflow for wet stand pipes etc as required. The FACP shall receive signals from the sprinkler flow switches to identify activation,

c) FACP shall also be interface with Public address and voice alarm system, lifts, Escalators, AFC gates, Electrical rooms, ECS, Fire pumps, SCADA system and all other systems as per requirement.

E22. 3.2.14 The response to alarms from various combinations of the detectors, flow switches, or manual call points shall, via the dedicated microprocessor, initiate performance of such other functions as required like:

a) Alert Station staff,

b) Alert Line controller,

c) Initiate operation of Fire Suppression Equipment,

d) On confirmation of Station Manager, initiate operation of Automatic Public Address System message,

e) Release Smoke stop doors held open,

f) Allow any emergency exit fastenings to open on transmission of the Evacuation signal,

g) Initiate illumination of Station No – Entry signs on transmission of the Evacuation signal (via SCR and Telecommunications),

h) Initiate closure of Fire shutters,

i) Initiate smoke extraction measures.

E22. 3.2.15 All detector and bell circuits shall be continuously monitored and a fault on any of these shall be indicated in the Main Fire Alarm Panel.

E22. 3.2.16 The FACP shall also control and monitoring of flow switches for Fire sprinkler system and control and monitoring of Gas suppression system.

E22. 3.2.17 Each system shall provide at least 25 % spare capacity for future expansion as per UL 864, 9th Edition.

E22. 3.3 Battery Charger and Batteries

E22. 3.3.1 A 24 VDC trickle type battery charger and batteries shall be provided. The unit shall incorporate the following components:-

a) Trickle charger assembly.

b) Rotary type selector switch.

c) One incoming double pole control fuse holder with suitably rated fuse.

d) SMF Lead Acid type Battery

e) Rectifiers and DC output voltage stabilizer

E22. 3.3.2 The unit shall be suitable for use on a 240 V AC single phase power supply and shall automatically maintain the 24 VDC batteries in a state approximate to full charge and at the same time to compensate for the standing load. The charger shall cater for re-charging the battery from fully-discharged condition to fully-charged condition in not more than 24 hours.

E22. 3.3.3 Batteries shall be of SMF Lead Acid type Batteryrequiring no maintenance throughout the normal life of the battery and shall be of capacity capable of maintaining the system in normal working condition for at least 48 hours without recharging and subsequently operating in the "alarm" condition continuously for at least one hour.

E22. 3.3.4 72 hours back up shall be provided to the indication lamp of the “sprinkler power loss”.

E22. 3.3.5 In selection of battery capacity, a deterioration factor of 0.9 minimum shall be applied.

E22. 3.4 Break-glass Units / Manual Call Point

E22. 3.4.1 Manual call point shall comply with BS 5839: Part 2. They shall be addressable type and shall be arranged to operate automatically upon pressing call point switch. The cover shall be locked in position with a special key and the glass panel shall be clipped firmly into place. It shall be manufactured in bright red compliant material, Operation shall be via a plastic membrane (non-breakable) with wording on method of operation in white lettering. The cover shall be etched in black lettering in Hindi and English “FIRE”, the letters measuring not less than 10mm high.

E22. 3.4.2 The surface of the Manual call point shall be provided with a LED indicator. It shall light up upon activation of the Manual call point. The operation of any call point connected to the system shall cause the station FACP to enter the alarm state within three seconds.

E22. 3.4.3 Contacts shall be of silver or approved non-deteriorating alloy, for normally close/open system. The voltage and current ratings of the contacts shall be marked within the unit.

E22. 3.4.4 The units shall be of the flush mounting type and suitable for direct connection to the type of wiring system therein specified without the addition of unsightly surface boxes, glands and adaptors. Special boxes compatible with the conduit system shall be provided where necessary for installation of the call points.

E22. 3.4.5 Manual call point shall be positioned at a height of 1.4m at strategic points throughout the station such that they are clearly visible from front and sides as practicable and Manual call point shall be located so that one is within 60 meters of any point in the station. Provide flush plates for the recess mounting units.

E22. 3.4.6 Each Manual call point shall be accompanied by an alarm bell except those installed in concourse and platform areas where no alarm bell is required. The alarm bells and flashing light units shall actuate upon receipt of a fire alarm signal from any of the Manual call points or detection systems.

E22. 3.4.7 Each Manual call point shall be complete with built-in testing slot, such that testing can be carried out by insertion of the test key without removing the glass front cover of the unit

E22. 3.5 Detectors

E22. 3.5.1 General

a) Unless otherwise specified, smoke detectors shall be of multisensor type.

b) Detectors shall comply with BS 5445: Part 1, LPCB/ UL 864, 9th Edition listed or equivalent standard, multi-sensor. The internal circuits shall be of solid state device and shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry shall be protected against typical electrical transients and electromagnetic interference based on BS EN 55104 and IEC 61000 to include IEC 801-2, IEC 801-3 and IEC 801-4.

c) Each detector shall carry a built-in address via easily understood decade switch.

d) There shall be a built-in magnetic test switch in each intelligent device.

e) Built-in testing facility shall be provided based on NFPA 72, 2010 Edition requirements.

f) The detector base shall have a positive mechanical means to hold the removable portion of the device. However, such provision shall provide a simple means to remove the detector from the base, either by hand or by the use of a special tool that can plug-in and/or remove the detector head from a distance of up to 6 m above floor level.

g) Detector base shall be compatible for connection of all types of analogue addressable detectors and shall have the facility to drive a remote visual alarm indicator which shall be provided for all concealed detectors. Remote indicator shall be compatible with the detector so that the operation of the indicator will not impair or affect the brightness of the detector’s built-in LED.

h) There shall be LEDs on the detector head so that alarm condition of the detector can be seen clearly from any direction or angle.

i) The designed operating range of detectors shall be between 0^{o}C and 50^{o}C and up to 95% RH non-condensing.

j) There shall be at least 3 levels (high, medium and low) of sensitivity, as approved by the agency listed or by Jaipur Fire and Emergency Services, which can be selected at any time at the FS control panel or by automatic day/night sensitivity change over program which shall be built into the FS control panel.

k) Detector shall be low profile, no more than 60mm in height including the base to minimize dust accumulation at detector head, resulting from the pattern of airflow.

l) The remote indicator with labelling shall be provided for all detectors installed above false ceiling as specified in clause (g) of this Specification.

m) Labels shall be provided adjacent to all detectors with appropriate letters indicating the corresponding address and letters shall be of not less than 20mm high.

E22. 3.5.2 Multi-Sensor Detectors

a) The multi sensor detector shall be a microprocessor based and operate on light scattering principle, containing an emitter and photo sensor. The scattered light reaching the photo sensor shall be proportional to the smoke density inside the detection chamber. It will combine both optical smoke and heat detector technology to detect clear burning fire products, which hitherto could only be easily detected by ion-chamber detectors. The detectors will not operate on a rate of rise of temperature alone. It shall meet the UL standard and comply with BS EN: 54 Part 15 or equivalent as appropriate.

b) The detector shall utilize advanced algorithms with time based analysis to provide early warning and an accurate analysis of alarm situations.

c) Under normal ambient conditions, the optical detector will behave as a normal optical detector. Only when a rapid rise in temperature is detected, the sensitivity of the detector shall increase together with the presence of smoke shall confirm a fire condition, which will be transmitted as a fire alarm level.

d) The detector will be fully compensated for temperature, humidity and barometric changes in the environment. All electronic components shall be hermetically sealed to prevent their operation from being impaired by dust, dirt, humidity, corrosion or mechanical shock. All circuitry must be protected against typical electrical transients and electromagnetic interference according to BS 6667: Part 3. The detector

will be fully operable between -20°C and + 70°C and up to 95% relative humidity non-condensing.

e) The Sensitivity shall be adjustable by means of a pre-set control only accessible by use of a special tool. Built-in wind-shields will be provided to ensure that air velocity of up to 10 meters / second do not affect the proper operation of the detector. The Combined Optical smoke & Heat detectors will be installed in the Mechanical Plant room areas.

E22. 3.5.3 Heat Detectors

a) Heat detector shall be an analogue addressable type designed to raise an alarm when the temperature is at a rate-of-rise of 8 °C per minute or higher or at a fixed alarm temperature of 57 °C. It shall comply with BS 5445: Part 5 Grade 1, UL 862, 9th Edition listed and Jaipur Fire and Emergency Services approved.

b) The detector shall employ two matching thermal sensing elements in a bridge configuration to give a response, which depends both on absolute temperature and rate of change of temperature. The reference and sensing thermal sensors shall be fabricated under identical conditions to ensure good matching and tracking with both temperature and ageing.

E22. 3.5.4 Probe Type Smoke Detectors

a) Probe type smoke detectors shall be installed in the supply or return air duct of all AHU/ PAU and ventilating fans as stipulated in the relevant Specification, and/or as shown on the Drawings.

b) Installation details shall comply with NEMA and NFPA standards.

c) An audible and visual alarm signal shall be provided at the Station Control Room of the respective station which upon receipt of a signal from the probe type smoke detector shall initiate the audible and visual alarm on the FS control panel and shut off the corresponding ventilating fans, fan units of the AHU and/or fan units of PAU.

d) Detectors shall be supplied with multisensor or photoelectronic detector heads and complete with, but not be limited to, the following:-

(1) Housing base and cover assembly;

(2) Sampling tube filters;

(3) Test and reset switch;

(4) Drilling template;

(5) O-rings;

(6) Tube bushing seals;

(7) Sampling tube.

(8) Filter adaptor; and

(9) Tube end plug.

e) Each smoke probe unit shall comprise a perforated inlet tube across the inside of the duct at 90^0 to the air flow and an expansion chamber containing an ionization or photoelectronic smoke detector.

f) The smoke probe unit shall contain a clear polycarbonate cover for convenient visual inspection.

g) The smoke probe units shall be either of the same addressable analogue type or conventional type ionization/photoelectric smoke detectors as specified with a suitably designed duct adapters. The whole assembly shall be suitable for monitoring air movement of up to 25 m/s.

h) For conventional type smoke probe unit, it shall be designed for standalone operation and powered by 240 V AC, or 24 V AC or DC power source.

i) The complete assembly (smoke detector with duct adapter) shall be supplied as a single unit for.

j) Connection of remote indicator shall be also available and compatible with the smoke probe unit so that the operation of the indicator shall not impair or affect the brightness of the detector's built-in LED.

E22. 3.5.5 Hooter cum Strobe

a) All the areas of Underground station shall be provided with sounder cum visual strobe units rather than public movement area. Public movement area shall be provided with strobe unit.

b) The unit shall be wall mounted, approved color, suitable for operation on 12V/24V with following features.

c) Visual Characteristics: The visual strobe shall consist of Xenon flash tube with associated lens / reflector. The feature selectable candela outputs (15, 15/75, 30, 75 or 110). The flash rate shall not exceeds two flashes per second (2Hz) and nor less than one flash per second (1 Hz) through out the listed operating range of appliances.

d) The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe.

e) Sounder pulse rate and decibel level above the ambient shall comply with NFPA standards. The unit shall be tapped for 1/4, 1, 2 and 4 watts outputs.

f) Strobe shall be placed wall mounted in corridors no more than 4570 mm (15 feet) from the end of a corridor with 30.48 m (100 feet) maximum distance between strobes. Where there is an obstruction to the viewing path in the corridors, such as a cross-corridor door or ceiling elevation change, consider the obstruction as defining a new corridor.

Strobe Unit

a) Visual Characteristics: The visual strobe shall consist of Xenon flash tube with associated lens / reflector. The feature selectable candela outputs (15, 15/75, 30, 75 or 110). The flash rate shall not exceeds two flashes per second (2Hz) and nor less than one flash per second (1 Hz) through out the listed operating range of appliances.

b) The light pattern shall be disbursed so that it is visible above and below the strobe and from a 90 degree angle on both sides of the strobe.

c) Strobe shall be placed wall mounted in corridors no more than 4570 mm (15 feet) from the end of a corridor with 30.48 m (100 feet) maximum distance between strobes. Where there is an obstruction to the viewing path in the corridors, such as a cross-corridor door or ceiling elevation change, consider the obstruction as defining a new corridor.

Flashing Light Units

(a) Flashing light units shall be of flush mounted pattern complete with red indicating lights.

(b) Each unit shall consist of one tungsten bulb and shall be fitted with all necessary flashing and control provisions. The unit shall be suitable for 24 VDC operations.

(c) The dimensions, construction and design details of the unit shall be in accordance with section 6-4 of NFPA 72 or other standards as acceptable to Jaipur Fire and Emergency Services.

(d) Flashing light unit installed outdoor shall be of weatherproof type and shall be designed to IP55 or better.

E22. 3.7 Fire Alarm Cables

E22. 3.7.1 Detector cable loops shall be fire survival screened cables complying with BS 7846:2009, BS 6387 CWZ EN 60701-1, BS EN 60702- part 2, BS 8434-2, and it shall be “Class A” wiring as per NFPA 72. The Contractor shall submit calculation on the overall current consumption and voltage drop in each detection loop in normal and alarm condition to substantiate their equipment selection.

E22. 3.7.2 All detection loops/network wiring shall be minimum size of 1.5mm^2 twisted pair, screened, fire survival cables complying with BS 7846:2009, BS 6387 CWZ, BS 8434-2 /BS EN 60702-1 category CWZ (as specified in Section 2.0 of Technical specifications).

E22. 3.7.3 All 24V DC power supply lines shall be minimum size of 2.5mm^2 fire survival screened cables complying with BS 7846:2009, BS 6387 CWZ BS EN 60701-1, BS EN 60702- part 2, BS 8434-2.

E22. 3.7.4 A separate cable tray, trunking or conduit shall be provided for fire alarm cables and 20% spare capacity shall be provided in cable trays/ trunking. All cable containment shall be of galvanized iron (GI) material.

E22. 3.8 Interfacing Relay Module

E22. 3.8.1 Signals to control other systems by means of dry contacts shall be equipped with a 24V DC relay, with dry contact rated at not less than 2A 240 VAC. The relay and terminal block shall be housed in a covered galvanized steel or stoved enamel steel box with adequate size to house all relays but in no case smaller than 110mm by 100mm by 50mm. Terminals shall be labelled clearly by means of silk screened or engraved lettering in metal or plastic plate.

E22. 3.9 Printers

A hard copy multi-colour graphics laser printer for recording graphic displays and associated dynamic data having Print speed - Black: up to 20 ppm; colour: up to 4 ppm, First page out - 18 seconds black, 29 seconds colour, Resolution - 600 by 600 dpi, Memory - 64 MB built-in SDRAM; expandable to 192 MB with one open memory SDRAM DIMM slot, Duty cycle - 30,000 pages per month, Media, Types Paper (plain, letterhead, bond, colour, rough, pre-printed, recycled), Glossy Media, Cover Paper, Colour LaserJet Transparencies, labels, envelopes, and card stock, Compatibility - Interfaces Hi-Speed USB 2.0, IEEE 1284-B complaint parallel port, Languages - PCL 6 and Postscript level 3 emulation with automatic language switching, Font capabilities - 80 True Type TM internal scalable PCL 6 fonts; 80 True internal.

E22. 3.10 Monitor Modules

E22. 3.9.1 Addressable contact monitoring module shall communicate via the detection cable loop with the FS control panel for continuous monitoring of any NO or NC dry contacts connected including breakglass, flow switch and repeating dry contact signals from gas flooding system and gas detection system. LED indication shall be provided to show the status of the module.

E22. 3.11 Control Modules

E22. 3.10.1 Control module shall provide an addressable output for a separately powered alarm indicating circuit or for a control relay and housed in covered galvanized steel or stove enamel steel box with sufficient size to house all modules.

E22. 3.10.2 The control module shall provide a supervised indicating circuit where indicated on the Drawings. Any open/short circuit fault shall be detected/highlighted/displayed at the FS control panel. Subsequent fire alarm signals shall activate the appropriate controls and signaling devices despite of the fault conditions.

E22. 3.10.3 The control module shall act as a control relay where required.

E22. 3.10.4 The control module shall contain a LED which blinks upon being scanned by the FS control panel. Upon activation of the module, the LED shall be latched on.

E22. 3.10.5 Status of control module shall be fed back to FS control panel and print out automatically once it is activated.

E22. 3.12 Fault Isolator Modules

E22. 3.11.1 Fault isolator modules shall detect and isolate a short-circuited segment of a fault-tolerant loop.

E22. 3.11.2 The module shall automatically detect a return-to-normal condition of the loop and restore the isolated segment.

E22. 3.11.3 Modules shall be provided for every 20 field addressable devices to limit the extent of devices affected in the event of a short-circuit. A minimum of two fault isolator modules shall be provided for one detection line loop.

E22. 3.13 Repeater Panels

E22. 3.13.1 Remote repeater panels for repeating all alarm status indication with LCD display shall be provided at the specified location and shall be Jaipur Fire and Emergency Services approved.

E22. 3.13.2 The repeater panel shall be fully stand alone complete with power supply, charger/batteries. The SAP will have its own micro- processor, software, and memory capabilities and provide indication for alarmed and troubled/faulted condition in each loop. All software (i.e. Programs and data system configuration) will be held in non-volatile ROM / EPROM.

E22. 3.13.3 The repeater panel shall be provided with warning buzzer which shall activate when an alarm occurs in the fire control room and a push switch shall be provided for silencing the warning signal. Lamp test control switch shall also be provided in the panel.

E22. 3.13.4 The panel shall contain an integral backlit LCD display of minimum 120 characters and built-in printer as per this Specification. LCD display shall be viewable through the panel door.

E22. 3.13.5 The repeater panel enclosure shall be flush mounted and all electronics shall be contained in the enclosure. Access to the repeater panel switches shall be protected by key-switch.

E22. 3.13.6 The panel construction shall be as per Specification.

E22. 3.14 Fire Zone Mimic Panel

E22. 3.14.1 An LED Fire Zone Mimic Panel**of size 900mm x 900mm, powder coated 2 mm thick,** shall be located in the Firemen's Staircase adjacent to the auxiliary FAP.

E22. 3.14.2 This panel shall provide a pictorial representation of the Station Layout identifying the zone boundaries and is intended to aid the fireman in the identification of the area of the station in fire condition.

E22. 3.14.3 In the event of a detector in a particular zone going into fire condition the associated Zone LED shall illuminate on the mimic panel.

E22. 3.15 Response Indicator

Response indicator of LED type shall be provided for above false ceiling and below false floor detectors and these shall be mounted outside/ inside the rooms wherever asked for by the Contractor/Employer representative for indication of fire through detector in the room. The design & colour shall be as per the standard.

SUMMARY OF FIRE PROTECTION SYSTEM				
Room /Area Ref. No.	Description	Sprinklers	Optical Smoke / Heat / Multi-Sensor Detectors	Inert Gas Flooding
U01	Station Entrance & Passageways		Yes	
U02	Concourse Public Area		Yes	
U03	Station Control Room		Yes	
U04	Station Manager Room		Yes	
U05N	Ticket Office (TOM)		Yes	
U05S	Ticket Office (TOM)		Yes	
U06N	Cash & Ticket Supervision			
U06S	Cash & Ticket Supervision		17.	
U07	Customer Care (EFO)		Yes	
U09	Security/Police Room		Yes	
U10N	Store (Stationary etc)	Yes	Yes	
U10S	Store (Stationary etc)	Yes	Yes	
U11	Store(Maintenance Equipment)		Yes	
U12	Cleaners Room	Yes	Yes	

18.	Staff Locker Room	Yes	Yes	
19.	Staff Locker Room	Yes	Yes	
U16N	Staff Mess Room		Yes	
U16S	Staff Mess Room		Yes	
U18N	DB Room		Yes	20.
U18S	DB Room		Yes	
U19	ECS Plant Room		Yes	
U20N	TVF Room		Yes	
U20S	TVF Room		Yes	
U22	Signaling Equipment Room		Yes	
U23	Telecom Equipment Room		Yes	
U24	S & T Room		Yes	
U25N	Auxilary Sub Station Room		Yes	21.
U25S	Auxilary Sub Station Room		Yes	22.
U26N	Station UPS/ Battery Room		Yes	
U26S	Station UPS/ Battery Room		Yes	
U27	Inert Gas Room		Yes	
U28	CDMA Room		Yes	
U29	GSM Room		Yes	
U31N	Sewage Ejector Room			
U31S	Sewage Ejector Room			
U32N	Sump Pump Room		Yes	

U32S	Sump Pump Room		Yes	
U43	Fire Water Pump Room		Yes	
U45	Diesel Generator Room		23.	
U48	Chiller & VAC Room		Yes	
U50	TR & HT Panel Room		24.	
U51	Emergency Equipment Room	-	Yes	
25.	Transformer Room		Yes	Yes
26.	Transformer Room		Yes	Yes

Note:-

At every entrance and in public areas manual call point at distance of 30-50 mtr. have been provided.

Repeater panel at each fire mean's entrance have been provided.

Portable Fire extinguishers have been provided in all public areas / readily accessible places in accordance with IS: 2190

E23. CLEAN AGENT / CO2 GAS BASED PROTECTION SYSTEM

E23. 1 CO2 gas based fire trace tube flooding system

E23. 1.1.1 The scope covers supply, installation, testing and commissioning of automatic CO_2 flooding system complete for electrical panels with fire trace tube, cylinder, valves, integration with fire alarm control panel for annunciation. The work shall cover:

i. Providing fire trace tube inside the panels.

ii. Arrangement of CO2 for flooding of the panels.

iii. Audio-visual annunciation devices for indicating incidence of fire.

iv. Wiring from alarm initiating devices with required conduits as per direction of engineer-in-charge.

v. Any other item required to the successful commissioning of the system.

vi. Providing manual arrangement for discharge of gas inside the panels.

E23. 1.1.2 The electrical panel fire suppression system shall be complete with CO2 gas storage cylinders of required capacities, extinguishing agent as specified, polymer fire trace tubing, filling and end-of-line adaptors, pressure switches, control equipment and all necessary accessories and fittings to form a complete and working installation to protect the specified areas to the approval of the engineer-in-charge.

E23. 1.1.3 The panels to be protected shall be determined as per the approval of the engineer-in-charge.

E23. 1.1.4 The system shall have an interface with Main Fire Alarm & Control Panel. In case of fire in the concerned Panel, indication & alarm should come in Main Fire Alarm & Control Panel.

E23. 1.2 Standards

E23. 1.2.1 The design and installation of the CO2 gas based Fire Trace Tubing system is based on the latest applicable codes and also as per the manufacturer's recommendations; the required CO2 gas quantity is arrived as per the volume of the respective panels to be protected. In addition, the following standards and rules and regulations shall be applicable:

(a) Fire protection manual of the tariff advisory committee, Fire Insurance Association of India

(b)	IS: 6382 - 1984	Code of Practice for Design and Installation of Fixed Carbon Dioxide Fire Extinguishing System
(c)	NBC Part-IV 2005	NationalBuilding Code -2005 Part-IV: Fire Safety System
(d)	IS: 7285 - 2004	Refillable Seamless Steel Gas Cylinders -

		Specification
(e)	IS: 307 – 1966	Carbon dioxide
(f)	Local Fire Brigade/Authority	

E23. 1.3 Technical and Installation Requirements

E23. 1.3.1 The system shall generally comply with IS 6382. The carbon-dioxide supply shall be of the high pressure type, in which the gas is stored in rechargeable containers designed to store liquefied carbon-dioxide at atmospheric temperature corresponding to a nominal pressure of 6MN/m^2 (60kgf/cm^2) at 27°C. High pressure cylinder shall hold pressurized CO_2 in liquid form at ambient temperature corresponding to a nominal pressure of 6MN/m^2 (60kgf/cm^2) at 27°C.

E23. 1.3.2 Thecomplete equipment design shall be reliable in operation. All components of the installation should be located, installed or suitably protected to ensure that no mechanical, chemical or other damage is possible which may render these inoperative.

E23. 1.3.3 All devices used in the installation shall be capable of functioning satisfactorily between - 29°C and 65°C.

E23. 1.3.4 Forenclosed tight electrical equipment, the quantity of carbon dioxide for extended discharge shall be sufficient to maintain carbon-dioxide concentration of at least 30% throughout the declaration period or for a minimum of 20 minutes.

E23. 1.3.5 Quantityof carbon dioxide for initial discharge shall be as per Table 5 of IS-6382.

E23. 1.3.6 The total amount of carbon dioxide, calculated shall be stored in a main battery of carbon-dioxide cylinders conforming to IS: 7285-2004. The carbon dioxide shall conform to IS: 307-1966.

E23. 1.3.7 All cylinders in the battery shall be interchangeable.

E23. 1.3.8 Each cylinder shall be provided with its own valve with a dip tube extending to the bottom inside the cylinder, and valve discharge head, which shall be connected to a common manifold through high pressure connecting pipes or tubes.

E23. 1.3.9 All carbon-dioxide cylinders in the battery and the common manifold shall be mounted and suitably supported in a rack provided for the purpose.

E23. 1.3.10 Flexible hoses used for discharge bend shall preferably be double wire braided (perforated) rubber covered hose suitable to withstand a minimum bursting pressure of 420kgf/cm^2 at 54°C.

E23. 1.3.11 All discharge heads and valves shall be designed taking into consideration the fact that liquefied carbon dioxide expands very rapidly (1 to 450) when discharged. The requirements of minimum flow of gas and the temperature at which these are required to operate shall also be taken into consideration. These shall conform to IS: 3224-2002.

E23. 1.3.12 All valves under constant high pressure shall have a minimum bursting pressure of not less than 42MN/m^2 (420kgf/cm^2) and those not under constant pressure shall have a bursting pressure of not less than 35MN/m^2 (350kgf/cm^2).

E23. 1.3.13 Discharge heads and valves shall be designed to permit a minimum discharge of 85% of the carbon dioxide in the cylinder is not more than 30s at a temperature of 27± 1°C. The discharge rate of carbon dioxide shall be not less than 0.68kg/s for the first 85% of the cylinder's contents.

E23. 1.3.14 Nozzles shall be sufficient in a number and so located that the gas discharge pattern shall completely cover the enclosure.

E23. 1.3.15 The complete distribution system shall be free from leakage when tested at a pneumatic pressure of 14MN/m^2 (140kgf/cm^2) with all nozzle outlets closed.

E23. 1.3.16 All sections of pipe having dead ends shall be fitted with suitable pressure relief devices designed to operate between 16.8MN/m^2 (168kgf/cm^2) and 21MN/m^2 (210kgf/cm^2).

E23. 1.3.17 The nozzles shall be designed and located in such a manner that an even distribution of gas will be achieved throughout the protected space and at the same time the discharge from the nozzles shall not cause undue splashing of flammable liquids or creation of dust clouds that might aid spread of fire.

E23. 1.3.18 Thesystem shall be simple self activating system, specifically designed for installation inside enclosures, cabinets and machinery housing to detect automatically and extinguish fire at source, at its very early stage. It should be suitable for application where the potential fire risk is located within an enclosed or confined space e.g. electrical panels etc.

E23. 1.3.19 The system should be an automatic self-seeking fire extinguisher, which puts fires where they start by means of a flexible fire detection and delivery tube. The tube shall be manufactured from specially produced polymer material to achieve the desired detection and delivery characteristics. The system shall have capability of linear detection i.e. detection of fire not only at a single stage point but also at any place along the tube's length.

E23. 1.3.20 This extinguishing system should be fully integrated with fire alarm system. The system should offer early warning of activation and should reduce the risk of damage to minimum. The system should consist of a valve, connected to a cylinder and to a flexible detection and delivery system i.e. flexible tube. This tube should be routed within the equipment to be protected. In case of fire, the tube shall melt and bursts at the hottest point and the extinguishing agent is then transported through the Fire trace tube exactly to the origin of fire (i.e. the point of burst).

E23. 1.3.21 The system should be simple self-activating system without human intervention and suitable for enclosed spaces like engine room, panels.

E23. 1.3.22 The system should have fast response - less than 10 seconds.

E23. 1.3.23 The system should extinguish fire at early stage and should trigger automatically and also manually.

E23. 1.3.24 The system should be safe against malfunction and should not need power supply for detection and extinguishing of fire.

E23. 1.4 **Fire Trace Tube.**

E23. 1.4.1 The tube should be a flexible type made of special polymer.

E23. 1.4.2 The tube should have OD 6mm and ID 4mm or thereabout.

E23. 1.4.3 The tube should be red in colour (or as directed by engineer) to indicate it is part of fire protection system.

E23. 1.4.5 The tube should be non – conductive, non- corrosive and flexible.

E23. 1.4.6 The tube should be capable of withstanding pressure up to 20 bars.

E23. 1.4.7 The tube must have approval for using to detect fire from loss prevention council.

E23. 1.4.8 The tube should be routed inside the panel for detecting fire and over heat. No drilling, soldering or any other damaging activity will be carried out inside the panel for fixing tube to detect the fire.

E23. 1.4.9 The CO_2 gas cylinder should have a valve which should operate automatically, in case the pressure in the tube reduces due to fire and bursting. The cylinder should have a different valve which is made of virgin brass with the following specifications:

1. The valve should be a Direct/indirect high pressure valve.
2. It should operate on sensing the drop in the pressure.
3. The valve should hold pressure up to 58 bar.
4. The discharge flow should be kgs to 7 kgs per minute.
5. The valve will have provision for connecting pressure switch, Pressure gauge, filling in adapter.
6. The cylinder will be mounted on automatic weight measurement system.

E23. 1.5 **Weight Measurement System**

E23. 1.5.1 The weight measurement system should be designed to monitor the weight of the CO_2 filled cylinder. It should consist of a load cell of high quality and precision with associated electronics and a cylinder ring for holding the CO_2 cylinder in place. The load cell shall operate in 5^oC to 70°C .The temperature effect on the span should be 0.006% and the effect on tare is 0.008%. The safe over load provision should be 200% of the rated capacity and should be highly reliable. The system should monitors CO_2 gas weight on continuous basis all the time. In the event of reduction in the weight of the CO_2 gas in the cylinder (either due to leakage or release of CO_2 gas) beyond the present limit the electronics circuitry provided in the unit should activate the respective audio visual alarm unit and annunciates the in the occurrence of fault of fire.

E23. 1.6 **System Operation**

E23. 1.6.1 The system should be self-activating detection & suppression type that must reliably suppress fires in few seconds. In the event of fire contacting the detection tube, the tube must bursts at the hottest point leading to a rapid reduction of pressure inside the tubing. This will make the differential high pressure valve fitted on the CO_2 cylinder open instantaneously and the CO_2 gas stored in the cylinder will get released through the tube at the burst point into the panel.

E23. 1.6.2 The drop of pressure in the tube followed by reduction in the weight of the CO_2 gas in the cylinder due to the discharge will activate an audio-visual alarm unit which will be interfaced / connected with the fire alarm system.

E23. 1.6.3 The proposed system is a direct release low-pressure system with UL & FM approval. The required CO2 gas quantity and size of the cylinder is selected based on the volume of the protected panel. The system must contain the following:

i. Automatic detection of fire
ii. Automatic flooding of carbon dioxide
iii. Activation of audio visual alarm unit
iv. Manual release value option
v. Indication & alarm in main fire alarm & control panel

E23. 1.6.4 The detection tube shall be made by a polymer tube, which can detect the fire anywhere along its length. The tube is highly flexible and can be conveniently routed to cover the various hazard areas in electrical panels. One end of the fire trace tube shall be connected to the CO2 cylinder and the other end to the end of line adaptor through a non return value. The CO2 cylinder assembly shall be mounted on a weight monitoring system.

E23. 1.6.5 Pressure switch shall be connected to the end-of-line adaptor, which shall be electrically connected to an audio visual alarm unit.

E23. 1.7 **Accessories**

The system shall include but not limited to the following:

- top
- Auto weigh measurement system
- Fire trace tube
- Indirect high pressure valves
- D/I adapters
- Pressure switches
- Spring Alarm units
- Non-sensing tube

- Manual actuation units
- CO2 cylinder
- CO2 discharge nozzles
- Hardware items
- Pressure switch to sense the drop in pressure.
- Filling in adapter to change the tube.
- Ball valve for closing and releasing.
- The spring top to protect the Fire trace tube at the cylinder end.
- Straight fitting for connecting Fire trace tube in case of need.
- Cross fittings
- T fittings.
- Cross panel fittings.
- End of line adapter.
- Non return valves.

E23.2 CLEAN AGENT BASED FLOODING SYSTEM FOR ELECTRICAL PANEL PROTECTION

E23.2.1 General

E23.2.1.1 The scope covers Supply, Installation, Testing and Commissioning of Automatic clean agent based Flooding System complete for electrical panels with flexible fire detection tubing, cylinder, valves, integration with Main Fire Alarm Control Panel for status monitoring etc. The scope of work includes, but not limited to the following

- Providing Direct Panel Gas Flooding System with flexible fire detection/ discharge tubing inside the panels.
- Clean agent storage cylinder for flooding gas inside the panels.
- Audio-visual annunciation devices for indicating incidence of fire.
- Any other item required to the successful commissioning of the system.

E23.2.1.2 The electrical panel fire suppression system shall be complete with Direct Clean Gas storage cylinders for required capacities, extinguishing agent as specified, fire detection tubing, filling and end-of-line adaptors, pressure switches, control equipment, Clean Agent Cylinder/Valve Assembly, Cylinder Mounting Bracket and all necessary accessories to protect the Electrical panel in case of fire. The system will have an interface with Main Fire Alarm and Control Panel. In case of fire in the concerned Panel, indication of Fire / discharge status should come in Main Fire Alarm and Control Panel.

E23.2.2 Design Requirements

E23.2.2.1 All the detecting devices, alarm, indicating devices, containers and other related equipment shall have required approvals & Authorization.

E23.2.2.2 All installations shall conform to NFPA requirements.

E23.2.2.3 Clean Agent should be used with below mentioned properties

(a) The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0)

(b) The Clean Agent should not have Global Warming Potential of more than 1.

(c) The Clean Agent should be a low pressure agent.

E23.2.3 System Equipment

E23.2.3**.1** Fire Trace Tubing

The tubing shall be installed throughout the Electrical Panel with one end connected to the top of the Clean Agent container valve. The tubing shall be pressurized with Dry Nitrogen to 150 psig and maintains the system in the "OFF" position. The tube shall burst at temp. 100-120 degree C. The tubing shall perform three functions:

Heat Detection, System Activation and Clean Agent discharge.

E23.2.3**.2** Clean agent Container

- Design, fabricate, certify and stamp containers in accordance with the requirements of NFPA (DOT). Containers shall be standard model and size of ease of replacement and addition.
- Each storage container shall be equipped with a nickel–plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the detection tubing. The quarter-turn ball valve shall be kept closed at all times when the container is not in service.
- All container valves shall be equipped with a pressure relief valve (rupture disc) device in compliance with DOT requirements.

E23.2.4 Technical and Installation Requirements

E23.2.4.1 Provide sufficient amount of Extinguishing Agent to Inert the Micro environment being protected considering the following when computing volume to verify suitability and to establish design limitations:

- Volume of hazard area.
- Specific volume of Clean Agent.
- Discharge time and flow rates.
- Design concentration and design factors.
- Detector/discharge tubing placement.

E23.2.4.2 Interface system with main control fire alarm system and BMS.

E23.2.4.3 All doors and holes in the enclosed/equipment should be closed or sealed to maintain the tightness of enclosure.

E23.2.4.4 The clean agent based Pre-Engineered automatic direct fire suppression system shall be approved by required approvals & Authorization.

E23.2.4.5 Each clean agent pre-engineered automatic system is equipped with its own detection/discharge tubing.

E23.2.4.6 The unit shall be a self-contained and shall be equipped with its own non-electric automatic detection system to detect the fire and agent release system into the Electric panel to suppress the fire.

E23.2.4.7 The Clean Agent is stored in DOT steel cylinders as a liquefied compressed gas, super-pressurized with Dry Nitrogen to 150 psig at 70F. The ambient operating temperature range for all system components should be 0 degree C to 54 degreeC.

E23.2.4.8 Each container is equipped with a nickel–plated brass valve, a pressure gauge to monitor container pressure, and a quarter-turn ball valve that interfaces with the Detection Tubing. In addition, the container valve shall be equipped with a pressure relief (rupture disc) device in compliance with DOT requirements.

E23.2.4.9 Provide wall-mounted painted steel bracket to mount the container/valve assembly in a vertical (upright) position. Each bracket should be equipped with atleast two integral quick-clamp straps.

E23.2.4.10 Install equipment as indicated on the approved shop drawings, and in accordance with requirements of NFPA-70 and NFPA-2001.

E23.2.4.11 All the necessary accessories required for operation of system shall be part of supply from single Manufacturer for UL listing of system.

E23.2.4.12 Make final connections between equipment and system detection tubing under direct supervision of factory trained and certified representative of manufacturer.

E23.2.4.13 It shall be so designed that it does not affect the IP ratings of electrical panels. The Sub-Contractor has to coordinate with manufactures of electrical panels for provision of holes to run the tube and brackets for mounting the tube. The entry of tube inside the panel shall be though suitable size of connector.

E23.2.4.14 The tubing shall be manufactured from specially processed polymer material to achieve the desired heat detection and delivery characteristics. Provide minimum two runs of fire trace tube along with any two sides of every compartment of the panel.

E23.2.4.15 The tubing shall be capable of working even when contaminated with oil, dust and debris as long as the contamination will allow the heat to pass through the tube.

E23.3 CLEAN AGENT BASED FLOODING SYSTEM FOR TRANFORMER ENCLOSURE PROTECTION

E23.3.1 **General**

E23.3.1.1 The scope covers Design, Supply, Installation, Testing and Commissioning of Automatic clean agent based indirect fire suppression system for Dry Type Transformer enclosure complete with storage cylinders, in-direct valves, detection tubingas per NFPA-2001including its safety guidelines with respect to “Hazards to Personnel”, electrical clearance and environmental factors in line with environmental considerations of Kyoto Protocol. The scope of work includes, but not limited to the following

- Clean agent storage cylinder
- Fire detection tubing and spray nozzles
- manual discharge facility
- Interface with BMS.
- Any other item required to the successful commissioning of the system

E23.3.2 Technical and Installation Requirements

E23.3.2.1 The system shall be a clean agent pre-engineered automatic indirect Fire Suppression System and shall be UL &FM Approved products and approval by Local Fire Authority.

E23.3.2.2 The system shall be self contained and have its own non-electric automatic detection system, which when actuated shall automatically release the suppression agent into the transformer cabinet.

E23.3.2.2 Interface system with BMS.

E23.3.2.3 The system shall be complete in all respects. It shall include agent storage container, detection tubing, discharge nozzles, fittings manual release, abort stations, audible and visual alarm devices and any other operations necessary for a functional Clean Agent suppression system.

E23.3.2.4 The System shall detect, control and extinguish the fire and also simultaneously give audio visual indication on the control panel.

E23.3.2.5 Storage containers shall be located as near as possible to hazard area but shall not be exposed to fire.

E23.3.2.6 Storage containers shall be carefully located so that they are not subjected to mechanical, chemical or other damage.

E 23.3.3 System Operation

E23.3.3.1 The system must operate automatically and its operation shall be as per following:

When the temperature of Fire Trace tube installed inside the Cabinet will increase to above 100 degree C or the detection tube comes in the direct contact of flame, the tube shall burst and initiates ILP Valve which allows the diffusion of

extinguishing medium which is Clean Agent gas through strategically placed pipes & nozzles.

E23.3.3.2 The system shall be designed for In Direct discharge of extinguishing agent through the pipes and nozzle when the tube rupture occurs. The diameter of tube for direct discharge shall be as per calculations and manufacturer recommendations but shall not be less than 6mm under any condition.

E23.3.3.3 The Contractor shall carry out the piping Isometric design and validate the same with a hydraulic flow calculation generated by using hydraulic calculation software. The appropriate fill density to be arrived at basis of the same.

E23.3.3.4 The design & calculation shall be checked & certified by manufacturers trained design engineer. The calculation is the only guarantee that the system shall work, provided the system is installed exactly as per the design.

E23.3.3.5 These documents shall be prepared by a fully experienced person and qualified in the design of gas based fire suppression system.

E23.3.4 Equipment Specifications

E23.3.4.1 Cylinder

- Design, fabricate, certify and stamp containers in accordance with the requirements of NFPA (DOT). Containers shall be standard model and size of ease of replacement and addition.

E23.3.4.2 *Not Used*

E23.3.4.3 Discharge Hose

- The Discharge Pipe should be high pressure braided hose with heavy duty adopters. The nozzle should be made of Brass/Gun Metal and should have 180 degree discharge pattern.

E23.3.4.4 *Not Used.*

E23.3.4.5 *Not Used.*

E23.3.4.6 *Not Used.*

E23.3.4.6.1*Not Used.*

E23.3.4.7 *Not Used.*

E23.3.4.8 System and Detection Tube

- The System will be UL/FM approved product
- Clean Agent should be used with below mentioned properties
- The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0)
- The Clean Agent should not have Global Warming Potential of more than 1.
- The Clean Agent should be a low pressure agent.

The detection tube shall be manufactured from specially processed polymer material to achieve the desired heat detection and delivery characteristics. The tube shall be capable of working even when contaminated with oil, dust and debris as long as the contamination will allow the heat to pass through the tube.